Barron's Review Course Series

Let's Review:

Biology
The Living Environment

Fourth Edition

G. Scott Hunter

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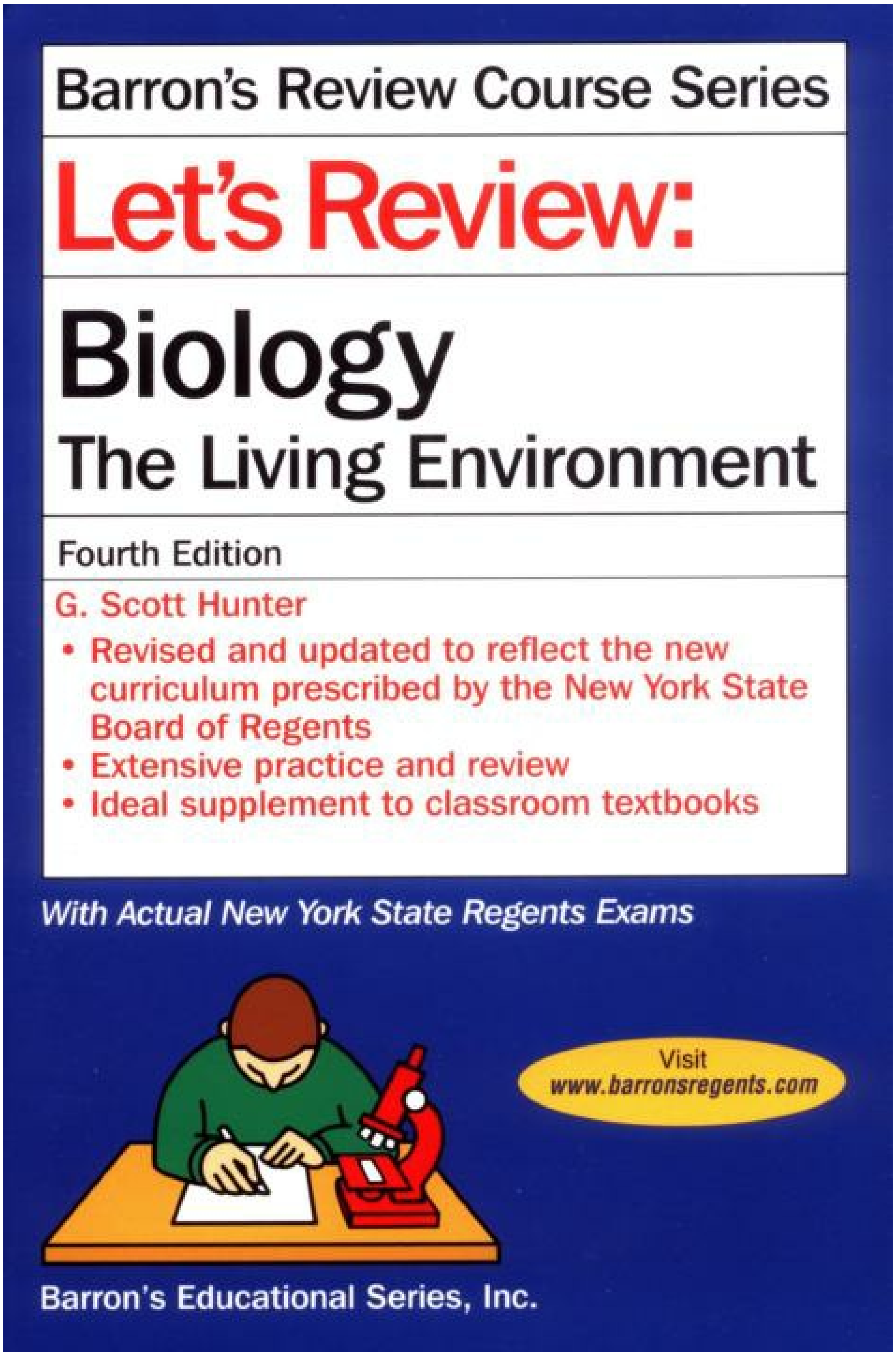

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Biology—The Living Environment

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Preface

TO THE STUDENT

For Which Course Can This Book Be Used?

This book is designed to be used as a review text for the New York State Regents course in The Living Environment. The material presented illustrates and complements the Core Curriculum released in 1999 for this course. Don't let the words "Core Curriculum" scare you. The Core Curriculum simply lists and describes what topics you must learn to complete this course. Because this book is comprehensive, it can be used to supplement any college-preparatory course in biology taught anywhere in the United States.

What Special Features Does This Book Have?

The topics in this book parallel those of the New York State Core Curriculum for The Living Environment. The Core Curriculum is reproduced in its entirety within the text of this book. All Key Ideas, Performance Indicators, and Major Understandings for Standards 1 and 4 of the Core Curriculum appear within the text. In addition, this edition contains information about the laboratory experiences required of all New York State biology students beginning in the 2003-2004 school year.

Each section contains the material considered to be most relevant to a Major Understanding. However, the contents of this book do not represent all the information you will be required to learn for this course. Requirements will vary between teachers and school districts. This book illustrates and explains the concepts contained in the Major Understandings. Students are expected to do more than simply memorize facts. You will now be required to demonstrate understanding of scientific concepts. Your teacher may supplement material in the basic curriculum due to interest expressed by a class or a particular student. Feel free to ask about the areas of biology that interest you.

Practice question sets that mirror the style and content of the new Regents examination appear in this book. The multiple-choice questions usually require that you use your knowledge of biology to make judgments and to select an appropriate choice from among a number of possible responses. Free-response questions ask you to construct single-word, complete-sentence, or essay answers that are understandable as well as scientifically accurate. Graphical analysis questions challenge you to organize, represent in graphic form, and draw inferences from experimental data.

Answers Explained for the practice multiple-choice questions provide an extensive analysis of each question, not simply an answer key. The explanations give you information about why choices are correct or incorrect. Sample free-response and essay answers guide you toward the standard required to perform successfully on a Regents examination in biology. Graphs and charts provide guidance for construction of responses that will meet new Regents standards.

An extensive glossary provides an alphabetical listing of terms commonly used in biology courses together with simple, easy-to-understand definitions. Many of these terms will appear in Regents examination questions or in your reading assignments.

Finally, two full-length Regents examinations are included. They will give you an opportunity to test your knowledge of biology and to practice your question-answering skills before taking the Regents examination.

Who Should Use This Book?

Any student enrolled in the New York State course on The Living Environment will find this book to be a valuable supplement to the regular class textbook. In addition, this book can be used to prepare for tests throughout the school year and for the year-end Regents examination on The Living Environment. It will help you do your best on the Regents examination by increasing your self-confidence in your test-taking abilities.

Students in any secondary-level biology course anywhere in the United States can use this book in much the same way. Its clear, concise style helps to clarify concepts. The absence of extraneous material enables you to concentrate on the learning standards without being bogged down in unnecessary details.

NEW YORK STATE LEARNING STANDARDS

Graduation Requirements

Several graduation or commencement standards are required of students in New York State public schools regarding their performance in math, science, and technology. The Living Environment Core curriculum addresses two of these standards as follows:

> Standard 1: Students will use mathematical analysis, scientific inquiry, and engineering design, as appropriate, to pose questions, seek answers, and develop solutions.
>
> Standard 4: Students will understand and apply scientific concepts, principles, and theories pertaining to the physical setting and living environment and recognize the historical development of ideas in science.

The Core Curriculum for The Living Environment was devised from these two commencement standards. The Core Curriculum is not a detailed outline, or syllabus, for biology. It does not prescribe what must be taught and learned in any particular classroom. Instead, it defines the skills and major understandings that you must master to achieve graduation standards for life science.

Key Ideas, Performance Indicators, and Major Understandings

Each topic within the graduation standards is broken down into a number of Key Ideas. Key Ideas are broad, general statements about what you as a student will be expected to know. Within Standard 1, three Key Ideas are concerned with laboratory investigation and data analysis. Within Standard 4, seven Key Ideas present a set of concepts that are central to the science of biology. The unifying principles develop your understanding of the essential characteristics of living things and how these characteristics allow them to be successful in diverse habitats.

Each Key Idea contains Performance Indicators. The Performance Indicators spell out what skills you should be able to demonstrate when you have mastered the Key Idea. Performance Indicators help you understand what is expected of you.

Performance Indicators are further subdivided into Major Understandings. The Major Understandings contain specific concepts that you must master in order to demonstrate the skills required by a Performance Indicator. The Major Understandings contain the material that will appear on your exams.

Laboratory Component

A meaningful laboratory experience is essential to the success of any science course. You're expected to develop a good sense of how scientific inquiry is carried out by a professional scientist and how these same techniques can assist in the full understanding of scientific concepts. The Regents requires 1,200 minutes of laboratory experience coupled with satisfactory written reports of your findings.

The Living Environment Regents: Format and Scoring

The format of the new Living Environment Regents, based on exams administered since June 2000, is as follows:

> Part A: 35 multiple-choice questions that test your knowledge of specific factual information. All questions in Part A must be answered. A maximum of 35 credits is awarded for this part.
>
> Part B: Variable number of questions representing a mixture of multiple-choice and free-response items. Questions may be based on your direct knowledge of biology, interpretation of experimental data, analysis of readings in science, and the ability to deal with representations of biological phenomena. All questions must be answered in Part B. A maximum of 30 credits is awarded for this part.
>
> Part C: Variable number of free-response questions. Questions may be based on your direct knowledge of biology, interpretation of experimental data, analysis of readings in science, and ability to deal with representations of biological phenomena. All questions must be answered in Part C. A maximum of 20 credits is awarded for this part.
>
> Part D: Laboratory component of the Regents examination beginning June 2004. Four required laboratory experiences are tested. See pages xiv and xv for additional information on the Part D requirement. A maximum of 15 credits is awarded for this part.

HOW TO STUDY

You've spent the school year learning many different facts and conceptsfar more than you could hope to remember from one review session. Your teacher has drilled you on these facts and concepts. You've done homework, taken quizzes and tests, and reviewed the material at intervals throughout the year. Now it's time to put it all together. The Regents exam may be only a few weeks away. If you and your teacher have planned properly, you will have finished the course material about a month before the exam. You now have to make efficient use of the days and weeks ahead to review all that you have learned and demonstrate your mastery of the material on the Regents.

It may seem like an impossible task, but you shouldn't be discouraged. You've actually retained much more of the year's material than you realize. The review process should be one that helps you to recall the many facts and concepts you have stored away in your memory. Your Barron's resources, including Let's Review Biology: The Living Environment, Regents Exams and Answers-The Living Environment, will help you to review this material as efficiently as possible.

You also have to get yourself in the right frame of mind. Being nervous and stressed during the review process won't help you one bit. The best way to avoid being stressed during an exam is to be well rested, prepared, and confident. This book is here to help you get prepared and build your confi dence. So, now is the time to get started on the road to a successful exam experience. To begin, carefully read and follow the steps outlined below:

1. Get started! Start your review early; don't wait until the last minute. Allow at least two weeks to prepare for the Regents exam. Set aside an hour or two a day over the next two weeks for your review. Less than an hour a day is not enough time for you to concentrate on the material in a meaningful way; more than two hours a day will give diminishing returns on your investment of time.

2. Get lost! Find a quiet, comfortable place to study. You should seat yourself at a well-lit work surface free of clutter and in a room without distractions of any kind. (You may enjoy watching TV or listening to music curled up in a nice, soft chair, but these and other distractions should be avoided when studying.)

3. Get prepared! Make sure you have the tools you need to work, including Barron's Regents Exams and Answers-The Living Environment, a pen and pencil, and some scratch paper for taking notes and doing calculations. Keep your class notebook at hand for looking up information between test-taking sessions. Have this book available for quick and efficient review of important concepts.

4. Get focused! Concentrate on the study material in the question sets in Barron's Let's Review Biology: The Living Environment. Think about the questions that you review. Read carefully and thoughtfully. Try to make sense out of the questions. Think carefully about the answers that you choose. See the section "Using This Book for Study" for additional information about question-answering techniques.

5. Get help! Use available resources, including a dictionary and the glossary of this book, to look up the meanings of unfamiliar words in the practice questions. Remember that these same terms can appear on the Regents exam, so take the opportunity to learn them now.

6. Go get 'em! Remember-study requires time and effort. Your investment in study now will pay off when you take the Regents exam.

Using This Book for Study

This book will be an invaluable tool for you if used properly. Answer all of the questions in the question sets and practice exams even though the exam directions may allow you to choose which questions to answer. The more you study and practice, the better your chances of increasing your knowledge about biology and of obtaining a high grade on the Regents exam. To maximize your chances, use this book as follows.

1. Answer all of the questions in each question set. Check and correct your responses by using Answers Explained and Wrong Choices Explained at the back of the book. Follow this procedure for each question set. Use Barron's Let's Review Biology: The Living Environment to study your areas of weakness. Then redo the questions you missed on the first round. Make sure you now understand fully what the question is asking and what makes one answer the correct answer.

2. When you've completed the questions in all the question sets, go on to the examination section. Take the exam under test conditions. Plan to answer all test questions; allow yourself no choices at this stage of the study process.

3. Test conditions should include the following:

- Be well rested-get a good night's sleep before attempting any exam
- Find a quiet, comfortable room in which to work
- Allow no distractions of any kind
- Have with you your copy of Barron's Let's Review Biology: The Living Environment
- Have a pen, pencil, and some scratch paper
- Set an alarm clock or watch for the three-hour exam limit

4. This step is very important. Take a deep breath, close your eyes for a moment, and RELAX! Tell yourself that you know this material. You have lots of time to take the Regents exam; use it to your advantage by reducing your stress level. Forget about your plans for later-your first priority right now is to do your best on the Regents exam, whether it is a practice exam in this book or the real thing.

5. Read all test directions carefully. Be sure you know how many questions you must answer to complete each part of the exam. If test questions relate to a reading passage, diagram, chart, or graph, be sure you fully understand the supplemental information before you attempt to answer the questions that relate to it.

6. When answering the multiple-choice questions on the Regents exam, TAKE YOUR TIME! Be sure to read the stem of the question very carefully; read it over several times. These questions are painstakingly written by the test preparers, and every word is chosen to convey a specific meaning. If you read the questions carelessly, you may answer a question that was never asked. Read each of the four choices carefully, using a pencil to mark the test booklet next to the answer you feel is correct.

7. Remember that three of the choices are incorrect; these incorrect choices are called distracters because they are selected by the test preparers to seem like plausible answers to poorly prepared or careless students. Make sure that you think clearly, using everything you have learned about biology since the beginning of the year, to eliminate each of the distracters as correct answers. This elimination process is just as important to your success on the The Living Environment Regents exam as knowing the correct answer. If more than one answer. seems to be correct, reread the question to find the words that will help you to distinguish between the correct answer and the distracters. When you have made your best judgment about the correct answer, circle its number in pencil in your test booklet.

8. Free-response questions appear in a number of different forms. Students may be asked to select a term from a list, write the term on the answer sheet, and define the term. Students may be asked to describe some biological phenomenon or state a true fact in biology using a complete sentence. Students may be asked to read a value from a diagram of a measuring instrument and write that value in a blank on the answer sheet. Exercise care when answering this type of questionfollow directions precisely. A complete sentence must contain a noun and a verb, must be punctuated, and must be written in an understandable way in addition to accurately answering the scientific part of the question. Values must be written clearly and accurately. They must include a unit of measure, if appropriate. Failure to follow the directions for a question may result in a loss of credit for that question.

9. The essay or paragraph question is a special type of free-response question. Typically, essay or paragraph questions provide an opportunity to earn multiple credits for answering the question correctly. As in the free-response questions described above, you must follow the directions for a question if you hope to earn the maximum number of credits for the question. Typically, the question will outline exactly what must be included in your essay to gain full credit. Follow these directions step by step, double-checking to be certain that all question components are addressed in your answer. In addition, your essay or paragraph should follow the rules of good grammar and good communication so that it is readable and understandable. Of course, it should contain correct information and answer all parts of the question asked.

10. Graphs and charts are used in a special type of question that requires the student to organize and

represent data in graphic format. Typically, for such questions you are expected to place unorganized data into ascending order in a data chart or table. You may also be asked to plot unorganized data on a graph grid, connect the plotted points, and label the graph axes appropriately. Finally, questions regarding data trends and extrapolated projections may be asked, requiring you to analyze the data in the graph and draw inferences from it. As with all examination questions, always follow all directions for the question. Credit can be granted only for correctly followed directions and accurate interpretation of the data.

11. When you've completed the exam, relax for a moment. Check your time; have you used the entire three hours? Probably not. Resist the urge to quit. Go back to the beginning of the exam and, in the time remaining, retake the exam in its entirety. Try to ignore the penciled notations you made the first time through the exam. If you come up with a different answer the second time through, stop and read over the question with extreme care before deciding which is the correct response. Once you've decided on the correct response, finalize the answer in ink in the answer booklet.

12. Score the exam using the answer key at the end of the exam. Review the Answers Explained section of Barron's Regents Exams and Answers-The Living Environment for each question to aid your understanding of the exam and material. Remember that understanding why an answer is incorrect is as important as understanding why an answer is correct.

13. Finally, focus your between-exam study on your areas of weakness in order to improve your performance on the next practice exam. Complete all the practice exams using the preceding techniques.

Test-Taking Techniques

By following the suggestions in the preceding section, "Using This Book for Study," you have already practiced many of the techniques needed for a successful examination experience. The following is a summary of test-taking techniques you should follow when taking the actual exam.

1. Complete your study and review at least one day before taking this examination. Last minute cramming may actually hurt, rather than help, your performance on the exam.

2. Be well rested the day of the exam. Get a good night's sleep before taking any examination.

3. Bring two pens, two pencils, and an eraser to the exam. If your school requires it, bring some form of identification with you, as well. Wear a watch, or sit where you see a clock. Before entering the room, remember that you will remain for the entire three-hour examination period.

4. Be familiar with the format of the examination. You must answer all questions in Part A (multiple-choice questions: 35 credits), all questions in Part B (mixed-format questions: 30 credits), all questions in Part C (free-response questions: 20 credits), and all questions in Part D (mixed format questions: 15 credits).

5. Before beginning the exam, take a deep breath, close your eyes for a moment, and RELAX. Use this technique any time you feel yourself tensing up during the exam.

6. Read all exam directions carefully. Be sure you fully understand supplemental information (reading passages, charts, diagrams, graphs) before you attempt to answer the questions that relate to it.

7. When answering questions on the Regents exam, TAKE YOUR TIME. Be sure to read the stem of multiple-choice questions very carefully. Read each of the four answer choices carefully, as well. With a pencil, make a mark in the test booklet next to the answer you feel is correct. If you're temporarily stumped by a question, put a check mark next to it and go on to the next question. Come back to the question later, when your mind is clear.

8. Remember that three of the multiple-choice answers are incorrect (known as distracters). If more than one answer seems to be correct, reread the question to find the words that will help you distinguish between the correct answer and the distracters. When you have made your best judgment about the correct answer, circle its number in pencil on your answer sheet.

9. Be certain to follow directions when completing free-response questions. Use complete sentences whenever they're required.

10. Complete charts and graphs according to instructions. If you're instructed to circle some part of an answer, be sure to circle it. If the directions call for you to connect points or list items in ascending order, then be certain to do so.

11. Answer essay or paragraph questions according to instructions. Be sure to include correct information that addresses every required point. Doing so will help to ensure that you receive full credit for your answers.

12. When you have completed the exam, relax for a moment. Go back to the beginning and, in the time remaining, retake the exam in its entirety. Once you have decided on the correct response, finalize the answer by marking an X in ink through the penciled circle on the answer sheet for multiple-choice questions. Be sure to finalize all of the answers for all parts of the exam.

13. Be certain to sign the declaration on your answer sheet. Unless this declaration is signed, your exam cannot be scored.

TIPS FOR TEACHERS

For teachers and administrators in New York State public schools, this book will provide an excellent source of primary instructional material for locally developed curricula for The Living Environment. The examples given and the factual material presented represent a reasonable body of knowledge to complement the commencement standards for life science. In addition, it will provide a ready source of review material to prepare students for the New York State Regents examination on The Living Environment.

All teachers will be able to use this book with their students as a companion to their regular textbooks and will find that students will gain considerable self-confidence and facility in test taking through its consistent use. Some school systems may wish to use this book as the primary text for their courses in college-preparatory biology; others may wish to employ it as the review text for test preparation.

Shift in Emphasis

Teachers familiar with the Regents Biology Syllabus (1982) will notice a significant reduction in the amount of factual detail in the The Living Environment Core Curriculum (1999). This change is a reflection of a fundamental shift in philosophy about what skills and abilities children should have at the point of commencement at the upper-secondary level. It is assumed that science concepts will have been taught and assessed at an ageappropriate level throughout the student's career, such that little additional detail will need to be presented at the upper-secondary level.

This change can be characterized as a switch from a fact-based curriculum to a process-based curriculum-one that is less concerned about content and more concerned about thinking. It is less about how much a child knows and more about what he/she can do with what he/she knows. The latter, after all, is what real learning is all about; these are the abilities that will last a lifetime, not facts and scientific terminology.

Local Curricula

This being said, it is acknowledged that students will have a difficult time expressing their views and making moral and ethical judgments about science if they lack a working knowledge of scientific principles and do not have at least a passing understanding of the terms used by the biologist. For this reason, teachers and administrators will need to develop local curricula that complement the Core Curriculum. It is up to the teacher/administrator to decide what examples and factual knowledge will best illustrate the concepts presented in the Core Curriculum, what concepts need to be reinforced and enhanced, what experiences will add measurably to the students' understanding of science, and what examples of local interest should be included. The teacher will immediately recognize the need to go beyond this level in the classroom, with examples, specific content, and laboratory experiences that complement and illuminate these Major Understandings. It is on this level that the locally developed curriculum is essential. Each school system is challenged to develop an articulated K-12 curriculum in mathematics, science, and technology that will position students to achieve a passing standard at the elementary and intermediate levels, such that success is maximized at the commencement level.

The addition of factual content must be accomplished without contradicting the central philosophy of the learning standards. If local curricula merely revert to the fact-filled syllabi of the past, then little will have been accomplished in the standards movement other than to add yet another layer of content and requirements on the heads of students. A balance must be struck between the desire to build students' ability to think and analyze and the desire to add to the content they are expected to master.

Lab Needs

A positive benefit of the reduction of factual detail in the Core Curriculum is that it should allow more in-depth treatment of laboratory investigations to be planned and carried out than was possible under the previous syllabus. Laboratory experiences should be designed to address Standard 1 (inquiry techniques) but should also take into account Standards 2 (information systems), 6 (interconnectedness of content), and 7 (problem-solving approaches). They should also address the laboratory skills listed in Appendix A of the Core Curriculum and of this book.

It is important to recognize that this and other assessment tools based on the learning standards may undergo transition in the first few years of implementation. Teachers and students should remain alert to the possibility of changes in the format and scoring of the Regents examination.

Part D

Beginning in June 2004, the Living Environment Regents examination will be changed to include a new Part D. This part of the examination will assess student knowledge and skills on any of four required laboratory experiences supplied to schools by the New York State Education Department. The specific laboratory experiences required in any year will vary according to a preset schedule (see chart below).

Part D is expected to be a 15-point section of the Regents examination. Questions on this section will be a combination of multiple-choice and constructed-response questions similar to those found in Parts A, B, and C of the Living Environment Regents examination. The content of these questions will reflect the four specific laboratory experiences required for that year. Teachers and students are strongly encouraged to include review of these laboratory experiences as part of their year-end Regents preparation activity. (See page 35 for additional information.)

The following chart summarizes the laboratory requirement at the time of this writing.

School Year / Laboratory Title	2003–2004	2004–2005	2005–2006	2006–2007
The Beaks of Finches	Required			
Relationships and Biodiversity	Required	Required		
Making Connections	Required	Required	Required	
Diffusion Through a Membrane	Required	Required	Required	Required
Adaptations for Reproductive Success in Flowering Plants*		Required	Required	Required
DNA Technology*			Required	Required
Environmental Conditions and Seed Germination*				Required

*Not available as of this writing.

UNIT ONE

Scientific Inquiry

STANDARD 1

> Students will use mathematical analysis, scientific inquiry, and engineering design, as appropriate, to pose questions, seek answers, and develop solutions.

Good science is a logical, yet creative, process that applies human intelligence to discovering how the world and the universe work. It depends as much on the published reports of past scientific work as on the ongoing experimental method used to create new knowledge. Scientists continually question the meaning of scientific discoveries and develop new theories based on combining old knowledge with new knowledge. In this way, there is a continual turnover of knowledge that serves the best interests of all people everywhere.

Discovering Truths

Understanding scientific inquiry and discovery is important because the truths that emerge from this discovery can and should be used in everyday social and ethical decision making. These decisions often involve issues of personal and community health, economic considerations, and technological claims. To fail to develop basic scientific literacy is to place oneself and one's community at great potential risk since proposed changes may carry significant negative consequences to any or all of these items.

1. EXPLANATIONS OF NATURAL PHENOMENA

KEY IDEA 1-PURPOSE OF SCIENTIFIC INQUIRY

> The central purpose of scientific inquiry is to develop explanations of natural phenomena in a continuing and creative process.

Scientific inquiry is used as a tool to aid scientists in the study of the natural world. Scientists ask questions, pose hypotheses, design experiments to test these hypotheses, collect and organize data, analyze collected data, draw inferences, and develop conclusions. Major scientific principles are developed from the combined knowledge that results from such experimentation. Scientific inquiry is a creative process that has been ongoing since humans have been on the Earth and will continue long into the future. We are only beginning to unlock the many secrets of the natural world.

Following Procedures

Scientific inquiry depends on an objective application of certain procedures. Some of these include modeling, research, reconciliation of opposing viewpoints, and presentation of explanations. The following sections will discuss each of these processes.

Modeling

Performance Indicator 1.1 The student should be able to elaborate on basic scientific and personal explanations of natural phenomena and develop extended visual models and mathematical formulations to represent one's thinking. Modeling is a way of putting complex scientific data into understandable terms. These models may be mathematical models, visual models, or both. Models frequently use easy references to help you understand-complex principles and relationships.

Scientific explanations are built by combining evidence that can be observed with what people already know about the world. Scientific explanations of natural phenomena come from many different sources, including scientific and personal observations. The modem scientist builds on the work of many earlier scientists who asked questions, developed hypotheses, designed experiments, made observations, analyzed experimental results, and drew inferences and conclusions. These scientists also wrote about their experiments and results, creating vast amounts of scientific literature. Scien tists often compare their results with the results of other scientists performing the same or similar experiments.

Learning about the historical development of scientific concepts or about individuals who have contributed to scientific knowledge provides a better understanding of scientific inquiry and the relationship between science and society. Many scientists have contributed to our current understanding of the natural world. Throughout this book, scientists and their accomplishments are noted. The descriptions demonstrate how their work has contributed to the betterment of society. Although the contributions of these scientists may seem to be complex and unachievable, each of them has used the basic concepts of scientific inquiry to seek out new knowledge. Often, this process occurs one piece at a time over many years before significant scientific theories are developed. Each small experiment adds to the body of knowledge we call modern science.

Science provides knowledge, but values are also essential to making effective and ethical decisions about the application of scientific knowledge. You need to understand scientific knowledge and its implications for social action. Technological advance can impact the lives of individuals, communities, and civilizations. Therefore, the decision must be made whether or not an advance should be introduced, controlled, or set aside.

Assessing the impact of technology on the human, plant, and animal populations that help to keep our environment balanced and healthy is also important. For example, the chemical dioxin, a by-product of certain manufacturing processes, has been linked to a higher-than-normal incidence of cancer in children. Important ethical decisions must be made concerning the release of dioxin into the environment. Do the economic advantages to be gained from the manufacturing processes that produce dioxin outweigh the risks this chemical poses to children's health, or vice versa?

As a responsible individual, you have an obligation to use your knowledge of scientific principles to make such judgments and act accordingly. You have an ethical and moral responsibility to exercise sound judgment based on a solid understanding of scientific fact.

Research

Performance Indicator 1.2 The student should be able to hone ideas through reasoning, library research, and discussion with others, including experts. Humans sharpen their intellect by reasoning, reading the ideas of others, and discussing topics with people whose ideas may differ from their own. By starting with the knowledge base of past generations, we develop ever greater understanding of the world around us. We constantly seek to understand natural phenomena in greater and greater detail. This is possible only by applying the scientific method of inquiry.

Inquiry involves asking questions and locating, interpreting, and processing information from a variety of sources. Scientists do not rely solely on the results of their own experiments when developing scientific principles. To broaden their knowledge, they depend heavily on a large body of scientific literature created from centuries of experimentation, thinking, and discussion. Each new generation of scientists adds to this body of knowledge and moves forward with the discovery of scientific truths.

Inquiry involves making judgments about the reliability of the source and relevance of information. Not all material written about science is reliable or accurate. In some cases, such material may be misleading or biased and may unfairly represent the data in order to support a particular point of view. Good scientific writing involves complete explanation of the experimental method used, a clear presentation of the data, and an objective analysis of the data with respect to other, prior experimentation. In order to be useful to science, the results of these reported experiments have to be reproducible by other scientists using the same experimental methods. Experiments that are not reproducible are considered unreliable and are usually not considered in this process. A good scientist also needs to be able to sort through scientific literature and discard material that does not appear to be relevant to the inquiry at hand. Relevant material should be reviewed and summarized as a n introduction to the new inquiry, even though it may suggest conclusions that differ from the scientist's hypothesis.

Reconciliation of Opposing Viewpoints

Performance Indicator 1.3 The student should he able to work toward reconciling competing explanations and clarify points of agreement and disagreement. Scientific explanations are accepted when they are consistent with experimental and observational evidence and when they lead to accurate predictions. A scientific principle, if it is to gain widespread acceptance, must enable scientists to make accurate predictions of how the natural world operates under a given set of conditions. The conclusions drawn from experimental results must accurately reflect an objective analysis of the data gathered from such experiments. These conclusions must predict the outcome of similar experimentation with reasonable accuracy in order to be considered valid. When they do not do so, conclusions are thrown into question until further investigation is conducted to determine their validity.

All scientific explanations are tentative and subject to change or improvement. Each new bit of evidence can create more questions than it answers. This increasingly leads to better understanding of how things work in the living world. Scientists are always at work to add to the body of knowledge we call science. This new knowledge often supports, but sometimes contradicts, previously held understandings. When contradictions occur, further scientific work is needed to determine where the truth lies.

You need to realize that these scientists do not always agree on the interpretation of scientific data. Divergent ideas and attitudes, as well as diametrically opposed conclusions and theories, also exist. Far from impeding the development of scientific thinking, these divergent concepts are used to stimulate new thinking and experimentation in a never-ending quest for the truths behind the theories. Ultimately, some theories are proven incorrect. However, the process of continual questioning and inquiry is responsible for moving science in a positive direction.

Presentation of Explanations

Performance Indicator 1.4 The student should he able to coordinate explanations at different levels of scale, points of focus, and degrees of complexity and specificity, and recognize the need for such alternative representations of the natural world. The information drawn from scientific investigation is discussed and analyzed from different points of view. By changing the way they look at the data, scientists begin to see patterns and trends not immediately apparent from a one-dimensional analysis.

When data collected from an experiment is represented graphically, the scale used to represent the dependent variable may be large or small. A large scale includes a wide range of possible data points. A small scale uses fewer possible data points. When a large scale is used, small variations in the data may not be easily seen. By decreasing the scale of the graph, the range of data represented is reduced so that small variations can be seen more easily. Analytical methods may involve decreasing the scale of the data to amplify small changes, or increasing it to examine general trends.

Looking at a broad range of data or focusing on specific components of the data may isolate the specific change being measured. The focus area may be the point at which the experimental variable has the most significant effect on the dependent variable. By focusing on this narrow range of data, the researcher can learn much about the changes that occur within this range. The scientist may then design a new experiment that breaks the experimental variable into smaller increments in order to determine more precisely how small changes in the experimental variable work to affect the dependent variable.

For example, an experiment on the effect of temperature on human enzyme action may be set up to measure the rate of enzyme activity at 10°C intervals from 0°C to 100°C. The results of this experiment may show little or no enzyme action from 0°C to 10°C, slight activity at 20°C, increased activity at 30°C, and no activity from 40°C to 100°C. This information should lead the researcher to focus his/her efforts on the temperature range from 10°C to 40°C. The scientist should change the experimental variable of temperature by oneor two-degree increments to determine the precise effect of temperature on this enzyme. By doing so, the researcher should learn the precise temperature at which the enzyme begins to work, what temperature is optimum for this enzyme, and at what temperature the enzyme denatures and ceases to function.

Changing the way data is viewed may involve describing the data in new ways to highlight a researcher's interpretation of the results of one or more scientific studies. Many concepts in the life sciences are extremely complex, with multiple variables operating at once to produce conditions that effect the changes noted by the researcher. It is often the job of the researcher to reduce this complexity for the reader by increasing the specificity of the study. By dealing with a single variable at a time, the researcher determines the effect of each variable independent of the others. When the isolated effect of each variable is understood, the reader can then comprehend how multiple environmental conditions affect the dependent variable in complex ways.

Well-accepted theories are the ones that are supported by different kinds of scientific investigations often involving the contributions of individuals from different disciplines. These varying methods of interpretation help to illuminate the data in new ways and to stimulate still more ideas about its meaning. Well-accepted theories are those supported by investigations involving different scientific disciplines (for example, biochemistry, cytology, genetics). As more and more evidence mounts supporting a theory, the more credibility it gains with the scientific community. Each discipline reports its findings independently of the others so that independent corroboration is achieved. In this way, an inference becomes a hypothesis, which then may develop into an accepted theory, and finally it becomes established scientific principle.

II. TESTING OF PROPOSED EXPLANATIONS

> KEY IDEA 2-METHODS OF SCIENTIFIC INQUIRY
>
> Beyond the use of reasoning and consensus, scientific inquiry involves the testing of proposed explanations involving the use of conventional techniques and procedures that usually require considerable ingenuity.

Scientific inquiry involves several well-defined procedural steps known collectively as the scientific method. These steps include several elements, the first five of which are discussed in the following section:

1. Pose a scientific question based on observation of the natural world.

2. Review available scientific literature relating to the scientific question.

3. Develop a hypothesis about the proposed answer to the scientific question.

4. Design an appropriate experimental procedure to test the hypothesis.

5. Collect and record data resulting from the experimental procedure.

By following this design, the researcher defines his/her goals prior to commencing an experiment. Doing so helps the researcher to focus on the problem at hand. The researcher can then conduct the experiment in a manner that will generate useful data. This data can then be analyzed to yield new knowledge about how the natural world operates.

Question and Observation

Performance Indicator 2.1 The student should he able to devise ways of making observations to test proposed explanations. Scientific inquiry, as its name implies, always begins with the fundamental step of asking a question. A nonscientist may be curious about something he/she observes in nature and ask a question something like "How do leaves turn color in the fall?" or "Why do fruit flies have red eyes?" While questions such as these provide a starting point for inquiry, they do not lend themselves to easy and understandable answers. They do not point to aspects of the observed phenomena that can be measured. They are focused more on reasons for the phenomena than on their observable and measurable characteristics.

By contrast, a scientific question is always asked in terms of observable qualities and measurable quantities. Scientific questions might ask "What pigments are found in the leaves of sugar maple trees?" or "What is the inheritance pattern of red eyes in fruit flies?" Questions such as these lead the researcher toward established laboratory methods. For instance, chromatography (separating pigments of differing molecular characteristics) and genetic crosses (studying the inheritance of genetic traits) provide clues to the broader questions posed above.

These questions, even though less general, can be broken down still further into even more specific, measurable questions. For example, "What pigment is most abundant in sugar maple leaves?" "How does temperature affect the production of chlorophyll in sugar maple leaves?" "What is the relative rate of destruction of the leaf pigments chlorophyll and anthocyanin under constant, intense white light?" and "At what temperature does chlorophyll function most effectively? Least effectively?" The researcher uses these, more focused, questions to help point the way toward research studies. These studies should produce data that lead to new knowledge about natural phenomena.

The simplest method for testing is direct field observation of the experimental subject. Such observations may be conducted informally but by taking careful notes. Later, more formal and controlled observations may be made as a part of an experimental procedure. Such observations are always made objectively, accurately, and in great detail. Conventional laboratory techniques may take on various characteristics depending on what idea is being tested and what variables are being measured. For example, an investigation into the anatomic characteristics of an earthworm should be conducted using dissection tools. An experiment designed to discover the different pigments present in it maple leaf should employ techniques of chromatography. An inquiry into the genetics of the fruit fly should include the tools and techniques necessary to isolate, mate, and count the offspring of fruit flies displaying specific genetic characteristics.

Review of Literature

Performance Indicator 2.2 The student should be able to refine research ideas through library investigations, including electronic information retrieval and reviews of the literature, and bye peer feedback obtained from review and discussion. A vast body of scientific information is available on a wide range of scientific topics. This information is available in books, professional journal articles, research databases, and other reference sources. This literature may contain the findings of other scientists who have conducted similar studies in the past. It may provide good clues to the researcher as to the likely outcome of his/her investigation. Pertinent sources in the scientific literature are normally cited in the introductory material of a report on the experiment at hand.

Increasingly, these resources are available though networked computer databases. You should possess the skills needed to search the Internet to locate reliable research information and to discriminate among sources based on their authenticity. This may require focusing on the archived databases of universities and research laboratories while excluding data sources that do not carry the endorsement of such institutions. You should recognize that posting information on the Internet does not require the editorial scrutiny of competent scientists which is necessary to publish in a professional journal. For this reason, exercise care when using the Internet for conducting literature reviews since the data and analyses presented may be inaccurate, misleading, or biased.

Development of a research plan involves researching background information and understanding the major concepts in the area being investigated. Recommendations for methodologies, use of technologies, proper equipment, and safety precautions should also be included. Such sources provide information about the appropriate methods and techniques to be used in conducting research in a particular area of scientific inquiry. They also inform the reader about what equipment and safety precautions should be used in such investigations. Having this information available in the literature saves valuable time since these techniques and precautions do not have to be discovered by each research scientist conducting a study in a similar area of inquiry. Having this information available also assists the researcher in developing a formal hypothesis.

Finally, being able to review and summarize information gained from such sources and to discuss it with other researchers engaged in the same sorts of investigations is an important skill. Peer feedback can benefit all participants since the shared information and ideas provide everyone with a better understanding of the phenomena being studied. Collaborative sharing is also an important skill that you, as a student, should learn.

Hypothesis

Performance Indicator 2.3 The student should he able to develop and present proposals including formal hypotheses to test explanations, that is, predict what should he observed under specific conditions if the explanation is true.

Hypotheses are predictions based upon both research and observation. A hypothesis is an educated guess made by a researcher about the likely outcome of an investigation. It is a prediction of what should be observed in an experiment run under a specific set of conditions. Hypotheses are based upon both research and observation.

Hypotheses are widely used in science for determining what data to collect and as a guide for interpreting the data. The hypothesis serves as a guide. It assists the researcher in designing the experiment and interpreting the data derived from that experiment. For example, a hypothesis concerning the effect of temperature on bacterial growth might state, "Escherichia coli bacteria will grow best at human body temperature." This hypothesis suggests that a series of identical experimental setups be created that provide a nutrient medium to a single species of bacterium. It further suggests that these setups be placed under a range of temperatures including temperatures below, at, and above human body temperature. Finally, it suggests that bacterial growth be measured in some way that will give the researcher a clear, objective understanding of differential growth rates.

Development of a research plan for testing a hypothesis requires planning to avoid bias (for example, repeated trials, large sample size, and objective data-collection techniques). A research plan is developed in such a way as to provide objective data that will help to answer the experimental question without introducing bias into the experiment. Bias is the tendency to prejudice the results of an experiment with one's own assumptions about the likelihood of its outcome. While developing a hypothesis is an important step in scientific research, the researcher must not let that hypothesis color his/her objective interpretation of the data. To do otherwise would be to introduce bias into the experiment. To ensure objective results, researchers use techniques such as repeated trials, large sample size, adequate controls, and objective data collection techniques.

If the researcher has interpreted the literature appropriately, the hypothesis will often be correct, and the results of the experiment will be as predicted. However, the experimental results may not match the hypothesis. When this occurs, it is not viewed as a failure by the researcher but as a means to suggest more probing questions that get at the real relationships among the variables in the experiment.

Experimentation

Performance Indicator 2.4 The student should he able to carry out a research plan for testing explanations, including selecting and developing techniques, acquiring and building apparatus, and recording observations as necessary. Carrying out a research plan requires a procedure, or set of steps. These steps are laid out within the plan and are specific to the experimental question being asked. The equipment being used, the method being followed, and the means of recording and analyzing data must be appropriate to answering that question. For example, an experiment to determine the structural similarities of five species of worm would probably require dissection equipment and a dissecting microscope. It would involve studying and collecting data about the external and internal structures of a reasonable number of representatives of each species. An experiment on the effects of auxins on geranium stem growth, on the other hand, would require several geranium plants, various concentrations of auxins, a constant light source, and instruments to measure stem elongation and rate of bending. Each experiment has its own unique setup and design.

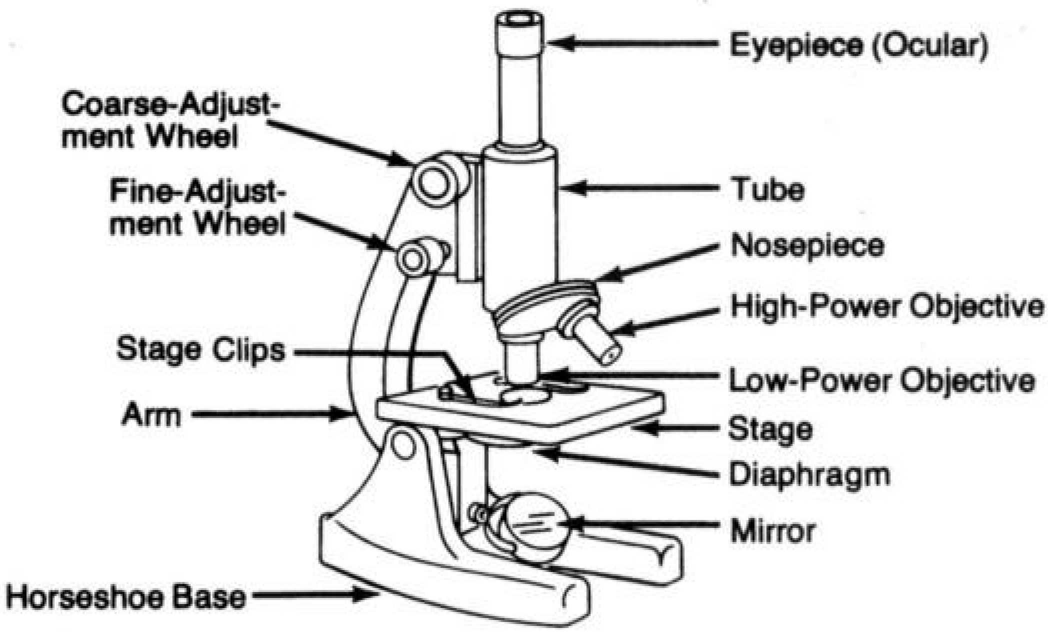
The Compound Light Microscope

The compound light microscope, developed hundreds of years ago by early scientists such as Anton von Leeuwenhoek and Robert Hooke, still represents a major tool of cell study used by biologists all over the world. Compound light microscopes of the type used in most school laboratories produce magnifications of 50x to 500x and are suitable for viewing whole cells and large organelles such as nuclei and chloroplasts. Since this tool is used commonly in the biology classroom, it is important that you understand its parts and workings thoroughly. The critical parts of the microscope include:

- Eyepiece lens (ocular) is the lens closest to the eye during study.
- Objective lens is the lens closest to the object of study.
- Coarse-adjustment knob is used to make large changes in the focus of the microscope; fine adjustment knob is used for small changes.
- Light source provides light, which must pass through the object in order to make it visible through the microscope.
- Diaphragm is used to make changes in the quality and amount of light passing through the object and entering the objective lens.

The compound light microscope provides two major advantages to the scientist studying the cell structure of living things:

- Magnification is the quality of the compound light microscope that makes the image of an object appear larger than the object itself. The magnification of a compound light microscope is determined by multiplying the power of the ocular by the power of the objective lens (for example, lOx ocular x 40x objective = 400x total magnification).
- Resolution is the quality of the compound light microscope that makes it possible to see two or more objects that are very close together as separate objects.



Compound Light Microscope

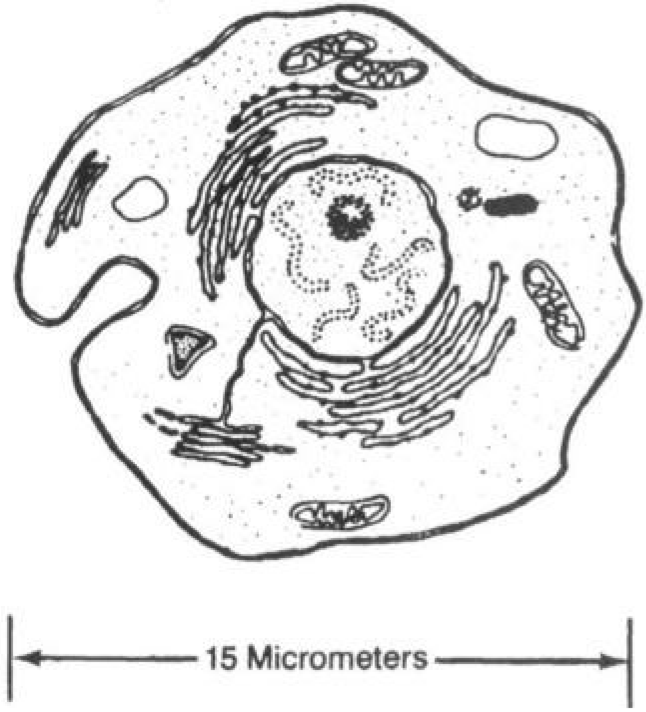
Use of the microscope is an important skill best learned in the laboratory. Practical laboratory experience is the best way to master the skills involved in preparing wet mount slides, focusing the microscope, and making observations of biological specimens. Students may wish to attempt to answer the practice questions below in conjunction with such practical laboratory experience. These questions are provided here and in the Laboratory Skills section to illustrate the kind of question that may be asked on the Regents examination. See the Laboratory Skills section for additional information.

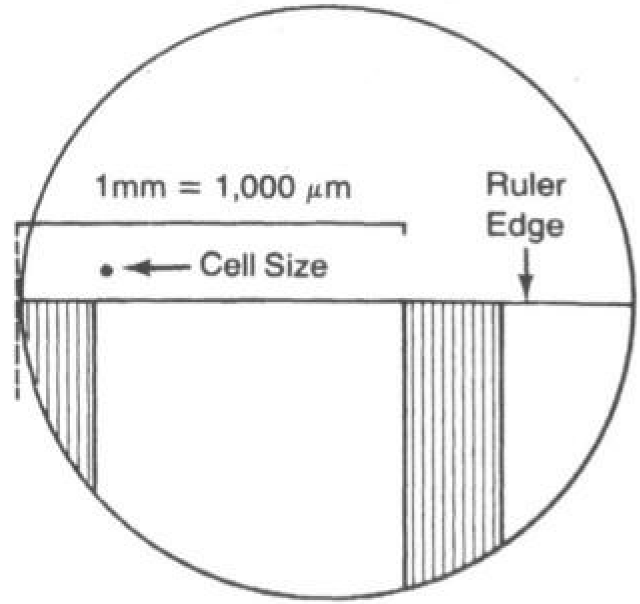
Scientific Measurement

The researcher must also have a good understanding of the various units of measurement and means of data collection used in each type of research study. The metric system is used universally in scientific measurement. Knowledge of the relative sizes of various metric measures is important to accurate data collection. For example, the units of linear measure include the meter (m), the centimeter (cm-1/100 of a meter), millimeter (mm-1/1,000 of a meter), and micrometer (µm-1/1,000,000 of a meter). The units of volume include the liter (1) and milliliter (mL). The metric unit of temperature is the degree (°C). Metric units of mass include the gram (g), kilogram (kg), and milligram (mg).

The Micrometer

Understanding the use of the compound microscope and the units of measurement for microscopic objects is very important for conducting research in the biological sciences. The unit of linear measurement used to measure cells and their organelles is the micrometer (µm). Micrometers are so small that 1,000 of them can fit inside 1 millimeter, and a million of them are required to equal 1 meter. Cells typically are found to have diameters of between 10 and 50 micrometers. If the diameter of the microscope field of view is known, it can be used to estimate the size of objects under it. The low-power field can be measured directly by placing a metric ruler under the low-power field of view. Most low-power fields have diameters of between 1,200 and 1,600 micrometers (1.2 and 1.6 millimeters). The diameter of a high-power field can be determined mathematically using a simple proportion as follows:





Typical Low-Power Field

Cell Measurement

$$\frac{\text{Low-Power Magnification}}{\text{High-Power Magnification}} = \frac{\text{High-Power Field Diameter}}{\text{Low-Power Field Diameter}}$$

To illustrate the use of this proportion, assume you are using a microscope with a 100x low-power magnification and a 400x high-power magnification. Direct measurement shows that the low-power field diameter is 1,200 micrometers (1.2 mm). The diameter of the high-power field is determined by substituting the known values into the formula and solving algebraically for the unknown value as follows.

$$\frac{100\times}{400\times} = \frac{\text{High-Power Field Diameter}}{1{,}200\ \mu\text{m}}$$

$$(400\times)\ (\text{High-Power Field Diameter}) = (100\times)\ (1{,}200\ \mu\text{m})$$
$$\text{High-Power Field Diameter} = 120{,}000/400\ \mu\text{m}$$
$$\text{High-Power Field Diameter} = 300\ \mu\text{m}$$

Indicators, Stains, Tools, and Safety

The use of indicators and stains is also important for working in this field, as is a basic knowledge of the structure of the cell. Indicators are used to help determine the chemical composition of materials used in the laboratory. Common indicators include litmus (acid/base indicator), Benedict's solution , (simple sugar indicator), Lugol's iodine (starch indicator), and bromthymol blue (carbon dioxide indicator). Stains are used to increase the contrast of cell organelles so that they can be viewed under the microscope more easily. Common stains include methylene blue and Lugol's iodine. See the Laboratory Skills section for additional information.

Being able to use and accurately read a variety of different measuring tools, including metric rulers, thermometers, balances, and graduated cylinders, is important to good data collection. The techniques for using these measuring tools are best learned in the laboratory, where demonstration and practice will provide valuable teaching and learning opportunities. Students may wish to attempt to answer the practice questions that follow in conjunction with such practical laboratory experience. These questions are provided here and in the Laboratory Skills section to illustrate the kind of question that may be asked in Regents examination. See the Laboratory Skills section for additional information.

Finally, a good understanding of laboratory safety is essential for conduction laboratory work in any area of study. Like the use of measuring tools, laboratory safety is something that is best learned in practice. A few simple safety rules should always be followed, however. A sampling is shown below. See the Laboratory Skills section for additional information.

- Always follow instructions given to you by your instructor and by your laboratory manual.
- Never use laboratory equipment that is damaged or with which you are unfamiliar.
- Never endanger yourself or others with dangerous horseplay in the laboratory.
- Never touch, taste, or smell objects, chemicals, or solutions unless you know what they are and know they are safe.

QUESTION SET 1.1-EXPLANATIONS OF NATURAL PHENOMENA (ANSWERS EXPLAINED, P. 243)

1. A biologist plans to spend a year investigating the mating behavior of a certain species of frog. To make meaningful observations, the biologist should observe

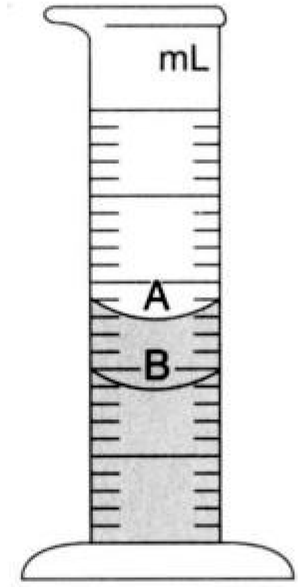
   (1) a small number of frogs in their natural habitat

   (2) a large number of frogs in their natural habitat

   (3) several groups of frogs maintained in different temperatures in the laboratory

   (4) several groups of frogs maintained on different diets in the laboratory

2. In the diagram below, letter A represents the starting volume of liquid in a graduated cylinder. Letter B represents the volume after 8 milliliters of this liquid was removed.



This information indicates that the scale on this graduated cylinder is in milliliter increments of

(1) 1

(2) 2

(3) 8

(4) 4

3. Which sentence represents a hypothesis?

(1) Environmental conditions affect germination.

(2) Boil 100 milliliters of water, let it cool, and then add 10 seeds to the water.

(3) Is water depth in a lake related to available light in the water?

(4) A lamp, two beakers, and elodea plants are selected for the investigation.

4. Zebra finches are small black-and-white birds that lay eggs about the size of a bean seed. Which unit of measurement is best for accurately measuring the length of these eggs?

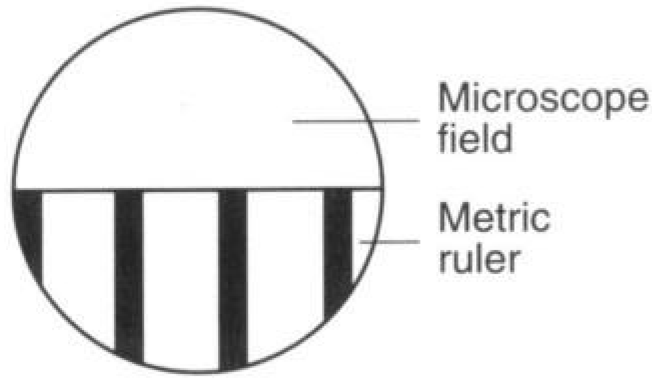
(1) millimeters

(2) micrometers

(3) feet

(4) meters

5. Each division of the metric ruler shown in the diagram below equals 1 millimeter.



The diameter of the field of vision is approximately

(1) 2,800 µm

(2) 3,700 pm

(3) 4,400 pm

(4) 4,700 µm

6. How does a control setup in an experiment differ from the other setups in the same experiment?

(1) It tests a different hypothesis.

(2) It has more variables.

(3) It differs in the one variable being tested.

(4) It utilizes a different method of data collection.

7. When a test tube of water containing elodea (an aquatic plant) is placed near a bright light, the plant gives off gas bubbles. When the light is placed at different distances from the plant, the rate of bubbling is affected. The experimental variable in this demonstration is the

(1) concentration of gas in the water

(2) type of aquatic plant in the test tube

(3) amount of water in the test tube

(4) distance of the plant from the light

8. Which procedure would be part of a laboratory investigation designed to determine if a specific nutrient is present in a food?

(1) Test a moist sample of the food with pH paper.

(2) Add Lugol's iodine solution to a sample of the food.

(3) Place a sample of the food into a test tube containing methylene blue.

(4) Add bromthymol blue to a sample of the food.

9. What is the first step of a scientific investigation?

(1) Perform the experiment.

(2) Analyze the experimental data.

(3) Formulate a hypothesis.

(4) State the problem.

10. By using one or more complete sentences, state one safety procedure that a student should follow when dissecting a preserved frog.

____

11. A new drug for the treatment of asthma is tested on 100 people. The people are evenly divided into two groups. One group is given the drug and the other group is given a glucose pill. The group given the glucose pill serves as the

(1) experimental group

(2) limiting factor

(3) control

(4) indicator

12. A scientific study showed that the depth at which algae were found in a lake varied from day to day. On clear days, the algae were found as much as 6 meters below the surface of the water but were only 1 meter below the surface on cloudy days. Which hypothesis best explains these observations?

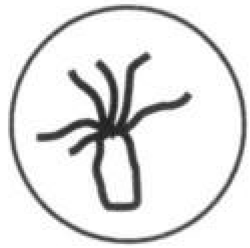
(1) Light intensity affects the growth of algae.

(2) Wind currents affect the growth of algae.

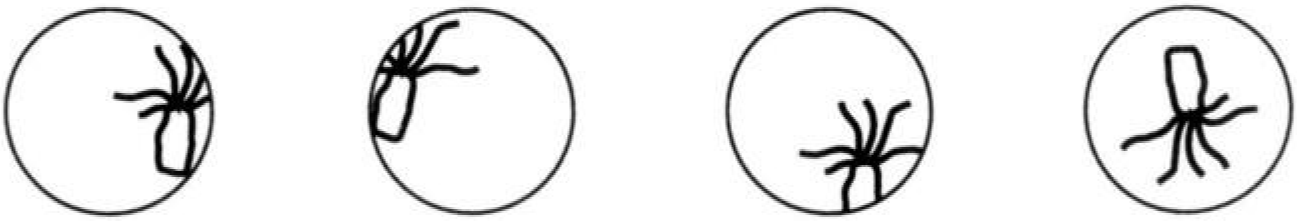
(3) Nitrogen concentration affects the growth of algae.

(4) Precipitation affects the growth of algae.

13. The diagram below represents a hydra as viewed with a compound light microscope.

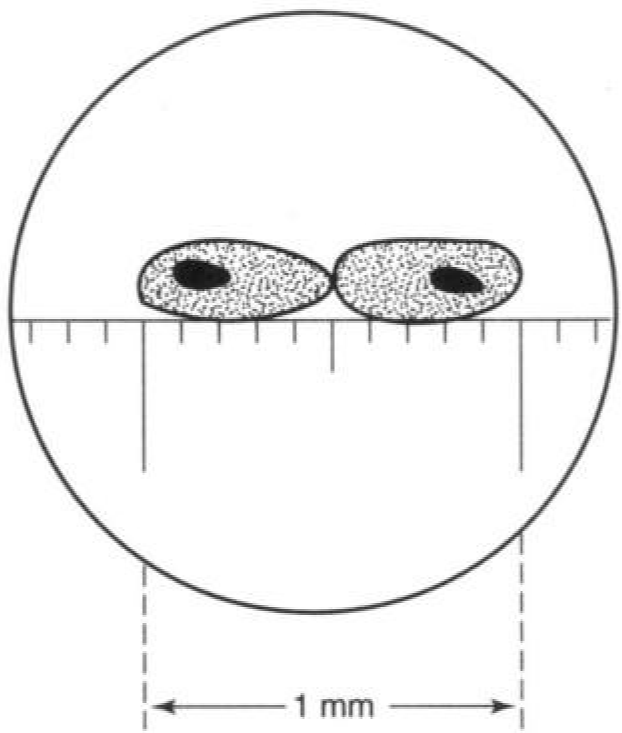


If the hydra moves toward the right side of the slide preparation, which diagram best represents what will be observed through the microscope?



(1) (2) (3) (4)

14. The diagram below represents two cells next to a metric measuring device as seen under low power with a compound light microscope.



What is the length of a nucleus of one of these cells?

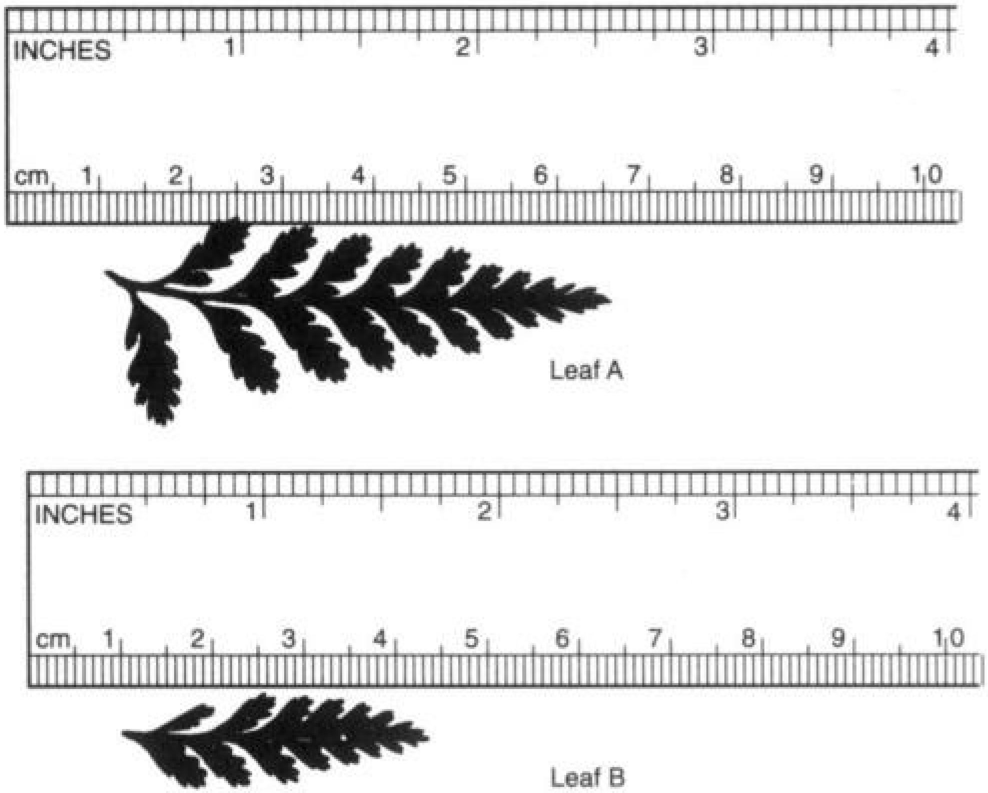
(1) 100 µm

(2) 500 gm

(3) 1,000 μm

(4) 1,500 gm

15. The diagram below represents measurements of two leaves.



The difference in length between leaves A and B is closest to

(1) 20 mm

(2) 20 cm

(3) 0.65 m

(4) 1.6 gm

III. ANALYSIS OF TESTING RESULTS

KEY IDEA 3-ANALYSIS IN SCIENTIFIC INQUIRY The observations made while testing proposed explanations, when analyzed using conventional and invented methods, provide new insights into natural phenomena.

Good, objective data analysis is very important to the scientific method of inquiry. The raw data from an investigation may be extensive, so proper organization and presentation of that data is important. Analysis of this data allows the researcher to compare experimental results against predicted results, to perform additional research, and finally to report confidently on the results of the research. The following section discusses the steps involved in data analysis.

1. Organize data in a manner that facilitates analysis.

2. Analyze data to identify trends and points of focus.

3. Summarize the data into a conclusion that answers the experimental question.

4. Propose and/or conduct additional research.

5. Report on the results of the investigation.

By following this design, the researcher is able to analyze effectively and report on the results of an experiment. This organization and analysis follows certain conventions, allowing researchers from different parts of the world to understand each other's work.

Organization of Data

Performance Indicator 3.1 The student should be able to use various methods of representing and organizing observations (for example, diagrams, tables, charts, graphs, equations, matrices) and insightfully interpret the organized data. Diagrams of observational data can be important for certain kinds of investigations, such as those carried out with the help of the compound microscope. The researcher focuses on the components being studied and sketches his/her interpretations of what is seen. The researcher emphasizes the details pertaining to the study at hand. Diagrams must be accurately labeled to be useful in research. An important skill to be used with this method is estimating the sizes in micrometers (gm) of microscopic objects when seen in the low-power and high-power fields.

Charts or tables are appropriate for presenting many kinds of data. These grids have the experimental variable presented in ascending order on the left side of the chart or table and the dependent variable labeled at the top. The dependent variable values are placed next to the corresponding experimental variable data. A data matrix operates in much the same way. It organizes data by category for ease of comparison.

When data elements relate to each other in complex ways, representing the data as mathematical equations is sometimes preferred. Such equations are derived only after extensive field and laboratory study have supplied extensive data that supports the mathematical model. For example, the Hardy-Weinberg principle of gene frequency describes a mathematical model of gene distribution in sexually reproducing populations. The mathematical equation for this distribution ($p2 + 2pq + q2 = 1$) was derived from studies of actual populations and their gene pools as well as from theoretical information supplied from other sources. This equation can now be used to make predictions about gene distribution in any sexually reproducing species, including those never included in the original research.

Often, a graphic representation of the data will aid in its interpretation, especially where trends are clearly identifiable. Selecting the kind of graph that will best illustrate the data being analyzed is important. A line graph is useful when both experimental variable and dependent variable are numerical. A bar graph is used when the experimental variable cannot be expressed as a number but the dependent variable can be. Pie graphs are useful for depicting data that adds up to 100 percent of some value. Appropriately title the graph in each graph style. Label and scale the axes in line and bar graphs. Accurately plot data points in line and bar graphs or determine percentage sections in pie graphs. Connect points in line graphs, complete bars in bar graphs or complete sections in pie graphs.

From these depictions of the data, seeing broad trends that would not be obvious if the data were not organized in chart or graphic formats becomes possible. By studying the trends in these data elements, researchers are able to develop new and more accurate hypotheses. These hypotheses are then tested using the scientific method of inquiry. With further data to review, researchers can make generalizations, draw inferences and conclusions, and formulate explanations of natural phenomena. At this point, the research is considered to have added new knowledge to science.

Statistical Analysis of Data

Performance Indicator 3.2 The student should be able to apply statistical analysis techniques when appropriate to test if chance alone explains results. One of the simplest statistical methods used in science is calculating the percentage of error. In this method, the value obtained in the laboratory investigation is compared with the result expected through a mathematical formula. The difference between these values is divided by the expected value, and the result multiplied by 100 to obtain the percentage of error in the experiment. The researcher should always speculate on the probable causes of the percentage of error. These causes generally fall into three categories: (1) experimenter error (the researcher fails to follow proper procedure), (2) instrument error (the laboratory equipment introduces error by being inaccurate), or (3) calculation error (calculating the values used in the experiment is inaccurate or rounded inappropriately).

A slightly more complex method used to determine whether the data is valid within statistical norms is the test of statistical significance. The accuracy of any investigation depends on the size of the experimental sample being taken. Small samples often yield unreliable results, while large samples tend to yield more reliable results when probabilities are involved. The test of statistical significance compares what is expected according to probability against results obtained in the laboratory in the light of the size of the sample taken.

The test of statistical significance described here is the chi-square (x2) test. The formula for the chi-square test is as follows: X2 = E(d2/e). In this formula, d represents the deviation from the expected results, e represents the expected results, and E is a symbol for "sum of."

A simple coin toss experiment can illustrate the chi-square method. In this experiment, a normal coin is tossed 10 times in one trial and 100 times in a second trial. Both trials are expected to result in 50 percent heads and 50 percent tails. The first trial results in 8 heads and 2 tails; the second trial results in 53 heads and 47 tails. In both trials, the deviation from expected heads is +3 and the deviation from expected tails is -3. Applying the values of d and e to the formula for chi-square yields results as shown below:

Trial 1:
$$\begin{aligned}\chi^2 &= \Sigma(d^2/e)\\ &= (+3^2/5) + (-3^2/5)\\ &= 9/5 + 9/5\\ &= 1.8 + 1.8\\ &= 3.60\end{aligned}$$

Trial 2:
$$\begin{aligned}\chi^2 &= \Sigma(d^2/e)\\ &= (+3^2/50) + (-3^2/50)\\ &= 9/50 + 9/50\\ &= 0.18 + 0.18\\ &= 0.36\end{aligned}$$

These chi-square values must now be compared to chi-square ranges on a table of probabilities. For this experiment, we can use the simplified table provided below. This table shows probabilities of events occurring as a matter of chance instead of by the effects of some other force. Simple experiments with only two variables, such as this one, are said to operate under one degree of freedom. Probabilities of 1 in 5 (0.20) or greater have a very high likelihood of having happened by chance (highly statistically insignificant), whereas probabilities of 1 in 100 (0.01) or less have a very low likelihood of having happened by chance (highly statistically significant). It is important to recognize that a probability of 1 in 20 (0.05) is the generally accepted dividing line between results that are statistically significant (< 0.05) and those that are statistically insignificant (> 0.05).

	Highly insignificant ←	Insignificant	| Significant		→ Highly significant
Probabilities (p) of chance occurrence	$p = 0.20$ (1 in 5)	$p = 0.10$ (1 in 10)	$p = 0.05$ (1 in 20)	$p = 0.01$ (1 in 100)	$p = 0.001$ (1 in 1,000)
Chi-square (χ^2) values for one degree of freedom	$\chi^2 = 1.64$ ^ Trial 2	$\chi^2 = 2.71$	$\chi^2 = 3.84$ ^ Trial 1	$\chi^2 = 6.64$	$\chi^2 = 10.83$

In this example, trial 1, with a chi-square value of 3.60, is considered to be on the borderline between statistical significance and insignificance. The results of 8 (80 percent) heads and 2 (20 percent) tails is far from the expected values of 5 (50 percent) heads and 5 (50 percent) tails. However, the small sample size brings it into the range of acceptable values for this type of experiment. The borderline value should raise questions in the researcher's mind and trigger additional study to determine whether chance alone is at work or whether some other force (for instance, inaccurate observations or a weighted coin) may be at fault.

In trial 2, whose chi-square value was 0.36, the probability is very high (greater than 1 in 5) that the results of 53 (53 percent) heads and 47 (47 percent) tails was a random event. Therefore these results are highly insignificant statistically. This chi-square test leaves little doubt that the laws of probability, rather than some outside force, are at work in this trial. Note that although the deviation from expected results in both trials was 3, the larger sample size in trial 2 made this deviation insignificant compared to trial 1.

Other, more complex tests of statistical significance may be used by professional scientists. These methods are beyond the scope of this course.

Summary and Conclusion

Performance Indicator 3.3 The student should be able to assess correspondence between the predicted result contained in the hypothesis and the actual result. The student should reach a conclusion as to whether the explanation on which the prediction was based is supported. After conducting a well-designed experiment with appropriate controls; having collected, organized, and objectively analyzed data; and determining the reliability of this data, the researcher is then ready to summarize his/her findings in the form of a conclusion. In its simplest form, the conclusion restates the experimental question and hypothesis. Then it objectively assesses the accuracy of that hypothesis in light of the data presented. If the hypothesis and the experimental results closely correspond, the conclusion should then go on to examine whether the results were produced in a manner that follows the logic used by the researcher in developing the hypothesis. In a well-researched investigation, both the hypothesis and the logic behind it should be reasonably accurate.

When a hypothesis is not supported by the experimental evidence, the conclusion should state that fact. The scientist should examine the literature review, experimental technique, and data analysis to try to detect flaws in the methodology used. Some fundamental omission in the literature review may have lead to the incorrect hypothesis. The techniques used may have been flawed, producing inaccurate data. The organization and analysis of the data may have been insufficient to permit trends to be appropriately identified. Far from being viewed as a failure, this situation is used by professional scientists to stimulate new questioning, additional research, and honed data analysis. Eventually, better results are obtained.

Additional Research

Performance Indicator 3.4 The student should be able to revise the explanation and contemplate additional research based on the results of the test and through public discussion. Investigations in science do not always work out as predicted. Frequently, the results vary in some way from those anticipated in the hypothesis. When this happens, a competent researcher will use the opportunity to examine the experiment, make improvements, and conduct further research. Performing additional research is basic to the pursuit of scientific knowledge.

Hypotheses are valuable, even if they turn out not to be true, because they may lead to further investigation. Hypotheses, even if found to be untrue, are valuable because they help to stimulate further investigation. As a part of the investigation, the researcher makes an objective judgment as to the accuracy of his/her hypothesis. If it is substantially correct, the hypothesis may add measurably to the information available to answer the question asked. Instead, it may take a partially answered question to new levels of understanding. If incorrect, the hypothesis leads the researcher to question the premise upon which the hypothesis was based, reexamine the literature for possible misinterpretation, and review the methods used to conduct the experiment. After performing this review, the researcher may well enter into a new round of experimentation to address any deficiencies found.

Claims should be questioned if the data are based on samples that are very small, biased, or inadequately controlled or if the conclusions are based on the faulty, incomplete, or misleading use of numbers. Claims should be questioned if the experimental design is not consistent with generally accepted experimental procedure. If samples are small or unrepresentative, the data collected may not fairly represent the population as a whole, leading to skewed results. If the data are biased or slanted to match the researcher's hypothesis, the objectivity of the entire investigation is called into question. Since science is based on objective interpretation of data, bias invalidates the inferences drawn from such experiments. If the experimental method is flawed (uses inappropriate tools or techniques), the data will be meaningless and not able to answer the question. An experiment that lacks appropriate controls (allows multiple variables to operate) does not allow the researcher to determine which variable is at work in producing the results reported. If data analysis is not accurate and objective, but rather is faulty, incomplete, or misleading, then trends in the data may be difficult or impossible to identify and project beyond the limited scope of the experiment. Conclusions drawn from flawed data or flawed data analysis are invalid since the basis of all science is objective data.

Claims should be questioned if fact and opinion are intermingled, if adequate evidence is not cited, or if the conclusions do not follow logically from the evidence given. Claims should be questioned if the data and its analysis are not objective in nature. If fact is mingled with opinion when reporting results, if adequate evidence is not cited, or if the conclusions do not follow logically from the evidence provided, be skeptical of the validity of the experiment. These flaws call into question the objectivity and completeness of the data collection and data analysis procedures. Good science is not based on opinion but on factual evidence. This evidence must be collected in sufficient quantity so it can provide a firm foundation for the conclusions drawn analyzing it. Conclusions must come from an objective analysis of the data collected and presented. Those that seem to ignore or make peripheral use of the data are immediately suspect and should be discarded.

Report of Experimental Results

Performance Indicator 3.5 The student should be able to develop a written report for public scrutiny that describes the proposed explanation, including a literature review, the research carried out, its result, and suggestions for further research. When scientific investigation results in valid conclusions, the researcher may choose to summarize his/her findings in a written report. If the findings are of sufficient significance, the report may be published in a professional journal or other medium for review by other researchers and the general public.

Repeatability

One assumption of science is that other individuals could arrive at the same explanation if they had access to similar evidence. Scientists make the results of their investigations public; they should describe the investigations in ways that enable others to repeat the investigations. A major assumption of professional science is that other researchers, by following the explicit descriptions found in such a report, could arrive at the same results as those reached in the original study. A scientific report should accurately and clearly summarize the literature examined when formulating the hypothesis, describe the methods used in designing and carrying out the investigation, present the data and its analysis in an organized fashion, state the conclusions drawn from this analysis, and suggest additional research to carry the investigation further. These items must be described in sufficient detail to allow others to duplicate the experiment in their own laboratories. If this is done and the same results are obtained, the additional research helps to val idate the original investigation. If this is done but different results are obtained, doubt is cast on the original investigation and its conclusions.

Peer Review

Scientists use peer review to evaluate the results of scientific investigations and the explanations proposed by other scientists. They analyze the experimental procedures, examine the evidence, identify faulty reasoning, point out statements that go beyond the evidence, and suggest alternative explanations for the same observations. Peer review either lends support to, or helps to discredit, the reported investigation. It also guides the researcher in the investigation's design, execution, analysis, and reporting. Every aspect of the investigation may fall under the scrutiny of the reviewers. The literature cited may be appropriate or inappropriate to the investigation undertaken. The hypothesis may correctly address the experimental question or may miss the mark. The experimental methods used may be those best suited to the investigation or may be inappropriate. The data may be presented and analyzed in an organized and concise manner or may be confusing and difficult to comprehend. The presentation of the experimental conclusions may accurately reflect the data presented or may be faulty in the way they deal with that data. Statements in the conclusions should always be made within the context of the data collected and reported. Statements that go beyond the data but fail to use mathematically correct extrapolation methods may indicate that researcher bias is at work in developing the conclusions. The explanations offered for the results of the investigation may or may not represent the full range of possible explanations. Peer review may be able to offer alternative explanations not presented by the researcher. Such peer review is meant to strengthen the quality of scientific inquiry and reporting. As this quality improves, so does the body of useful knowledge available to the public.

QUESTION SET 1.2-ANALYSIS OF TESTING RESULTS (ANSWERS EXPLAINED, P. 247)

1-4 Base your answers to questions 1 through 4 on the information and data table below and on your knowledge of biology. The table shows the average systolic and diastolic blood pressure measured in millimeters of mercury (Hg) for humans between the ages of 2 and 14 years.

DATA TABLE

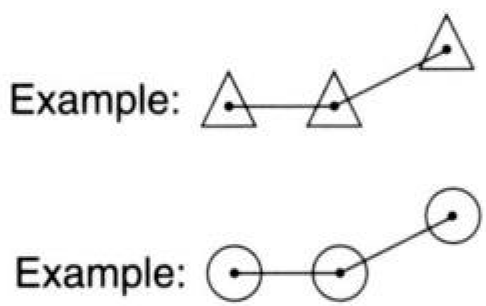
	Average Blood Pressure (mm of Hg)	
Age	Systolic	Diastolic
2	100	60
6	101	64
10	110	72
14	119	76

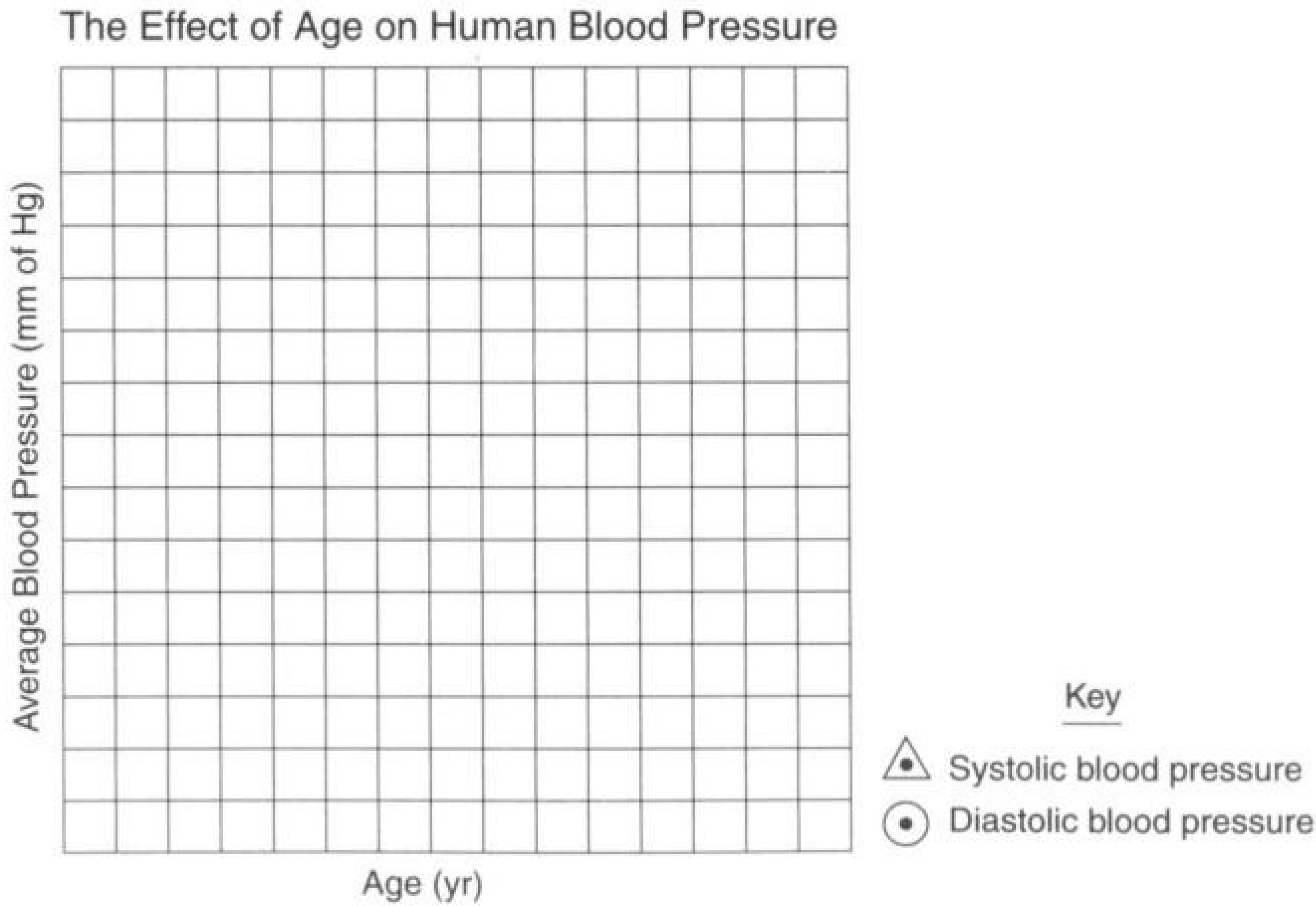
Directions (1-4): By using the information in the data table, construct a line graph on the grid provided, following the directions below.

1. Mark an appropriate scale on each labeled axis.

2. Plot the data for systolic blood pressure on your graph. Surround each point with a small triangle, and connect the points.

3. Plot the data for diastolic blood pressure on your graph. Surround each point with a small circle, and connect the points.





4. By using one or more complete sentences, state one conclusion that compares systolic blood pressure with diastolic blood pressure in humans between the ages of 2 and 14 years.

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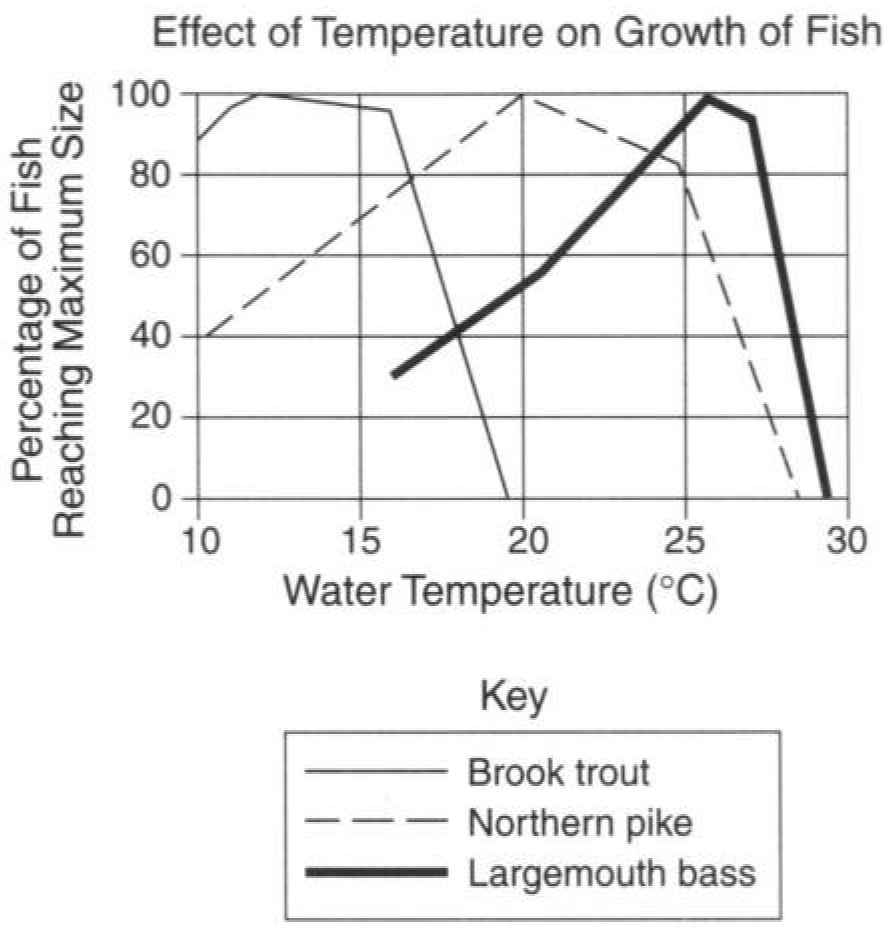
5. The graph below shows the results of an experiment.



At 16°C, what percentage of the brook trout reached maximum size?

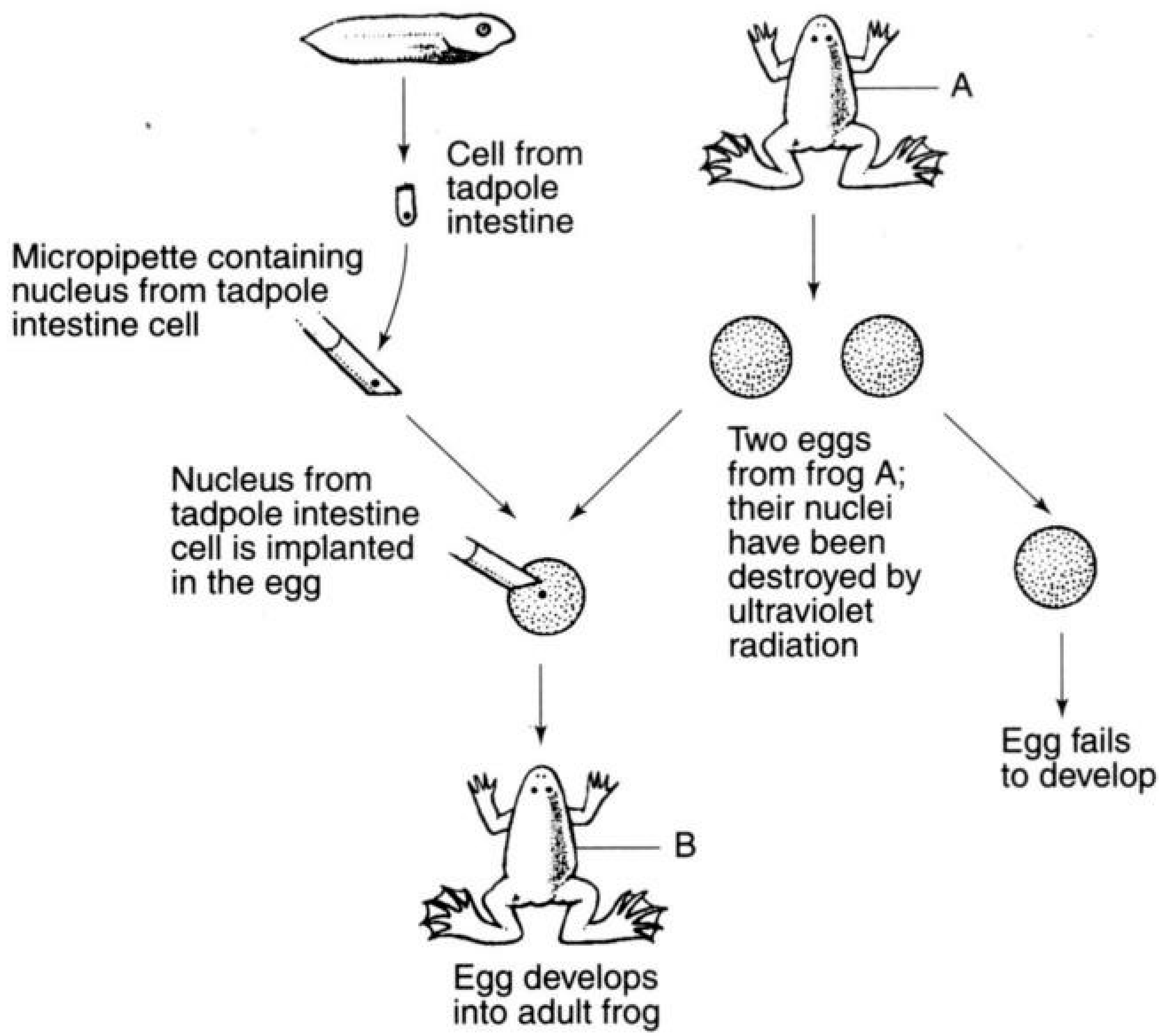
(1) 30%

(2) 55%

(3) 75%

(4) 95%

6. An experiment is represented in the diagram below.



An inference that can be made from this experiment is that

(1) adult frog B will have the same genetic traits as the tadpole

(2) adult frog A can develop from only an egg and a sperm

(3) fertilization must occur in order for frog eggs to develop into adult frogs

(4) the nucleus of a body cell fails to function when transferred to other cell types

7. The charts below show the relationship of recommended weight to height in men and women age 25-29.

HEIGHT-WEIGHT CHARTS

MEN Age 25–29 Weight (lb)				
Height Feet	Inches	Small Frame	Medium Frame	Large Frame
5	2	128–134	131–141	138–150
5	3	130–136	133–143	140–153
5	4	132–138	135–145	142–156
5	5	134–140	137–148	144–160
5	6	136–142	139–151	146–164
5	7	138–145	142–154	149–168
5	8	140–148	145–157	152–172
5	9	142–151	148–160	155–176
5	10	144–154	151–163	158–180
5	11	146–157	154–166	161–184
6	0	149–160	157–170	164–188
6	1	152–164	160–174	168–192
6	2	155–168	164–178	172–197
6	3	158–172	167–182	176–202
6	4	162–176	171–187	181–207

WOMEN Age 25–29 Weight (lb)				
Height Feet	Inches	Small Frame	Medium Frame	Large Frame
4	10	102–111	109–121	118–131
4	11	103–113	111–123	120–134
5	0	104–115	113–126	122–137
5	1	106–118	115–129	125–140
5	2	108–121	118–132	128–143
5	3	111–124	121–135	131–147
5	4	114–127	124–138	134–151
5	5	117–130	127–141	137–155
5	6	120–133	130–144	140–159
5	7	123–136	133–147	143–163
5	8	126–139	136–150	146–167
5	9	129–142	139–153	149–170
5	10	132–145	142–156	152–173
5	11	135–148	145–159	155–176
6	0	138–151	148–162	158–179

The recommended weight for a 60" man with a small frame is closest to that of a

(1) 5'10" man with a medium frame

(2) 5'9" woman with a large frame

(3) 6'0" man with a medium frame

(4) 6'0" woman with a medium frame

8-11 Base your answers to questions 8 through 11 on the information below and on your knowledge of biology.

A group of biology students extracted the photosynthetic pigments from spinach leaves using the solvent acetone. A spectrophotometer was used to measure the percent absorption of six different wavelengths of light by the extracted pigments. The wavelengths of light were measured in units known as nanometers (nm). One nanometer is equal to one-billionth of a meter. The following data were collected:

yellow light (585 nm)-25.8% absorption blue light (457 nm)-
49.8% absorption orange light (616 nm)-32.1% absorption

violet light (412 nm)-49.8% absorption red light (674 nm)-
41.0% absorption green light (533 nm)-17.8% absorption

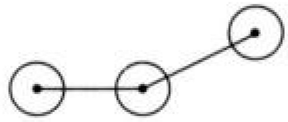
8. Complete all three columns in the data table below so that the wavelength of light either increases or decreases from the top to the bottom of the data table.

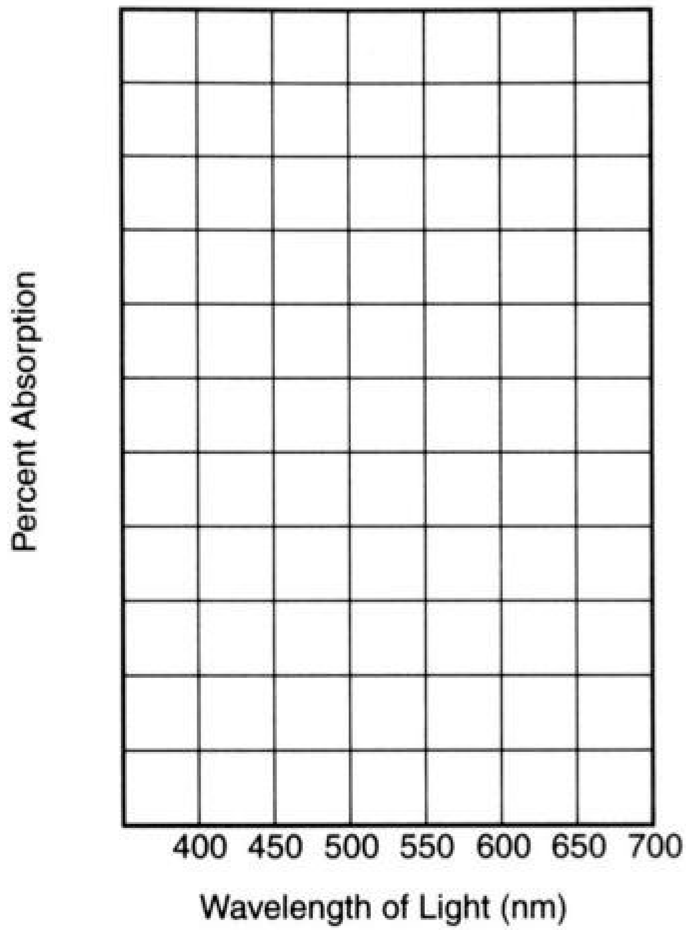
Color of Light	Wavelength of Light (nm)	Percent Absorption by Spinach Extract

Directions (9-10): By using the information in the data table, construct a line graph on the grid provided, following the directions below.

9. Mark an appropriate scale on the axis labeled "Percent Absorption."

10. Plot the data from the data table on your graph. Surround each point with a small circle, and connect the points.

Example: 



11. Which statement is a valid conclusion that can be drawn from the data obtained in this investigation?

(1) Photosynthetic pigments in spinach plants absorb blue and violet light more efficiently than red light.

(2) The data would be the same for all pigments in spinach plants.

(3) Green and yellow light are not absorbed by spinach plants.

(4) All plants are efficient at absorbing violet and red light.

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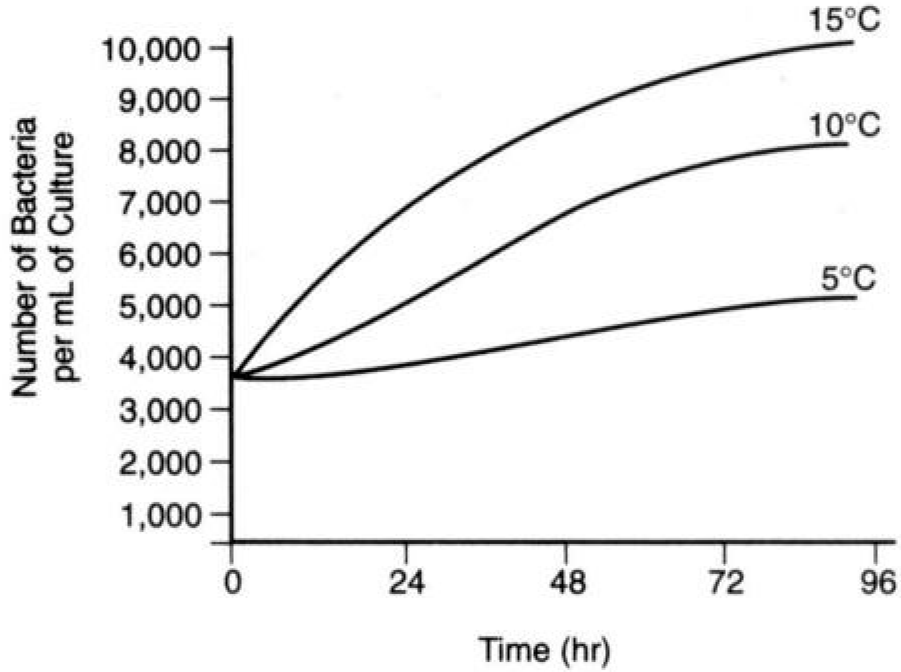
12. The graph below represents the results of an investigation of the growth of three identical bacterial cultures incubated at different temperatures.



Which inference can be made from this graph?

(1) Temperature is unrelated to the reproductive rate of bacteria.

(2) Bacteria cannot grow at a temperature of 5°C.

(3) Life activities in bacteria slow down at high temperatures.

(4) Refrigeration will most likely slow the growth of these bacteria.

13. A study was conducted using two groups of ten plants of the same species. During the study, the plants were placed in identical environmental conditions. The plants in one group were given a growth solution every 3 days. The heights of the plants in both groups were recorded at the beginning of the study and at the end of a 3-week period. The data showed that the plants given the growth solution grew faster than those not given the solution.

When other researchers conduct this study to test the accuracy of the results, they should

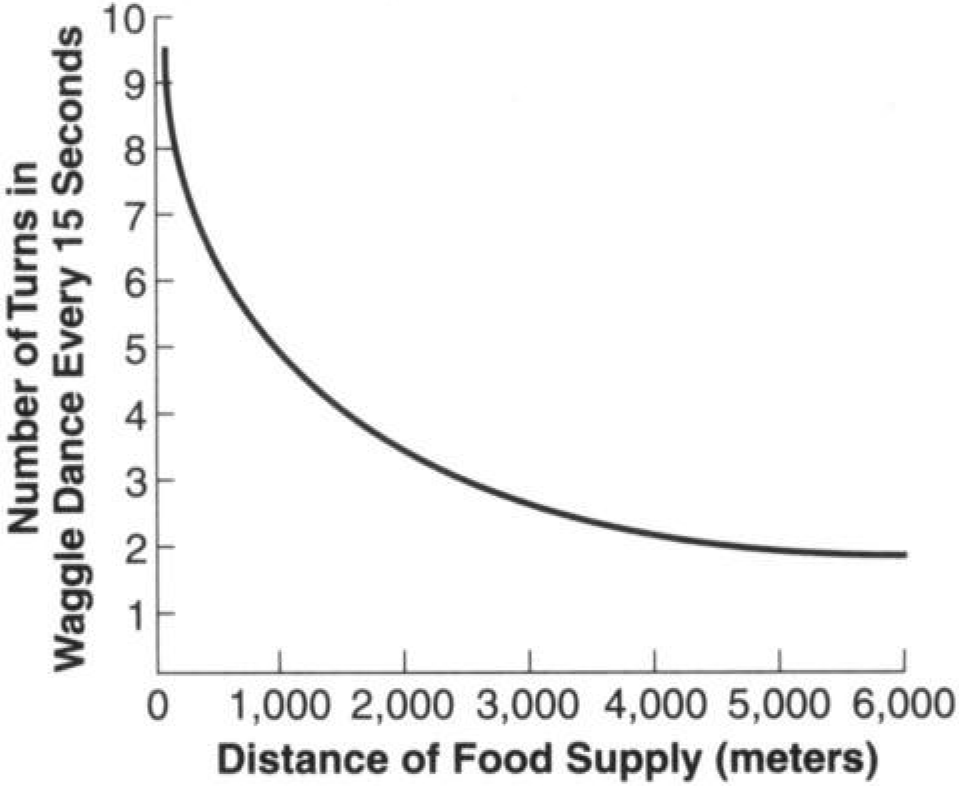
(1) give growth solution to both groups

(2) make sure that the conditions are identical to those in the first study

(3) give an increased amount of light to both groups of plants

(4) double the amount of growth solution given to the first group

14. Worker bees acting as scouts are able to communicate the distance of a food supply from the hive by performing a waggle dance. The graph below shows the relationship between the distance of a food supply from the hive and the number of turns in the waggle dance every 15 seconds.



By using one or more complete sentences, state the relationship between the distance of the food supply from the hive and the number of turns the bee performs in the waggle dance every 15 seconds.

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15. Based on experimental results, a biologist in a laboratory reports a new discovery. If the experimental results are valid, biologists in other laboratories should be able to perform

(1) an experiment with a different variable and obtain the same results

(2) the same experiment and obtain different results

(3) the same experiment and obtain the same results

(4) an experiment under different conditions and obtain the same results

16-18 Base your answers to questions 16 through 18 on the information provided below and on your knowledge of biology. Refer to the section on statistical analysis (pp. 19-21).

A researcher was conducting an experiment on the genetic inheritance of the common garden pea. In this experiment, the researcher cross-pollinated a number of parent plants that were hybrid for the simple dominant trait of seed shape. This trait is controlled by two genes. R (for round seed) is dominant over r (for wrinkled seed). The experimental cross can be illustrated as Rr x Rr.

Only two possible phenotypes can be expected for this trait: round seed and wrinkled seed. The phenotypic ratios for the offspring of this cross are expected to be 75% round seed and 25% wrinkled seed. In a sample of 1,000 offspring plants of this cross, the researcher counted 732 plants with round seeds and 268 plants with wrinkled seeds.

The researcher wanted to find out whether the sample taken was random or biased. He has assigned you to perform a chisquare test on the results of this trial.

16. By using the method outlined in the section about statistical analysis, determine the value of chi-square (X2) for this trial to the nearest hundredths place.

____

17. By using the one degree of freedom chart in the section about statistical analysis, determine the range of probabilities (p) for this trial. State the result in one or more complete sentences.

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18. In one or more complete sentences, use your answers for questions 16 and 17 to state whether the results of this trial are more probably the result of randomness or experimental bias.

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19-21 Base your answers to questions 19 through 21 on the information provided below and on your knowledge of biology. Refer to the section on statistical analysis (pp. 19-21).

A naturalist was gathering field data on the incidence of light and dark coloration in a natural population of a certain species of moth. Based on the genetic inheritance patterns involved in the production of this trait, 75% of the members of this population are expected to display the dark coloration and 25% should display the light coloration.

In a sample of 10,000 moths, the naturalist recorded 8,500 dark moths and 1,500 light moths. The naturalist wanted to find out whether the sample taken represents a random occurrence or if some force other than chance is affecting the outcome. She has assigned you to perform a chi-square test on the results of this data.

19. By using the methodology outlined in the section about statistical analysis, determine the value of chi-square (,Y2) for this data to the nearest hundredths place.

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20. By using the one degree of freedom chart in the section about statistical analysis, determine the range of probabilities (p) for this data. State the result in one or more complete sentences.

____

21. In one or more complete sentences, state whether the results of this study are more probably the result of randomness or some nonrandom force according to your answers for questions 19 and 20.

IV. LABORATORY REQUIREMENTS FOR PART D

As of the 2003-2004 school year, New York State's biology students will be required to complete four state-developed laboratory activities as part of their laboratory experience. A chart of the laboratory titles and the years that they will be required can be found on page xv of this book.

The chart is based on the information available from the New York State Education Department as of September 2002. This information covers the years 2003-2004 through 2006-2007. It appears from this chart that each laboratory will be required for a four-year period that overlaps with that for other required laboratory activities. "Retired" laboratory activities may be brought back again in future years or may be permanently retired from use.

In addition to performing these laboratory activities and completing laboratory reports on your findings for each of them, you will be expected to answer questions concerning them on The Living Environment Regents examination, Part D. Following this section are practice questions and answers based on the first four of these required laboratory activities as known at the time of this publication.

Required Laboratory: The Beaks of Finches (Required for 2003-2004)

This laboratory exercise explores the competitive advantages of beak sizes and shapes by means of a simulation activity. You are asked to examine a variety of common tools with which to pick up seeds of different sizes and to predict which tools will prove most and least effective in picking up a particular seed.

In the data collection portion of the experiment, you and your partner will use the tool assigned to you to pick up seeds over four equal-length time trials. You are asked to record on a data chart the number of seeds picked up during each trial.

In a variation of the data-collection process described above, you and your partner will join other lab teams to compare the effectiveness of your assigned tool against those of the other teams.

By completing this laboratory activity, you will be able to:

- Describe how structural differences in beak shape may affect the survival rate of members of a species;
- Analyze the role of competition for limited resources in the survival of members of a species with varying beak shapes;
- Comprehend how environmental conditions act to select favorable variations within a species;
- Draw inferences and conclusions concerning the accuracy of your hypothesis.

Required Laboratory: Relationships and Biodiversity (Required for 2003-2004 and 2004-2005)

This laboratory exercise helps you to explore similarities and differences among different plant species. You will carry out observations of the gross and microscopic anatomical features, chemical characteristics, and genetic makeup of four simulated plant species.

Based on your observations of anatomical features, you will be expected to develop a hypothesis concerning the species that is most similar to a hypothetical species, Botana curus. You and your lab partner will then conduct a number of tests, including chromatography, use of indicators, gel electrophoresis, and genetic sequencing, to test your hypothesis.

As a result of completing this activity you should be able to:

- Accurately predict the relative degree of relatedness of two or more plant species based on their anatomical features;

- Analyze the results of several laboratory tests to determine the biochemical relatedness of two or more plant species;

- Draw inferences and conclusions concerning the accuracy of your hypothesis.

Required Laboratory: Making Connections (Required for 2003-2004, 2004-2005, and 2005-2006)

In this laboratory activity, you and your lab partner will explore the reactions of the human body to fatigue. An important skill needed for this activity is the ability to accurately take another person's pulse. Once you have mastered this skill, you will be asked to use it as one of your primary data-collection techniques.

You are asked first to determine your average resting pulse rate. This data will become the "baseline" data for your experiment. You will then be expected to pool this data with that of the rest of your class and to represent class data graphically on a histogram.

In the next segment of the laboratory, you are asked to gather data about the effect of fatigue on muscle performance. Squeezing a clothespin repeatedly is the measurable activity.

Finally, you will be presented with hypothetical conflicting claims concerning the relationship between exercise and the rate at which a clothespin can be squeezed. You and your lab partner are asked to develop a hypothesis concerning which of these claims you believe to be true. You will then be expected to design a scientific experiment to test your hypothesis.

As a result of completing this experiment you will be able to:

- Accurately determine the pulse rate of another person;

- Collect, organize, and analyze class data on average pulse rate;
- Develop a hypothesis concerning the effect of exercise on muscle performance;
- Design and carry out an experiment to test your hypothesis;
- Draw inferences and conclusions concerning the accuracy of your hypothesis;
- Synthesize a report of your findings and present it to the class.

Required Laboratory: Diffusion Through a Membrane (Required for 2003-2004, 2004-2005, 2005-2006, and 2006-2007)

This laboratory experience involves the creation of a simulated "cell" from dialysis tubing and some simple mixtures of common substances. The cell you create will behave in much the same way as a real cell. Like a real cell, it will contain a mixture of complex organic molecules suspended or dissolved in water. Like a cell membrane, the dialysis tubing will be a semipermeable membrane, allowing some substances to pass through and others not.

Once constructed, the cell will be subjected to two chemical tests to determine the nature of its semipermeability. These tests will involve the use of indicator solutions that indicate the presence of either glucose (blue-colored Benedict's solution) or starch (tan-colored Lugol's solution).

In the second part of the experiment, you will be asked to investigate the nature of a special kind of diffusion known as osmosis (the diffusion of water). You and your lab partner will place living cells in a solution containing dissolved salt. Your observations will help you to understand the nature of osmosis in living tissues.

By the time you complete this activity you should be able to:

- Demonstrate the use of chemical indicators to identify substances dissolved or suspended in water;
- Explain diffusion and osmosis as they relate to semipermeable membranes;
- Describe how the various chemical substances used in this experiment diffused in or out of the semipermeable cell constructed from dialysis tubing.

Required Laboratory: Adaptations for Reproductive Success in Flowering Plants (Required for 2004-2005, 2005-2006, 2006-2007, and presumably 2007-2008)

No information was available about the details of this laboratory activity at the time of this revision. Presumably, this laboratory will deal with the structure and function of the flower as a reproductive structure found in many plant species.

Required Laboratory: DNA Technology (Required for 2005-2006, 2006-2007, and presumably 2007-2008 and 2008-2009)

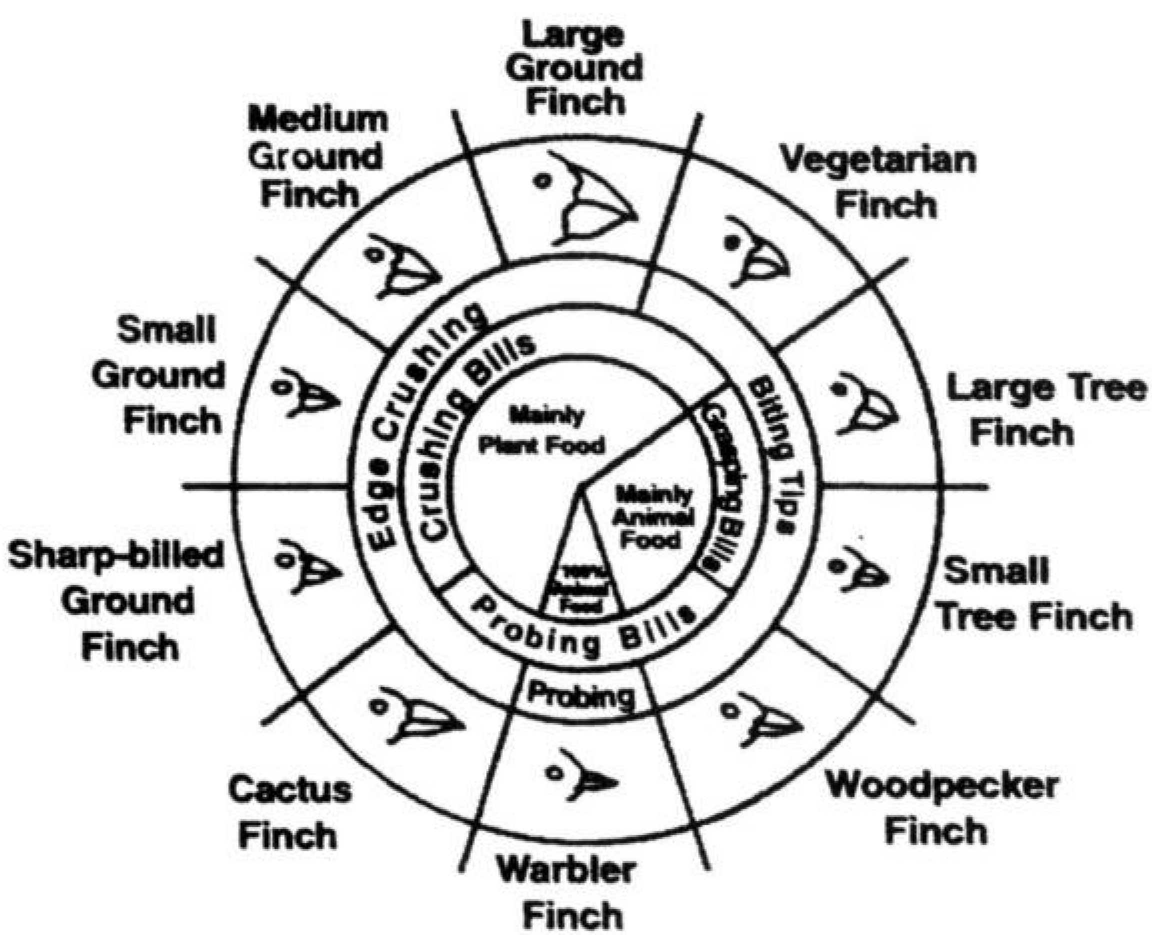
No information was available about the details of this laboratory activity at the time of this revision. Presumably, this laboratory will deal with the various techniques used to analyze the structure and function of DNA.

Required Laboratory: Environmental Conditions and Seed Germination (Required for 2006-2007 and presumably 2007-2008, 2008-2009, and 2009-2010)

No information was available about the details of this laboratory activity at the time of this revision. Presumably, this laboratory will deal with how environmental conditions such as temperature, moisture, and oxygen affect the germination of seeds of various types.

QUESTION SET 1.3-PART D REQUIRED LABORATORY EXPERIENCES (ANSWERS EXPLAINED, P. 252)

Base your answers to questions 1 through 3 on the diagram below which represents various finch species on the Galapagos Islands, your specific knowledge of the laboratory entitled "The Beaks of Finches," and your general knowledge of biology.



- from Galapagos: A Natural History Guide

1. An isolated island in the Galapagos supports four native finch species. These species are the large ground finch, the large tree finch, the small ground finch, and the small tree finch. A new species (the sharp-billed ground finch) is introduced to the island. Which of the native species will be most strongly affected by the introduction of the sharp-billed ground finch, and how will it be affected? In your answer, be sure to include:

- the native finch species affected [1]
- what will likely occur that will affect this native species [1]

____

____

2. A major environmental change occurs on this island that eliminates most of the plants that produce small seeds, leaving only plants that produce large seeds with thick, hard coverings. In terms of food gathering, the finch species having the greatest adaptive advantage under this changed set of conditions is most probably the

(1) large ground finch

(2) small ground finch

(3) large tree finch

(4) small tree finch

3. When one finch species tries to gain an advantage in obtaining the specific type of food it needs for survival to the disadvantage of other species in the same habitat, this represents

(1) variation within a species

(2) environmental change

(3) interspecies competition

(4) mutagenic agents

Base your answers to questions 4 through 6 on the partial genetic code chart and information below, your specific knowledge of the laboratory entitled "Relationships and Biodiversity," and your general knowledge of biology.

A plant species with the scientific name S. hunta is known to produce a protein substance with valuable medicinal qualities. Its genetic makeup is analyzed, and the gene for this protein is located at a specific gene locus on a certain chromosome. This gene is found to contain the following sequence of DNA codons:

GAA-CAA-TGA-CTT-GTA-GTA-GGG-CAA

Partial Genetic Code Chart

DNA Codons	mRNA Codons	Amino Acids
CTT CTC	GAA GAG	Glu
GTA GTG	CAU CAC	His
GAA GAC	CUU CUG	Leu
GGA GGG	CCU CCC	Pro
TGA TGG	ACU ACC	Thr
CAA CAC	GUU GUG	Val

4. The messenger RNA (mRNA) codon sequence that will result from this DNA sequence is

(1) CUU-GUU-ACU-GAA-CAU-CAU-CCC-GUU

(2) GAA-CAA-UGA-CUU-GUA-GUA-GGG-CAA

(3) CTT-GTT-ACT-GAA-CAT-CAT-CCC-GTT

(4) UGG-AGG-CUG-ACC-UCG-UCG-UUU-AGG

5. The amino acid sequence in a protein segment that will result from this DNA codon sequence during protein sysnthesis is

(1) Leu-Glu-His-Pro-Val-Val-Pro-Val

(2) Leu-Val-Thr-Leu-Glu-Glu-His-Pro

(3) Leu-Pro-His-Val-Thr-Thr-Glu-Pro

(4) Leu-Val-Thr-Glu-His-His-Pro-Val

6. Four new plants (species W, X, Y, and Z) are discovered that appear to be related to S. hunta. Upon analysis of their genetic makeup, the following DNA sequences were found at the same gene locus on the same chromosome as was found in S. hunta:

Species W: GAC-CAC-TGA-CTT-CAA-GAA-TGA-CAA

Species X: GAA-CAA-TGG-CTT-GTA-GTG-GGA-CAA

Species Y: GAC-GGG-GTG-GTA-CAC-GTA-GGG-CAC

Species Z: GAA-CAA-GAA-GGG-CTT-CTC-TGG-CAC

Which species produces a protein segment most similar to that produced

by S. hunta?

(1) Species W

(2) Species X

(3) Species Y

(4) Species Z

Base your answers to questions 7 through 9 on the experimental data below, your specific knowledge of the laboratory entitled "Making Connections," and your general knowledge of biology.

Data on Resting Pulse Rate (Beats per Minute)

Student (M/F)*	Average Pulse Rate (3 Trials)	Student (M/F)*	Average Pulse Rate (3 Trials)
Juan (M)	58	Jessica (F)	66
Sue (F)	81	Sean (M)	75
Tae Moon (M)	67	Mai Le (F)	86
Louise (F)	69	Cesar (M)	80
Sam (M)	72	Rita (F)	63
Erika (F)	60	Guiseppe (M)	71
Jose (M)	85	Meredith (F)	68
Tatiana (F)	65	Bill (M)	88
Brad (M)	91	Concetta (F)	74
Madelena (F)	76		
Greg (M)	62	AVERAGE	72.85

*M/F = male/female.

7. Represent the data in the chart in the form of a histogram (bar chart) in the grid below. Shade the histogram bars that result from your data analysis. [1]

Number of Students

10						
9						
8						
7						
6						
5						
4						
3						
2						
1						
	<51	51–60	61–70	71–80	81–90	>90

Average Pulse Rate Range (beats per minute)

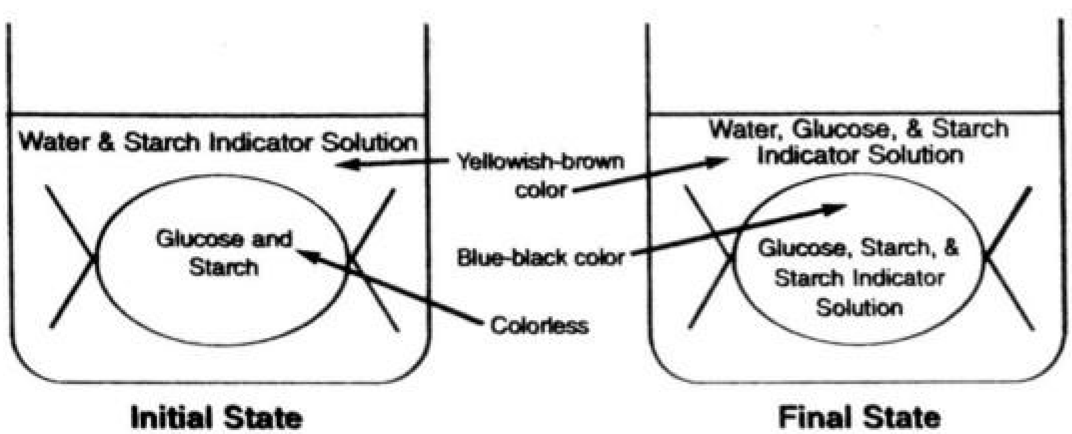
8. In a complete sentence, describe one pattern that is evident in the data that would help someone else to understand how pulse rate is distributed among these 20 students. [1]

____

9. State a question that someone might ask about pulse rate that could be answered by further analyzing the data above or by collecting additional data about the same 20 students. [1]

____

Base your answers to questions 10 through 12 on the experimental data below, your specific knowledge of the laboratory entitled "Diffusion Through a Membrane," and your general knowledge of biology.



10. The following chart shows data that was collected by a student laboratory group as a result of performing the laboratory entitled "Diffusion Through a Membrane." It shows the results of chemical tests that were done on various fluids in the initial and final setups shown above.

Indicator / Fluid Tested	Initial Setup		Final Setup	
	Lugol's Solution	**Benedict's Solution**	**Lugol's Solution**	**Benedict's Solution**
Beaker fluid	Tan	Blue	Tan	Red
Dialysis tube fluid	Blue-black	Red	Blue-black	Red

The difference between the fluids in the initial and final setups is that

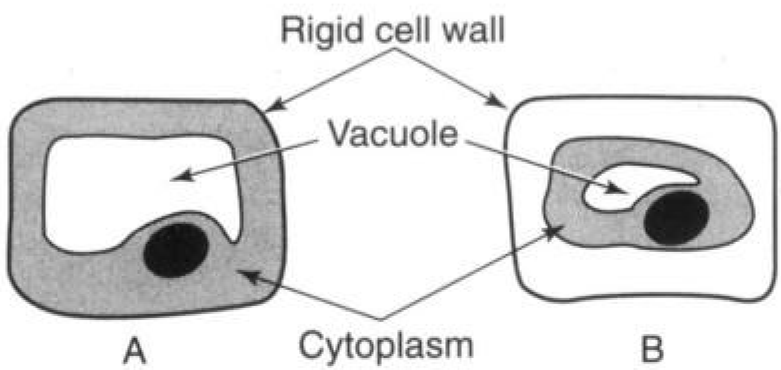
(1) Lugol's solution has been converted to Benedict's solution

(2) starch has been converted to glucose by the indicator solutions

(3) starch has diffused from the fluid inside the dialysis tubing, across the membrane, and into the beaker fluid

(4) glucose has diffused from the fluid inside the dialysis tubing, across the membrane, and into the beaker fluid

11. A biologist observed a plant cell in a drop of water as shown in diagram A. The biologist then added a 10% salt solution to the slide and observed the cell as shown in diagram B.



The change in appearance of the cell resulted from

(1) more salt moving out of the cell than into the cell

(2) more salt moving into the cell than out of the cell

(3) more water moving into the cell than out of the cell

(4) more water moving out of the cell than into the cell

12. A farmer irrigating his corn fields irrigates field A with normal well water. In preparing to irrigate field B, he makes an error and loads a 10% saltwater solution (instead of well water)

into his irrigation tanker. He then proceeds to irrigate field B with this 10% saltwater solution. Within 24 hours, he notes that all the corn plants in field A are standing straight and healthy, whereas all the corn plants in field B have wilted. Fortunately, a rainstorm the next day restores the corn plants in field B to a healthy condition.

In the space provided, write a brief paragraph that describes the biological explanation for the farmer's observations of the corn plants in field B. In your answer, be sure to:

- define the terms osmosis and equilibrium [2]
- describe the movement of water into and out of the corn plants in field B during each of the two days of this observation [2]

V. LABORATORY SKILLS.AND CURRENT EVENTS IN BIOLOGY

The New York State Regents Examination on The Living Environment tests the student's knowledge of both content and practical skills. In general, the skills required include basic laboratory technique, analysis of readings in science, written expression of biological concepts, and general awareness of current events in biology. Specific laboratory requirements are discussed on pages 49 and 50.

LABORATORY SKILLS

The Laboratory Checklist (see pages 49 to 50) mentions a set of specific laboratory skills that should be mastered in preparation for the year-end Regents examination. Students should be able to do the following.

1. Formulate a question or define a problem and develop a hypothesis to be tested in an investigation.
2. When given a laboratory problem, select suitable lab materials, safety equipment, and appropriate observation methods.
3. Distinguish between controls and variables in an experiment.
4. Identify parts of a light microscope and their functions, and focus in low and high power.
5. Determine the size of microscopic specimens in micrometers.
6. Prepare wet mounts of plant and animal cells, and apply staining techniques using iodine and methylene blue.
7. Identify cell parts under the compound microscope, such as the nucleus, cytoplasm, chloroplast, and cell wall.
8. Use and interpret indicators, such as pH paper, Benedict's (Fehling's) solution, iodine (Lugol's)

solution, and bromthymol blue.

9. Use and read measurement instruments, such as metric rulers, Celsius thermometers, and graduated cylinders.

10. Dissect plant and animal specimens for the purpose of exposing major structures for suitable examination. Suggestions of specimens include seeds, flowers, earthworms, and grasshoppers.

11. Demonstrate safety skills involved in heating materials in test tubes or beakers, using chemicals, and handling dissection instruments.

12. Collect, organize, and graph data.

13. Make inferences and predictions based on data collected and observed.

14. Formulate generalizations or conclusions based on the investigation.

15. Assess the limitations and assumptions of the experiment.

16. Determine the accuracy and repeatability of the experimental data and observations.

These laboratory skills may be subdivided into three broad areas:

1. The methods by which a laboratory experiment is designed.

2. The techniques used in conducting a laboratory experiment.

3. The skills related to interpreting the results of a laboratory experiment.

Methods Used in Designing a Laboratory Experiment (Skills 1-3)

Skill 1 Students should be able to express an experimental problem as a statement or as an experimental question to be answered. Such questions should be written so as to indicate a quantity to be measured in a laboratory experiment. Students also should be able to state the expected results of such an experiment in the form of a hypothesis.

Skill 2 When presented with a hypothetical experiment to perform, students should be able to select the group of tools that would be most appropriate to use for conducting that experiment. For example, an experiment involving comparative anatomy would probably be carried out most effectively with dissecting instruments; one involving the chemical nature of an unknown food would be performed most effectively using chemical indicators; one involving plant growth might use a variety of measuring instruments.

Skill 3 When given an outline of an experiment, students should be able to identify the variables, which are the (changing) quantities being measured in the experiment. Certain variables are manipulated by the investigator (independent variables), whereas others vary as a result of experimental factors (dependent variables). Students should also be able to identify the aspects of the experiment, known as controls, designed to exclude possible interference by unwanted variables.

Techniques Used in Conducting Laboratory Experiments (Skills 4-11)

Skill 4 Students should have a basic familiarity with the compound light microscope-its parts, the function of each part, its use as a tool for measuring small objects, the procedure for determining its magnification, and the appearance of objects within its visual field. Students should be prepared to describe each of these aspects in sentence form.

Skill 5 Students should be able to express the sizes of microscopic objects in metric units. An understanding of the micrometer (μm), a metric unit of linear measure, is required. Students should be able to convert measurements in micrometers to millimeters (or centimeters) and from larger units to micrometers (1 pm = 0.001 mm = 0.0001 cm = 0.000001 m).

Skill 6 Students should be able to describe, in sentence form, how to prepare a wet-mount slide for examination under the compound light microscope. A basic familiarity with the application of biological stains and the stains iodine and methylene blue is also required.

Skill 7 Students should be able to recognize and label the major organelles of typical plant, animal, and protozoan cells as shown in photomicrographs (photographs taken through a microscope). Students should also be prepared to describe the major functions of these organelles in sentence form as well as to judge their sizes in micrometers.

Skill 8 Students should be familiar with the use of indicators used to determine the chemical characteristics of food samples and solutions. Students should be prepared to describe, in sentence form, the use of each of the following indicators.

- pH paper is used to determine the relative acidity (pH) of a solution. A pH paper containing litmus will turn red in acid solution and blue in basic solution.

- Bromthymol blue turns yellow under acid conditions and remains blue under basic conditions. It may be used to detect the presence of carbon dioxide in solution since carbon dioxide forms a weak acid when dissolved in water.

- Benedict's (Fehling's) solution is used to detect the presence of simple sugars in food samples or solutions. Benedict's solution is blue when first prepared. When heated in the presence of simple sugar, it turns color, ranging from yellow to brick red.

- Iodine (Lugol's) solution, normally light tan, turns blue-black when applied to a food sample or solution containing starch.

Skill 9 Students should be able to determine quantities and dimensions, using a variety of metric measuring instruments. The dimensions of common objects should be determinable in millimeters and centimeters, using metric rulers and scales. Students should be able to read correctly the volume of liquid in a graduated cylinder by sighting the bottom of the meniscus. Students should be able to read the temperature indicated on a Celsius thermometer.

Skill 10 Students should be able to recognize, identify, and label the major organs and organ systems of common dissection specimens, including earthworms, grasshoppers, seeds, and flowers.

Skill 11 Students should be able to describe the proper methods of dealing with a variety of laboratory situations. This includes the correct means of handling chemicals so as not to cause harm to oneself or others. Also included is the safe use of dissecting tools, such as scalpels and other sharp instruments. Students should also be able to describe the approved techniques for heating liquids and for handling hot objects. Students should be prepared to describe these methods in sentence form.

Skills Used in Interpreting Experimental Results (Skills 12-16)

Skill 12 When given unorganized raw data, students should be able to collect and organize these data in chart form according to increasing values of the independent variable. Students should also be familiar with the proper techniques to use in representing data in graph form. Knowledge of the correct methods for constructing both bar charts and line graphs is required. Students should be able to label and increment graph axes properly, appropriately title graphs, and correctly plot graphic data points.

Skill 13 Students should be able to analyze the data that result from a laboratory experiment and to draw inferences (conclusions based on facts) that help to solve the experimental problem or answer the experimental question. Students should also be able to predict the outcome of experiments that broaden the range of the independent variable. In order to do this, students should understand how to interpret data organized in either chart or graph form. Students should be prepared to describe their inferences and predictions in sentence form.

Skill 14 When given an experiment whose data have been properly organized and analyzed, students should be able to develop generalizations (broad conclusions) concerning the effect of the test variable on the experimental question. It should then be possible to project these generalizations onto situations outside the laboratory where similar variables interact. Students should be prepared to express such generalizations in sentence form.

Skill 15 Students should recognize the limitations of their experimental methods in the context of professional science. This requires an understanding of the limits of accuracy of measuring equipment, the errors that may be introduced through incompletely developed laboratory skills, the ambiguities that result from inadequate experimental controls, and other limitations affecting experimental results.

Skill 16 Once a laboratory experiment is completed, students should be able to determine the accuracy of the experimental results through a review of the experimental methods. Where appropriate, calculating the percent error may assist in determining experimental accuracy. The experimental methods should allow for repeatability of the experiment to assist in the verification of experimental accuracy.

ANALYSIS OF READINGS IN SCIENCE

.Part B and C of the New York State Regents examination may include items that require the analysis of short readings in science. These readings may deal with New York State Core Curriculum understandings or with concepts related to, but outside of, the curriculum. Students are expected to comprehend the meanings of technical terms that appear in the curriculum (see the glossary of this book). If other technical terms are used, they will be defined within the passage.

Students are expected to be able to read through the passage and answer questions based on it. Students should also be able to draw on their knowledge of Major Understandings to answer some questions about these reading passages.

WRITTEN EXPRESSION OF BIOLOGICAL CONCEPTS

Students in the Regents Biology-The Living Environment course are expected to be able to express themselves in complete sentences concerning biological principles. Although this requirement is not meant to be a test of the grammatical skills of the student, it is a test of the student's ability to express himself/herself clearly in scientific terms. Students should be prepared to answer Part B and C questions in sentence form.

CURRENT EVENTS IN BIOLOGY

Students should maintain an awareness of current events in biology that have reached statewide, national, or international prominence. Students will not be tested directly on current events but rather through use of reading comprehension and analysis of graphs and other data representations. Topics that may be selected for inclusion on Parts B and C include environmental situations (for example, acid precipitation, toxic waste disposal), advances in genetic research (for example, genetic engineering), aspects of biomedical research (for example, immunology, AIDS research), and others of a similar nature.

Following are typical Part B and C questions, grouped by the skills tested, that have appeared on actual Regents examinations in recent years. Students can find additional practice questions in the Regents examinations at the end of this book.

LABORATORY CHECKLIST

In addition to demonstrating performance indicators relating to scientific inquiry described in Standard 1, biology students need to develop profi ciency in certain laboratory or technical skills in order to successfully conduct investigations in biological science. During the school year, students must develop the capacity to successfully perform each of the laboratory skills listed below. Proficiency in performing these laboratory skills may also be evaluated by items found on certain parts of the New York State Living Environment assessment, including the new Part D.

Follows safety rules in the laboratory

Selects and uses correct instruments

- Uses graduated cylinders to measure volume
- Uses metric ruler to measure length
- Uses thermometer to measure temperature
- Uses triple-beam or electronic balance to measure mass

Uses a compound microscope/stereoscope effectively to see specimens clearly, using different magnifications

- Identifies and compares parts of a variety of cells
- Compares relative sizes of cells and organelles
- Prepares wet-mount slides and uses appropriate staining techniques
- Uses other laboratory skills
- Designs and uses dichotomous keys to identify specimens
- Makes observations of biological processes
- Dissects plant and/or animal specimens to expose and identify internal structures
- Follows directions to correctly use and interpret chemical indicators
- Uses chromatography and/or electrophoresis to separate molecules
- Demonstrates ability to design, carry out, and report the results of simple biological experiments
- Designs and carries out a controlled, scientific experiment based on biological processes
- States an appropriate hypothesis
- Differentiates between independent and dependent variables
- Identifies the control group and/or controlled variables

- Collects, organizes, and analyzes data, using a computer and/or other laboratory equipment
- Organizes data through the use of data tables and graphs
- Analyzes results from observations/expressed data
- Formulates an appropriate conclusion or generalization from the results of an experiment
- Recognizes assumptions and limitations of the experiment

QUESTION SET 1.4-LABORATORY SKILLS QUESTION SET (SKILLS 1-14) (ANSWERS EXPLAINED, P. 257)

Skill 1

1. A student reported that a wilted stalk of celery became crisp when placed in a container of ice water. The student then suggested that water entered the stalk and made it crisp. This suggestion is considered to be

(1) a control

(2) a hypothesis

(3) an observation

(4) a variable

Skill 2

Base your answers to questions 2 through 4 on the four sets of laboratory materials listed below and on your knowledge of biology.

Set A

Light source

Colored filters

Beaker

Test tubes

Test tube stand

Set B

Droppers

Benedict's solution

Iodine

Test tubes

Starch solution

Sugar solution

Test tube holder

Test tube rack

Heat source

Goggles

Set C

Scalpel

Forceps

Scissors

Pan with wax bottom

Pins

Stereomicroscope

Goggles

Set D

Compound light microscope

Glass slides

Water

Forceps

2. Which set should a student select in order to test for the presence of a carbohydrate in food?

3. Which set should a student select to determine the location of the aortic arches in the earthworm?

4. Which set should a student use to observe chloroplasts in elodea (a green water plant)?

Skill 3

5. Some scientists have concluded that stressful situations cause a decrease in the normal operation of the immune system in human beings. In a recent study, people who were under severe stress were examined to measure how well their immune systems were functioning. These people showed poorer immune system function during times of severe stress than when they were under less stress.

If the experimental group studied consisted of truck drivers who drove daily for 8 hours in very heavy traffic, a corresponding control group would most likely consist of truck drivers who drove

(1) daily for 12 hours in very heavy traffic

(2) every third day for 8 hours in very heavy traffic

(3) every other day for 12 hours in very light traffic

(4) daily for 8 hours in very light traffic

6. A student is studying the effect of temperature on the hydrolytic action of the enzyme gastric protease, which is contained in gastric fluid. An investigation is set up using five identical test tubes, each containing 40 milliliters of gastric fluid and 20 millimeters of glass tubing filled with cooked egg white. The five test tubes are each placed in a different temperature-controlled environment at 0°C, 10°C, 20°C, 30°C, and 40°C. After 48 hours, the amount of egg white hydrolyzed in each tube is measured. Which is a variable in this investigation?

(1) gastric fluid

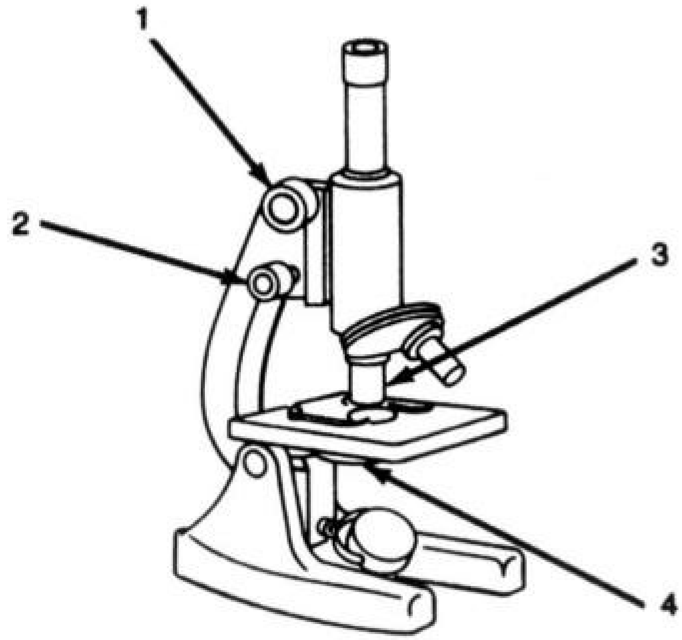
(2) length of glass tubing

(3) temperature

(4) time

Skill 4

7. The diagram below represents a compound light microscope. Choose one of the numbered parts. In a complete sentence, name the part selected and describe its function.



8. To view cells under the high power of a compound microscope, a student places a slide of the cells on the stage and moves the stage clips over to secure the slide. She then moves the high-power objective into place and focuses on the slide with the coarse adjustment.

Two steps in this procedure are incorrect. For this procedure to be correct, she should have focused under

(1) low power using the coarse and fine adjustments, and then under high power using only the fine adjustment

(2) high power first, and then under low power using only the fine adjustment

(3) low power using the coarse and fine adjustments, and then under high power using the coarse and fine adjustments

(4) low power using the fine adjustment, and then under high power using only the fine adjustment

Skill 5

Base your answers to questions 9 and 10 on the information following and on your knowledge of biology.

A student was using a microscope with a lOx eyepiece and lOx and 40x objective lenses. He viewed the edge of a metric ruler under low power and observed the following field of vision.

9. What is the diameter, in micrometers, of the low-power field of vision?

(1) 1

(2) 2

(3) 1,000

(4) 2,000

10. The diameter of the high-power field of vision of the same microscope would be closest to

(1) 0.05 mm

(2) 0.5 mm

(3) 5 mm

(4) 500 mm

Skill 6

11. Which substance, when added to a wet mount containing starch grains, would react with the starch grains and make them more visible?

(1) litmus solution

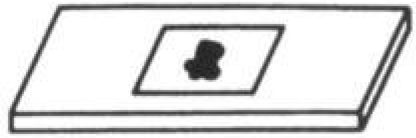
(2) iodine solution

(3) distilled water

(4) bromthymol blue

Base your answers to questions 12 and 13 on the diagrams below and on your knowledge of biology. The diagrams show wet-mount microscope slides of fresh potato tissue.

Slide A



Slide B

12. The formation of air bubbles on slide A could have been prevented by

(1) using a thicker piece of potato and less water

(2) using a longer piece of potato and a coverslip with holes in it

(3) holding the coverslip parallel to the slide and dropping it directly onto the potato

(4) bringing one edge of the coverslip into contact with the water and lowering the opposite edge slowly

13. A drop of stain is put in contact with the left edge of the coverslip on slide B, and a piece of absorbent paper is placed in contact with the right edge of the coverslip. What is the purpose of this procedure?

(1) It prevents the stain from getting on the ocular of the microscope.

(2) It prevents the water on the slide from penetrating the potato tissue.

(3) It allows the stain to penetrate the potato tissue without the removal of the coverslip.

(4) It helps increase the osmotic pressure of the solution.

Skill 7

Base your answers to questions 14 and 15 on the drawing below, which shows a piece of tissue stained with iodine solution, as viewed with a microscope under high power.

14. The tissue represented in the drawing is most likely made up of

(1) onion epidermal cells

(2) ciliated protists

(3) cardiac muscle cells

(4) blue-green algae

15. The organelle labeled B in the drawing is most likely a

(1) mitochondrion

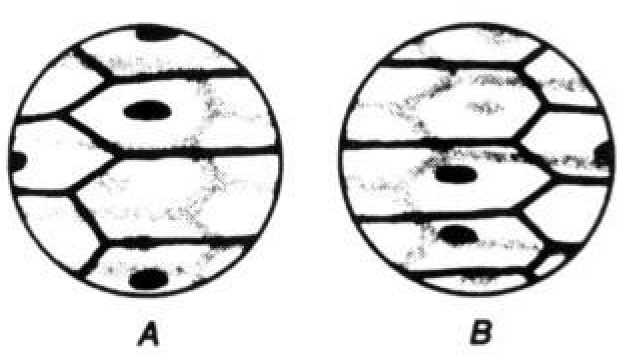
(2) centriole

(3) lysosome

(4) cell wall

---

16. Diagram A represents the appearance of a wet mount of plant tissue as seen through a compound light microscope. Diagram B represents the appearance of the same field of view after the fine adjustment knob is turned. What is the best conclusion to be made from these observations?



(1) The tissue is composed of more than one layer of cells.

(2) The tissue is composed of multinucleated cells.

(3) The cells are undergoing mitotic cell division.

(4) The cells are undergoing photosynthesis.

Skill 8

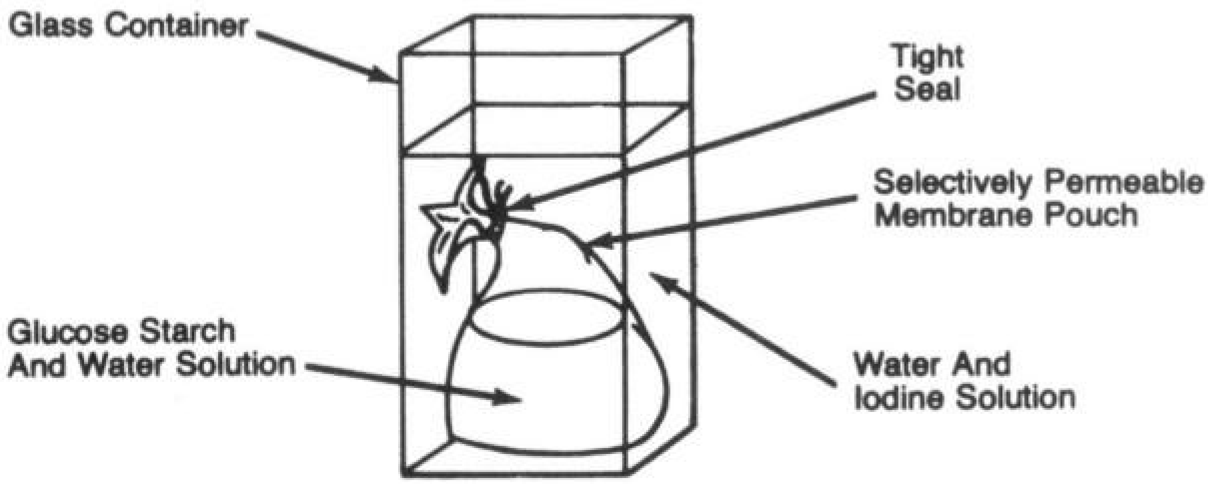
17. A student was testing the composition of exhaled air by exhaling through a straw into a solution of bromthymol blue. The presence of carbon dioxide in the exhaled air would be indicated by

(1) a color change in the solution

(2) a change in atmospheric pressure

(3) the formation of a precipitate in the solution

(4) the release of bubbles from the solution



18. A student tested a sample of the fluid in the glass container for glucose 30 minutes after the apparatus had been set up. Which indicator should be used for this test?

(1) iodine solution

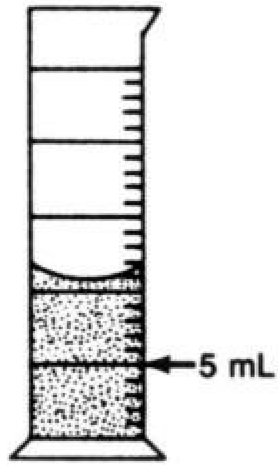
(2) bromthymol blue

(3) Benedict's solution

(4) pH paper

Skill 9

19. What is the total volume of water indicated in the graduated cylinder illustrated below?



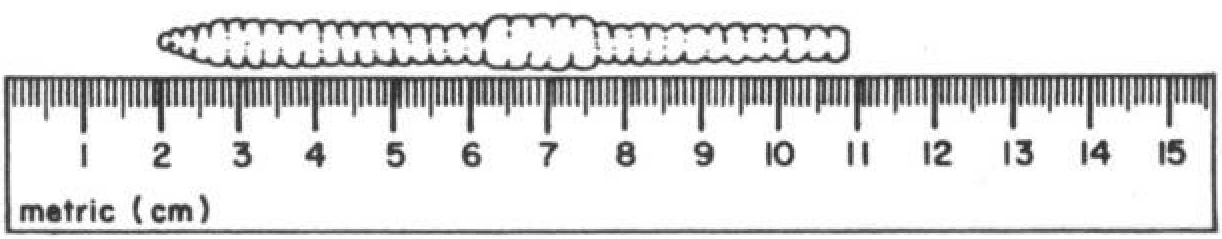
(1) 10 mL

(2) 11 mL

(3) 12 mL

(4) 13 mL

20. The diagram below represents a segment of a metric ruler and part of an earthworm. What is the length of the part of the earthworm shown? You must include the correct units in your answer.



21. Which group of measurement units is correctly arranged in order of increasing size?

(1) micrometer, millimeter, centimeter, meter

(2) millimeter, micrometer, centimeter, meter

(3) meter, micrometer, centimeter, millimeter

(4) micrometer, centimeter, millimeter, meter

Skill 10

22. In earthworms and grasshoppers, which structure is ventral to the esophagus?

(1) gizzard

(2) brain

(3) intestine

(4) nerve cord

Base your answers to questions 23 and 24 on the illustration below of the flower of an amaryllis plant.

23. Name the circled part of the stamen.

24. Using a complete sentence, state a process carried out within the circled structure.

Skill 11

25. A student performing an experiment noticed that the beaker of water she was heating had a slight crack in the glass, but was not leaking. What should the student do?

(1) Discontinue heating and attempt to seal the crack.

(2) Discontinue heating and report the defect to the instructor.

(3) Discontinue heating and immediately take the beaker to the instructor.

(4) Continue heating as long as fluid does not seep from the crack.

26. Which would be the proper laboratory procedure to follow if some laboratory chemical splashed into a student's eyes?

(1) Send someone to find the school nurse.

(2) Rinse the eyes with water and do not tell the teacher because he or she might become upset.

(3) Rinse the eyes with water; then notify the teacher and ask further advice.

(4) Assume that the chemical is not harmful and no action is required.

27. While a student is heating a liquid in a test tube, the mouth of the tube should always be

(1) corked with a rubber stopper

(2) pointed toward the student

(3) allowed to cool

Skill 12

(4) aimed away from everybody

A student was investigating the relationship between different concentrations of substance X and the height of bean plants. He started with six groups, each of which contained the same number of bean plants with identical heights. Conditions were kept the same except that each group was watered with a different concentration of substance X for a period of 2 weeks. Then the concentration of substance X used in watering each group of plants and the average height for each group of plants were recorded by the student as follows:

Group *A*—6%, 32.3 cm

Group *B*—0%, 28.7 cm

Group *C*—2%, 29.4 cm

Group *D*—8%, 37.1 cm

Group *E*—4%, 31.5 cm

Group *F*—10%, 30.7 cm

For questions 28 and 29, organize the above data by filling in the Data Table on page 59, following the directions given in the questions.

28. Label column III with an appropriate heading. [Include the proper unit of measurement.]

29. Complete all three columns in the Data Table so that the concentrations of substance X are increasing from the top to the bottom of the Data Table.

DATA TABLE

I	II	III
Group	Concentration of Substance *X* (%)	

The Data Table shows the wolf and moose populations recorded at the end of June from 1970 to 1980 on an isolated island national park where no hunting by human beings is allowed. Before the arrival of wolves on the island (1965), the moose population had increased to more than 300 members. Wolves have been observed many times on this island hunting cooperatively to kill moose.

DATA TABLE

	Number of Members	
Year	Wolf Population	Moose Population
1970	10	90
1972	12	115
1974	20	145
1976	25	105
1978	18	95
1980	18	98

For questions 30 through 33, use the information in the Data Table to construct a line graph on the grid, following the directions given in the questions.

30. Mark an appropriate scale on the axis labeled "Number of Members of Each Population."

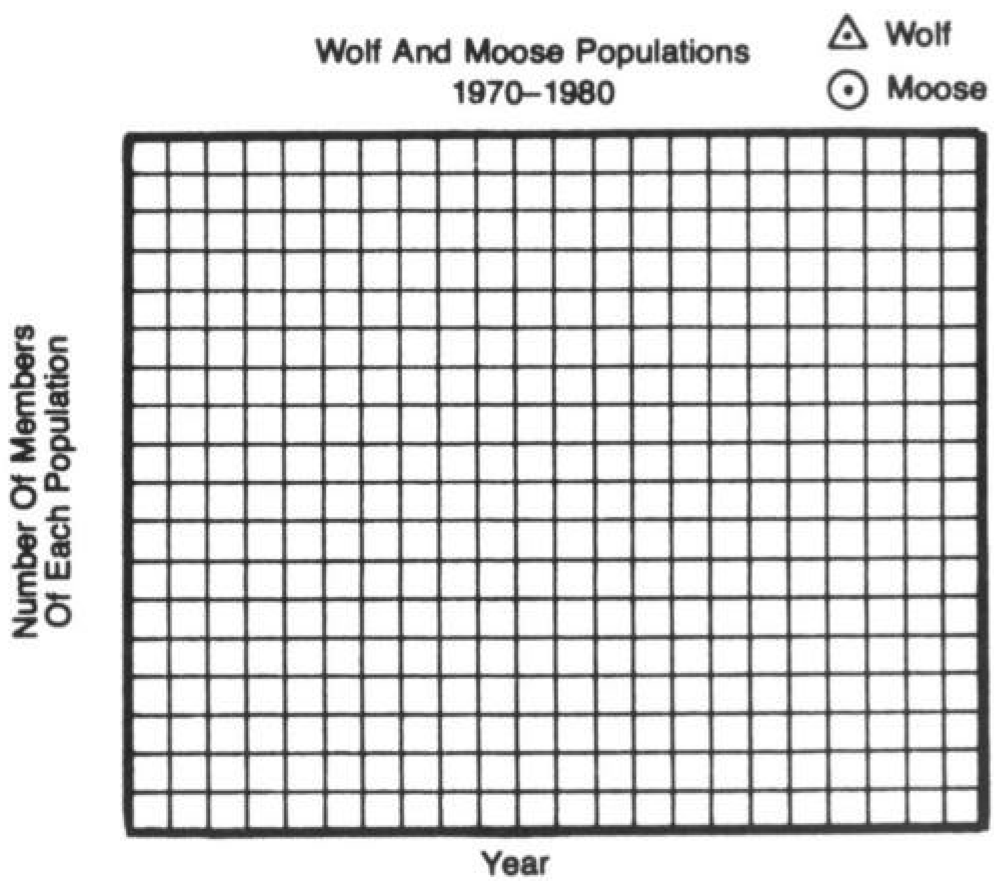
31. Mark an appropriate scale on the axis labeled "Year."

32. Plot the data for the wolf population on the graph. Surround each point with a small triangle and connect the points.

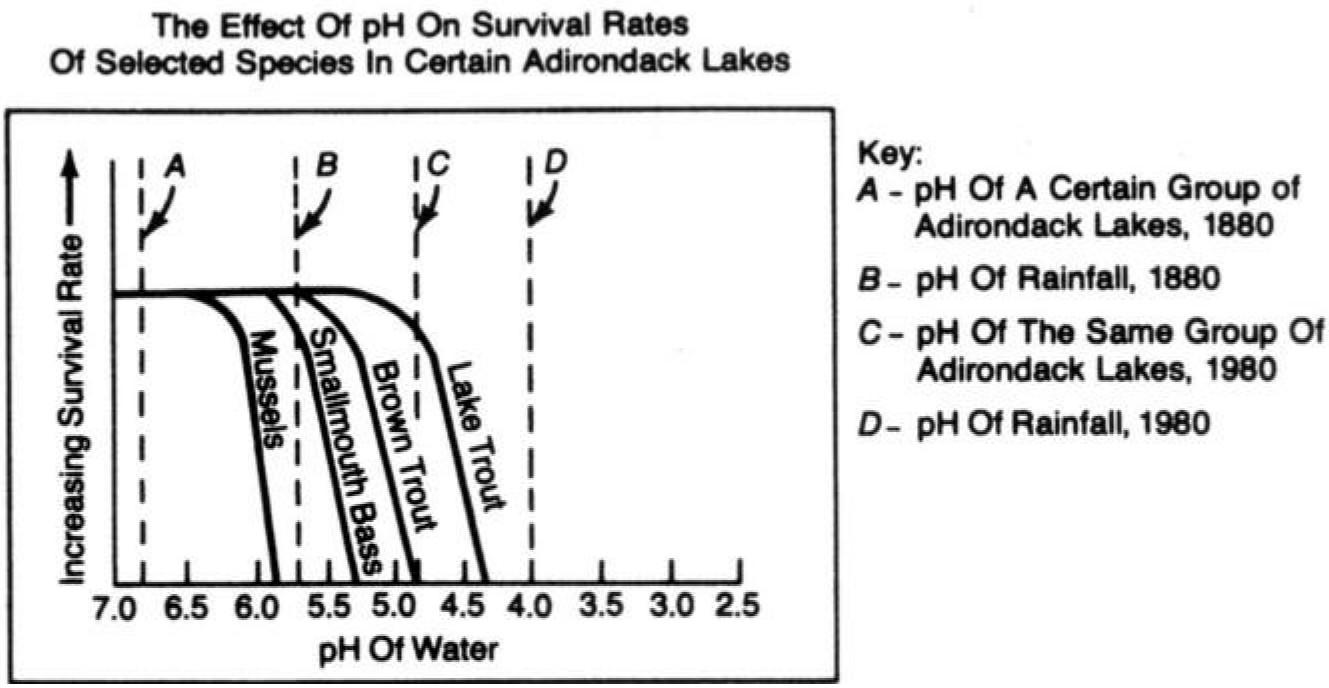
Example

33. Plot the data for the moose population on the graph. Surround each point with a small circle and connect the points.

Example



Base your answers to questions 34 through 36 on the following graph representing survival rates of fish species at various pH levels.



- National Geographic (Adapted)

34. Which species can tolerate the highest level of acidity in its water environment?

(1) mussels

(2) smallmouth bass

(3) brown trout

(4) lake trout

35. In the years between 1880 and 1980, which species would most likely have been eliminated first because of the gradual acidification of Adirondack lakes?

(1) mussels

(2) smallmouth bass

(3) brown trout

(4) lake trout

36. What is the total change in the pH value of rainwater from 1880 to 1980?

(1) 1.3

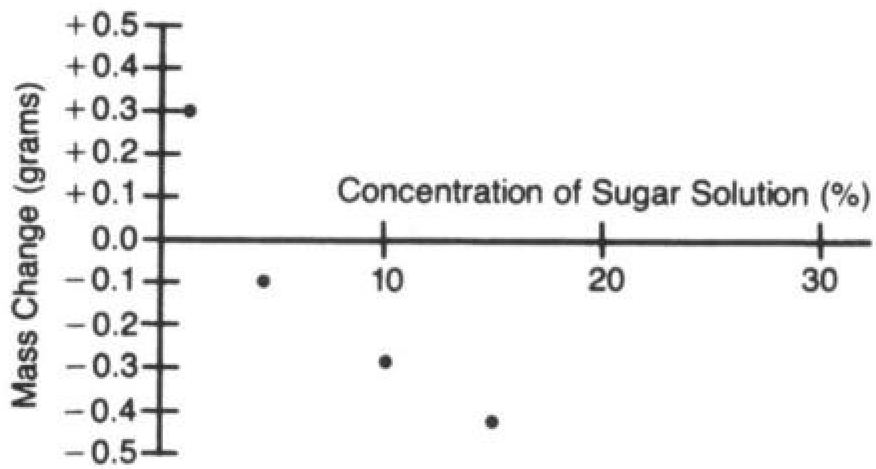
(2) 1.7

(3) 5.3

(4) 9.7

Base your answers to questions 37 and 38 on the information and the graph given below, which shows the effect of sugar concentration on osmotic balance.

Four pieces of apple were cut so that all were the same mass and shape. The pieces were placed in four different concentrations of sugar water. After 24 hours, the pieces were removed and their masses determined. The graph below indicates the change in the mass of each piece.



37. What was the change in mass of the apple piece in the 10% sugar solution?

(1) a decrease of 0.45 gram

(2) an increase of 0.30 gram

(3) a decrease of 0.30 gram

(4) an increase of 0.10 gram

38. At approximately what sugar concentration should the pieces neither lose nor gain weight?

(1) 6%

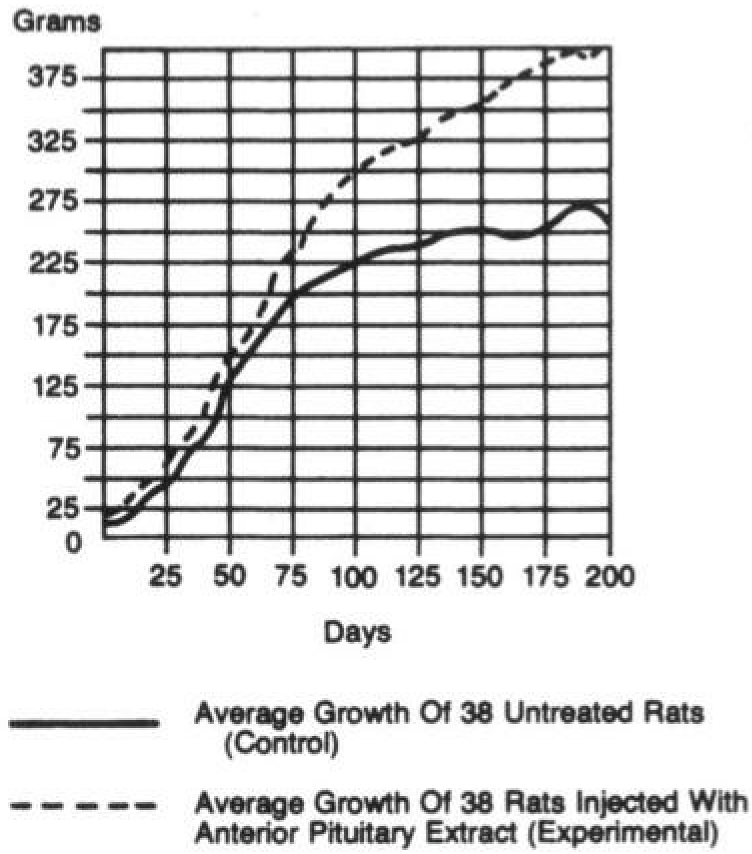
(2) 10%

(3) 3%

(4) 20%

Skill 14

39. The graph below shows the average growth rate for 38 pairs of newborn rats. One of each pair was injected with anterior pituitary extract. The other member of each pair served as a control.



Based on the graph, it can be correctly concluded that the pituitary extract

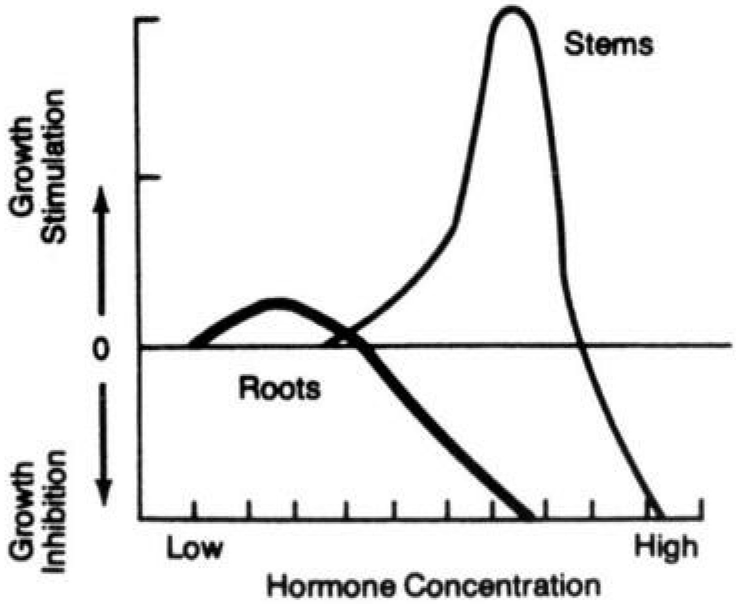
(1) is essential for life

(2) determines when a rat will be born

(3) affects the growth of rats

(4) affects the growth of all animals

40. Plant hormones are chemical regulators that stimulate or inhibit growth depending on their concentration and the type of tissue in which they are found.



Based on the information in the preceding graph, which is a correct conclusion about plant hormones?

(1) They stimulate maximum root growth and stem growth at the same concentration.

(2) They stimulate maximum stem growth at low concentrations.

(3) They most strongly inhibit root growth at low concentrations.

(4) They stimulate maximum root and stem growth at different concentrations.

41. The data below are based on laboratory studies of male Drosophila, showing the inherited bar-eye phenotype.

Culture Temperature (°C) During Development	15	20	25	30
Number of Compound Eye Sections	270	161	121	74

Which is the best conclusion to be drawn from an analysis of these data?

(1) The optimum temperature culturing Drosophila is 15°C

(2) Drosophila cultured at 45°C will show a proportionate increase in the number of compound eye sections.

(3) Temperature determines eye shape in Drosophila.

(4) As temperature increases from 15°C to 30°C, the number of compound eye sections in male Drosophila with bar-eyes decreases.

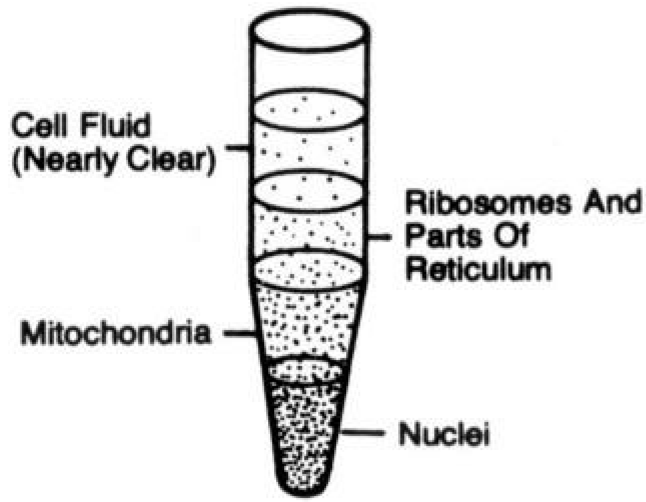
42. The diagram below represents the result of spinning a suspension of broken cells in an ultracentrifuge. Which is a correct conclusion?

(1) Ribosomes are more dense than mitochondria.

(2) Nuclei are more dense than mitochondria.

(3) Mitochondria and ribosomes are equal in density.

(4) The cell consists of only solid components.



Ultracentrifuge Tube, Showing Various Layers

READING, WRITING, AND CURRENT EVENTS IN SCIENCE QUESTION SET (ANSWERS EXPLAINED, P. 272)

Base your answers to questions 1 through 5 on the passage below.

Gene Splicing

Recent advances in cell technology and gene transplanting have allowed scientists to perform some interesting experiments. Some of these experiments have included splicing a human gene into the genetic material of bacteria. The altered bacteria express the added genetic material.

Bacteria reproduce rapidly under certain conditions. This means that bacteria with the gene for human insulin could multiply rapidly, resulting in a large bacterial population which could produce large quantities of human insulin.

The traditional source of insulin has been the pancreases of slaughtered animals. Continued use of this insulin can trigger allergic reactions in some humans. The new bacteria-produced insulin does not appear to produce these side effects.

The bacteria used for these experiments are E. coli, bacteria common to the digestive systems of many humans. Some scientists question these experiments and are concerned that the altered E. coli may accidentally get into water supplies.

For each statement below, write the number 1 if the statement is true according to the paragraph, the number 2 if the statement is false according to the paragraph, or the number 3 if not enough information is given in the paragraph.

1. Transplanting genetic material into bacteria is a simple task.

2. Under certain conditions bacteria reproduce at a rapid rate.

3. Continued use of insulin from other animals may cause harmful side effects in some people.

4. The bacteria used in these experiments are normally found only in the nerve tissue of humans.

5. Bacteria other than E. coli are unable to produce insulin.

Base your answers to questions 6 through 8 on the reading passage below. Write your answers in complete sentences.

Time Frame for Speciation

Evolution is the process of change through time. Theories of evolution attempt to explain the diversification of species existing today. The essentials of Darwin's theory of natural selection serve as a basis for our present understanding of the evolution of species. Recently, some scientists have suggested two possible explanations for the time frame in which the evolution of species occurs.

Gradualism proposes that evolutionary change is continuous and slow, occurring over many millions of years. New species evolve through the accumulation of many small changes. Gradualism is supported in the fossil record by the presence of transitional forms in some evolutionary pathways.

Punctuated equilibrium is another possible explanation for the diversity of species. This theory proposes that species exist unchanged for long geological periods of stability, typically several million years. Then, during geologically brief periods of time, significant changes occur and new species may evolve. Some scientists use the apparent lack of transitional forms in the fossil record in many evolutionary pathways to support punctuated equilibrium.

6. Identify one major difference between gradualism and punctuated equilibrium. [1]

7. According to the theory of gradualism, what may result from the accumulation of small variations? (1]

8. What fossil evidence indicates that evolutionary change may have occurred within a time frame known as gradualism? [1]

9. An organism contains many structures that enable it to survive in a particular environment. The human body has many such structures that have adaptive value. Several of these structures are listed below.

- sweat gland
- pancreas
- liver
- epiglottis
- capillary
- villus
- kidney
- platelet

Choose three (3) of the structures listed above. For each one chosen, write the name of the structure and then, using a complete sentence, describe one of its adaptive values to the human body. [3]

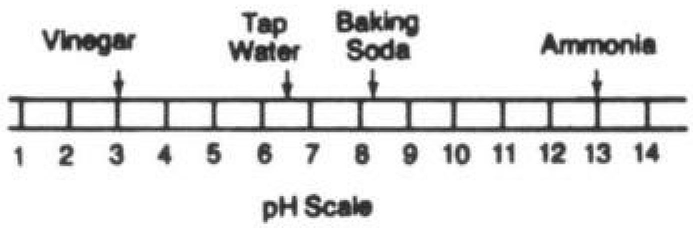
Base your answers to questions 10 through 14 on the information below and on your knowledge of biology.

Acid rain is a serious environmental problem in large areas of Canada and the northeastern United States, including New York State. It is partly created as rain "washes out" sulfur and nitrogen pollutants from the air. Acid rain alters the fundamental chemistry of sensitive freshwater environments and results in the death of many freshwater species. The principal sources of this pollution have been identified as smokestack gases released by coal-burning facilities located mainly in the midwestern United States.

"Unpolluted" rain normally has a pH of 5.6. Acid rain, however, has been measured at pH values as low as 1.5, which is more than 10,000 times more acidic than normal. Commonly, acid rain has a pH range of 3 to 5, which changes the acidity level of the freshwater environment into which it falls. The effect of the acid rain depends on the environment's ability to neutralize it. Evidence is accumulating, however, that many environments are adversely affected by the acid rain. As a result, the living things within lakes and streams that cannot tolerate the increasing acidity gradually die off.

There are many environmental problems that result from acid rain. Most of these problems center around the food web upon which all living things, including humans, depend. If freshwater plants, animals, and protists are destroyed by the acid conditions, then terrestrial predators and scavengers dependent on these organisms for food are forced to migrate or starve. These changes in a food web can eventually affect the human level of food consumption.

10. The accompanying scale shows the pH values of four common household substances. Acid rain has a pH closest to that of which of these substances?



(1) ammonia

(2) tap water

(3) baking soda

(4) vinegar

11. What is most likely the source of acid rain in New York State?

(1) far western United States

(2) midwestern United States

(3) far eastern Canada

(4) far western Europe

12. Which food chain includes organisms that would most immediately be affected by acid rain?

(1) grass → rabbit → fox → decay bacteria

(2) algae → aquatic insect → trout → otter

(3) shrub → mouse → snake → hawk

(4) tree → caterpillar → bird → lynx

13. Acid rain is generally considered a negative aspect of human involvement with the ecosystem. As such, it would most correctly be classified as a type of

(1) biological control

(2) conservation of resources

(3) technological oversight

(4) land-use management

14. A strain of fish that could survive under conditions of increased acidity could best be obtained by

(1) binary fission

(2) vegetative propagation

(3) selective breeding

(4) budding

UNIT TWO

Understanding and Applying Scientific Concepts

STANDARD 4

Students will understand and apply scientific concepts, principles, and theories pertaining to the physical setting and living environment and will recognize the historical development of ideas in science.

1. SIMILARITY AND DIVERSITY AMONG LIVING THINGS-LIFE PROCESSES

KEY IDEA 1 APPLICATION OF SCIENTIFIC PRINCIPLES Living things are both similar to and different from each other and from nonliving things.

Life Processes

Living things rely on many of the same processes to stay alive. Yet the ways that these processes and interactions are carried out are diverse. The life processes carried out by living things include nutrition, transport, respiration, regulation, reproduction, and (in animals) locomotion. These life processes provide mechanisms for living things to obtain and process foods (nutrition), circulate essential materials around their bodies (transport), con vert food energy to cell energy (respiration), coordinate life activities (regulation), produce more members of their kind (reproduction), and move from place to place in their environment (locomotion). Although almost all living things perform these same life functions, they are performed in many different ways in different kinds of living organisms. These different mechanisms are known as adaptations. Together, the various patterns of adaptation represent species diversity. (See the section "Human Physiology" for additional information on life functions in humans.)

Homeostasis

Nearly all living things are composed of cells. Cells are small living units that serve as the structural and functional building blocks of most living organisms. Cells carry on dynamic chemical activities that together constitute the cell's metabolism (metabolic activity). By carefully balancing this metabolic activity, cells are able to maintain a balanced internal stability known as homeostasis. Nonliving things differ from living things in that nonliving things lack the ability to perform these life processes. (See the section "Genetic Material" for additional information on cell theory.)

The components of living systems must work together to maintain homeostatic balance. This is true whether the systems are represented by cells, multicelled organisms, or ecosystems. Each level of complexity brings a new degree of variation to the theme of homeostasis. On the cellular level, life functions are performed by organelles, or small organs, found within the cell. Multicellular organisms, depending on their complexity, are made up of specialized organ systems that perform different aspects necessary to carry out separate, but interrelated, life functions. On the ecosystem level, species populations of all kinds interact to help achieve homeostatic balance in the living environment. (See the section "Human Physiology" for additional information on cell organelles.)

Diversity and Ecosystem Stability

Performance Indicator 1.1 The student should be able to explain how diversity of populations within ecosystems relates to the stability of ecosystems. Recognizing the interrelatedness of all living things, including humans, is important. It is also important to understand the unique, yet interdependent, roles that these organisms play in maintaining the stability of life on Earth. See material under "Interdependence of Living Things" for a complete discussion of ecology (p. 193).

Life Functions in Humans

Human Physiology

Performance Indicator 1.2 The student should be able to describe and explain the structures and functions of the human body at different organi zational levels (for example, systems, tissues, cells, organelles). Humans, like all living things, must perform basic life functions in order to survive. These life functions include nutrition, transport, respiration, excretion, regulation, and locomotion. The bodies of human beings are organized to provide efficient and effective means of performing these life functions. Each life function in a human is carried out by an organ system that contains organs and tissues specialized for the tasks involved. In turn, these structures are composed of cells whose metabolic processes are specialized for assisting these life functions. In addition, the activities of each organ and organ system must be coordinated so as to provide an integrated, homeostatic balance that promotes the maintenance of life. When any part of this complex system breaks down or becomes inefficient, this balance may be disrupted. Diseases may result from such disturbances.

Important levels of organization for structure and function include organelles, cells, tissues, organs, organ systems, and whole organisms. Several specific adaptations are found in humans (and in many other living things) to carry out these life functions. The simplest of these adaptations is the cell, which is the unit of structure and function of all living things. Cells contain subcomponents, known as organelles, that are specialized to perform aspects of these life functions. Some important organelles and their respective functions are listed below.

Above the cellular level of organization, the bodies of living things contain groupings of cells that are similar in structure and function. Such groupings of similar cells are known as tissues. For example, muscle tissues in humans are composed of spindle-shaped cells rich in contractile fibers. These cells are specialized to act together and assist in body movement. Because of their similar structure and function, muscle cells comprise a tissue. The bodies of complex organisms such as humans contain hundreds of distinct tissues.

An organ is a structure, composed of several different tissues, that plays a major role in the performance of a life function. Examples of organs in the human include the heart, the stomach, the liver, and the kidney. A series of organs that function together to assist in the performance of a life function is known collectively as an organ system. For example, the digestive system of the human is made up of the esophagus, stomach, small intestine, and large intestine, as well as several accessory organs. Each organ in the system has a specific role to play in the performance of the life function. Organ systems of humans are described in detail below.

Human Organ Systems

Humans are complex organisms. They require multiple systems for digestion, respiration, circulation, excretion, movement, coordination, and immunity. The systems interact to perform the life functions. Humans are complex organisms whose existence depends on the coordinated functioning of several integrated organ systems. Each organ system is specialized for the tasks involved in carrying out a separate apd distinct life function. By utilizing these systems, humans are able to:

- take in and process complex foods to produce simpler subunits;
- move essential materials to all parts of the body;
- obtain respiratory gases and metabolize these foods to produce cellular energy;
- remove potentially harmful wastes from the body;
- coordinate all life functions to produce an efficient, integrated system;
- move from place to place in the environment; and
- provide immunity from disease.

Perhaps the most essential feature of this process is the coordination of the separate systems into an integrated whole, promoting the maintenance of life in each individual human being. Without this integration, complex functional living units would probably not exist on Earth.

Nutrition is the life function by which human beings obtain materials needed for energy, growth and repair, and other life functions. As part of this process, these materials are converted to a simplified form that can be used by the cell. Nutritional requirements of humans are similar to those of other animals. A diet that includes the proper balance of carbohydrate, protein, lipid, roughage, vitamins, and minerals is essential to the physical health of the human body. These requirements are known to vary, however, with the age, sex, and physical activity of the individual.

The digestive system enables the human to carry out the life function of nutrition. In general, the human digestive tract resembles that of simpler organisms whose body plan is that of a one-way tube within a tube. The outer tube is the body exterior; the inner tube is the digestive tract. Within the digestive tract, food materials are progressively converted into molecular end products. The components of this system are as follows.

- Oral cavity-The human oral cavity (mouth) is used to ingest food. The teeth and tongue help to manipulate and break the food down mechanically. This process increases the surface area of the food, thereby aiding the process of chemical digestion by enzymes in saliva. Saliva is produced by salivary glands and secreted into the mouth cavity. The enzymes in saliva are responsible for the partial digestion of complex carbohydrates, such as starch, into double sugars, such as maltose.

- Esophagus-The esophagus is a short tube that connects the oral cavity to the stomach. The swallowing action initiated at the back of the oral cavity continues in the esophagus as a wave of muscular contraction known as peristalsis. This peristaltic action moves the chewed food to the stomach for further digestive action.

- Stomach-The stomach is a muscular organ whose main function is to liquefy and further digest food materials. The lining of the stomach contains digestive glands that secrete the digestive enzymes and hydrochlo ric acid that make up gastric fluid. Stomach enzymes are specifically designed to digest proteins. Unlike most of the body's enzymes, gastric enzymes work best in an acidic condition. This acidic condition is provided by the hydrochloric acid secreted by the stomach's digestive glands.

- Small intestine-Liquefied and partially digested food enters the small intestine from the stomach. There, enzymes secreted by intestinal glands complete the digestive process. These enzymes include protease (to digest proteins), lipase (to digest fats and oils), and enzymes such as maltase and sucrase (to digest maltose and sucrose sugars). In addition to the digestive process carried on within the small intestine, the lining of the small intestine acts as the principal surface for the absorption of the molecular end products of digestion. To facilitate this absorption, the lining of the small intestine contains millions of microscopic projections known as villi. The villi contain microscopic blood vessels, known as capillaries, and extensions of the lymphatic system, known as lacteals, that receive the dissolved nutrients and conduct them throughout the body.

- Large intestine-The large intestine receives food materials that have passed through the entire digestive tract but have not been digested. These materials are normally in a liquid state when they pass from the small to the large intestine. The large intestine reabsorbs much of the water from the waste matter and solidifies it into semisolid waste known as feces. The feces are stored in the lower end of the large intestine in an area known as the rectum. The feces pass out of the body via the anus by means of strong muscular (peristaltic) contractions. This action constitutes the process of egestion.

- Accessory organs-Accessory digestive organs include the salivary glands, liver, gallbladder, and pancreas. The term accessory refers to the fact that these organs are not a part of the food tube. The liver produces bile, which is important in the digestion of fats. Bile acts by breaking up (emulsifying) fat into small droplets. The gallbladder stores bile for release into the small intestine. The pancreas manufactures and stores several digestive enzymes important for the complete digestion of several kinds of complex molecules into simple, soluble end products. These end products include glucose, amino acids, fatty acids, and glycerol.

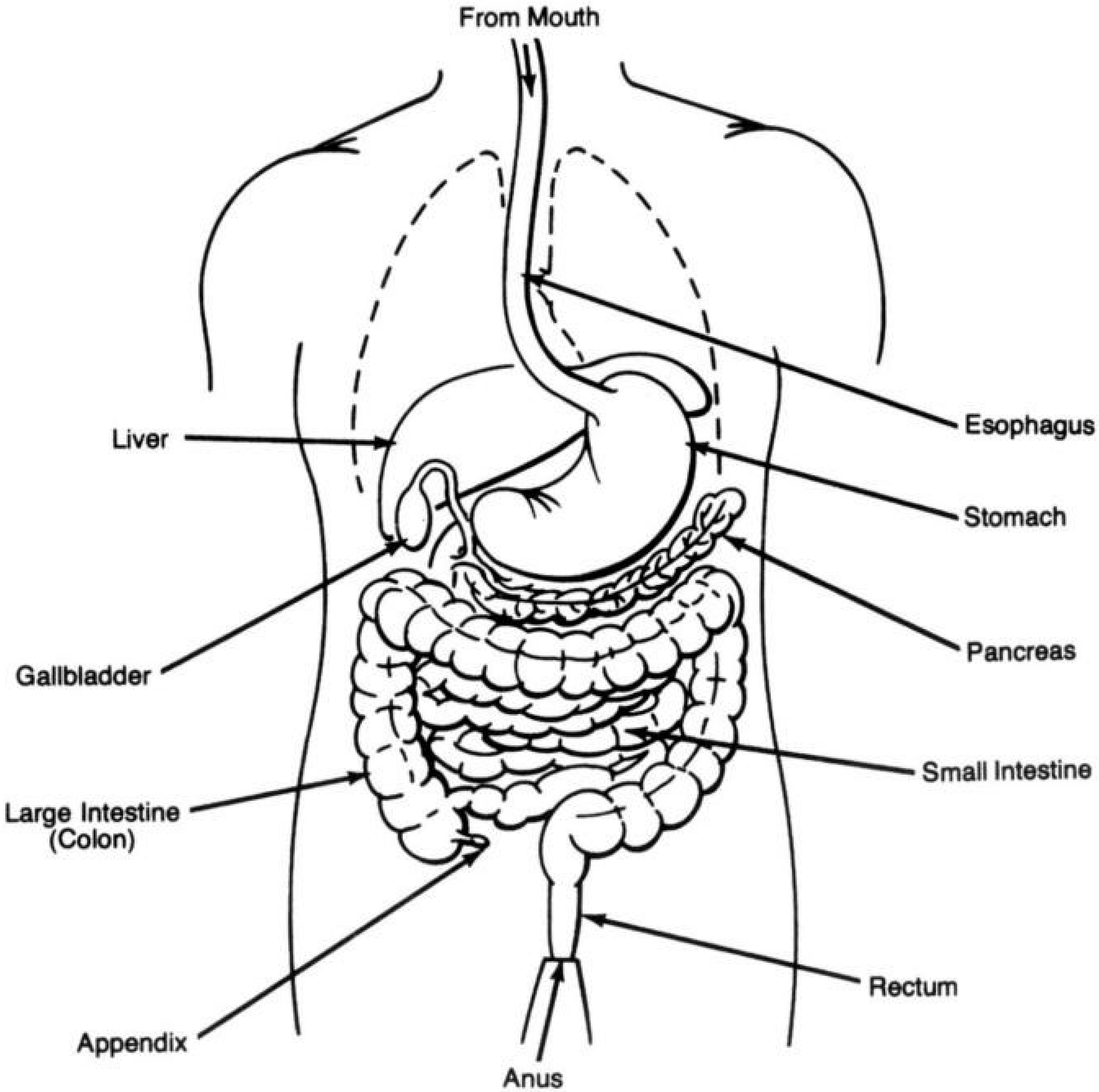
The underlying mechanism of digestion is the chemical process known as hydrolysis. This term literally means "splitting by adding water." In this reaction, large, insoluble molecules are converted to small, soluble molecules. To accomplish this, the cell uses enzymes to add the atoms that constitute water (hydrogen and oxygen) to the structure of the complex molecule. This reaction breaks the complex molecule at specific locations, producing smaller subunit molecules that can be absorbed by the cell.

This enzyme-catalyzed reaction may be accomplished with each of the major types of food and is illustrated by the following equation:

$$\text{maltose} + \text{water} \xrightarrow{\text{maltase}} 2\ \text{glucose}$$

$$C_{12}H_{22}O_{11} + H_2O \xrightarrow{\text{maltase}} 2\ C_6H_{12}O_6$$

In this reaction, the double sugar maltose is hydrolyzed to two molecules of the simple sugar glucose by the addition of a single molecule of water. The enzyme maltase catalyses this reaction. In similar reactions, starch molecules are hydrolyzed to double sugars, protein molecules are hydrolyzed to amino acid molecules, and fat molecules are hydrolyzed to fatty acid and glycerol molecules.



Digestive Tract

Transport is the life function by which human beings absorb and distribute the materials necessary to maintain life. The human circulatory system is specially adapted to move essential materials through the body to all cells. At the same time, waste materials resulting from cellular metabolism are carried to areas where they can be released to the environment away from living cells. Immunity from disease is also provided by transport mechanisms. Specialized tissues and organs assist in the transport function.

Transport media include blood and lymph. The blood is a fluid tissue suspended in liquid plasma. Plasma is made up of water, dissolved salts, nutrients, gases, and molecular wastes. Also found in the plasma are hormones and a large variety of manufactured proteins such as antibodies, clotting proteins, and enzymes. The plasma also suspends the cellular fraction of the blood.

The cellular fraction of the blood contains several different cell types. Red blood cells are the most abundant cell type in the blood. These small (about 8 micrometers in diameter), dish-shaped cells lack nuclei and cannot reproduce. Red blood cells contain hemoglobin, a red oxygen-carrying pigment that makes the blood an efficient medium for transporting oxygen to all body tissues. Phagocytes, a type of white blood cell, engulf and destroy bacteria that enter the bloodstream though breaks in the skin surface. Lymphocytes, another type of white blood cell, produce antibodies specifically designed to recognize and attack particular types of proteins (antigens) that may enter the blood by various routes. Platelets are small, noncellular components of the blood that contain chemicals important to the clotting process. The body's immune reactions are discussed in detail in the section "Disease as a Failure of Homeostasis."

Intercellular fluid (ICF) and lymph are abundant in human tissues. All cells in the body are bathed in ICF, which is rich in salts and various components important to the homeostatic balance of the cell. ICF drains from the tissues within lymphatic vessels, where it is known as lymph.

The circulatory system includes a series of structures (vessels and organs) designed to move the transport fluids throughout the body efficiently. These transport vessels and organs include the following.

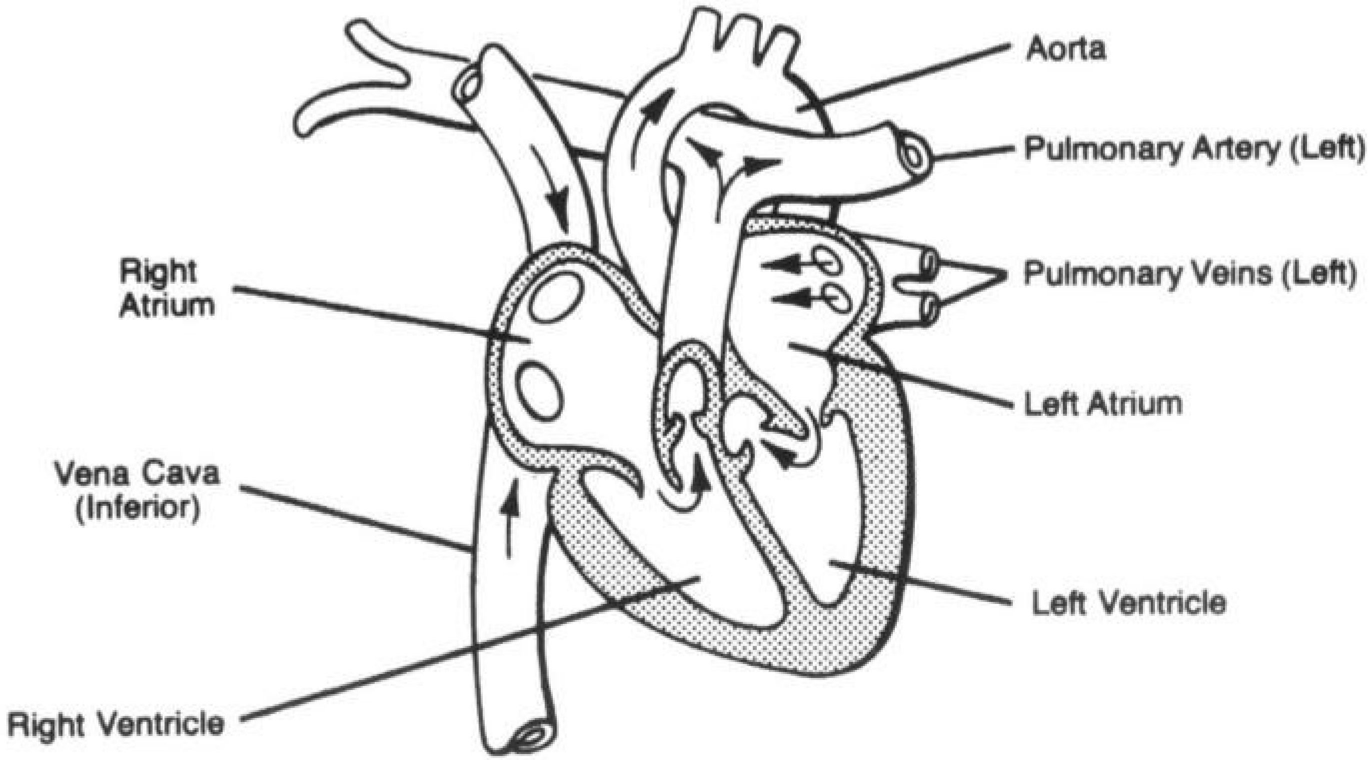
- Arteries-Arteries are relatively thick-walled blood vessels that contain cardiac muscle tissues. These muscles enable the artery to maintain blood flow via rhythmic contractions known as the pulse. Arteries are always involved with conducting the blood away from the heart toward the body's tissues.

- Veins-Veins are relatively thin-walled blood vessels that lack muscular tissues. Veins contain one-way valves that aid the forward movement of blood by preventing backflow within the vein. Veins are always involved with conducting the blood back toward the heart and away from the body tissues.

- Capillaries-Capillaries are microscopic blood vessels whose walls are only one cell in thickness. Capillaries branch from the ends of small arteries and carry blood rich in oxygen and nutrients to all tissues in the body. Dissolved materials are readily exchanged by diffusion between the blood and the body tissues through the thin walls of the capillaries.

- Lymph vessels-Lymph vessels form a branching series of microscopic vessels containing lymph. The lymph vessels carry lymph to and from the body tissues where it bathes the cells and is known as intercellular fluid. To aid the movement of the lymph, the lymph vessels contain valves similar to those found in veins. Lymph vessels become enlarged and are gathered in masses known as lymph nodes at specific parts of the body. These nodes contain phagocytic white blood cells that attack and destroy bacteria in the lymph.

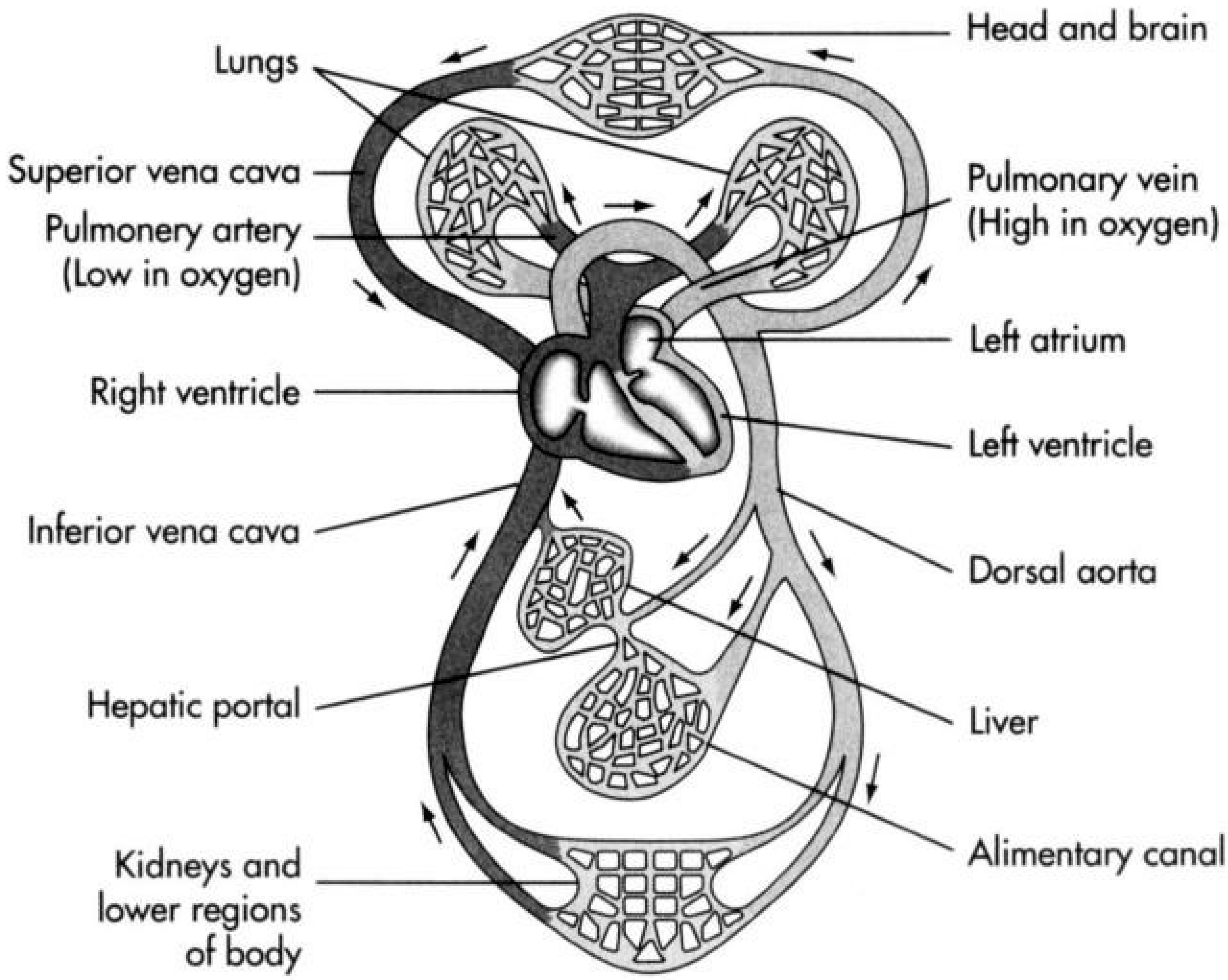
- Heart-The structure of the heart permits efficient movement of blood throughout the body within blood vessels. The heart is a muscular pump with four chambers. Two of these chambers, the atria, receive blood from veins leading from body organs. Two other chambers, the ventricles, have thick, muscular walls that contract to force blood out under great pressure through arteries to other organs.



Heart Circulation

The circulatory function can be traced from the entry of deoxygenated blood (blood whose hemoglobin has given up its oxygen) into the right atrium of the heart via the vena cava. The vena cava is a large vein that collects blood from smaller veins. This blood then passes through a one-way valve to the right ventricle. Strong muscular contractions in this ventricle force the blood out through the pulmonary arteries and into the lungs. A valve in the pulmonary artery prevents the backflow of blood. In the lungs, the blood passes through capillaries, where gas exchange occurs. This process oxygenates the blood and removes carbon dioxide from the blood. The oxygenated blood then returns via the pulmonary veins to the heart, entering through the left atrium. From the left atrium, the blood passes through another one-way valve on its way to the left ventricle. Contraction of the left ventricle sends the oxygenated blood out of the heart to body organs by way of the aorta. As in the pulmonary artery, a valve prevents the blood from flowing backward into the heart. The aorta branches into a series of smaller arteries. They eventually terminate in capillary networks within body tissues. In the capillaries, oxygen and nutrients are absorbed from the blood and carbon dioxide and metabolic wastes are absorbed into the blood. The capillaries then carry the blood to veins, which eventually lead back to the vena cava at the heart.

The circulation of blood through the lungs is known as pulmonary circulation. The circulation of blood through the body organs is known as the systemic circulation. The movement of blood through the blood vessels serving the heart muscle is known as the coronary circulation.



Circulatory Patterns

Blood pressure from both the pumping action of the heart and the contractions of the muscular artery walls maintains the flow of blood through the arteries and capillaries. During blood pressure testing, the higher pressure (systole) is registered when the ventricles contract; the lower pressure (diastole) is registered when the ventricles relax.

QUESTION SET 2.1-HUMAN PHYSIOLOGY I (ANSWERS EXPLAINED, P. 275)

1. Some characteristics of digestive systems are listed below.

A Food is moved along by peristalsis.

B Food is moved along by involuntary muscles.

C Accessory organs are present.

Which characteristics best describe the human digestive system?

(1) A, B, and C

(2) A only

(3) B only

(4) B and C only

2. Which statement most accurately describes the human heart?

(1) It has two atria and one ventricle, and it pumps blood directly into veins.

(2) It has one atrium and one ventricle, and it is composed of cardiac muscle.

(3) It has one atrium and two ventricles, and it is composed of visceral muscle.

(4) It has two atria and two ventricles, and it pumps blood directly into arteries.

3. A malfunction of the lymph node would most likely interfere with the

(1) release of carbon dioxide into the lymph

(2) filtering of glucose from the lymph

(3) release of oxygen into the lymph

(4) filtering of bacteria from the lymph

4. A heart attack may be due to all of the following except

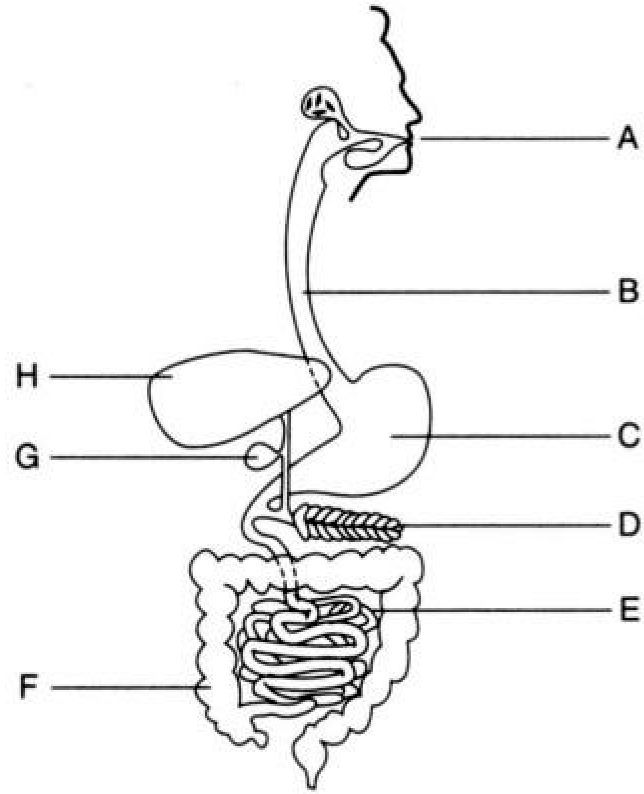
(1) an increase in arterial blood pressure

(2) oxygen deprivation of cardiac muscle

(3) narrowing of the arteries transporting blood to the heart muscle

(4) decreased consumption of complex carbohydrates

5-7 Base your answers to questions 5 through 7 on the diagram below of the human digestive system and on your knowledge of biology.



5. In which structure does the initial hydrolysis of carbohydrates occur?

(1) A

(2) E

(3) C

(4) D

6. From which structure are glucose and amino acids normally absorbed into the circulatory system?

(1) F

(2) H

(3) C

(4) E

7. In which structure does extracellular chemical digestion of protein begin?

(1) G

(2) B

(3) C

(4) E

---

8. A pulse can be detected most easily in

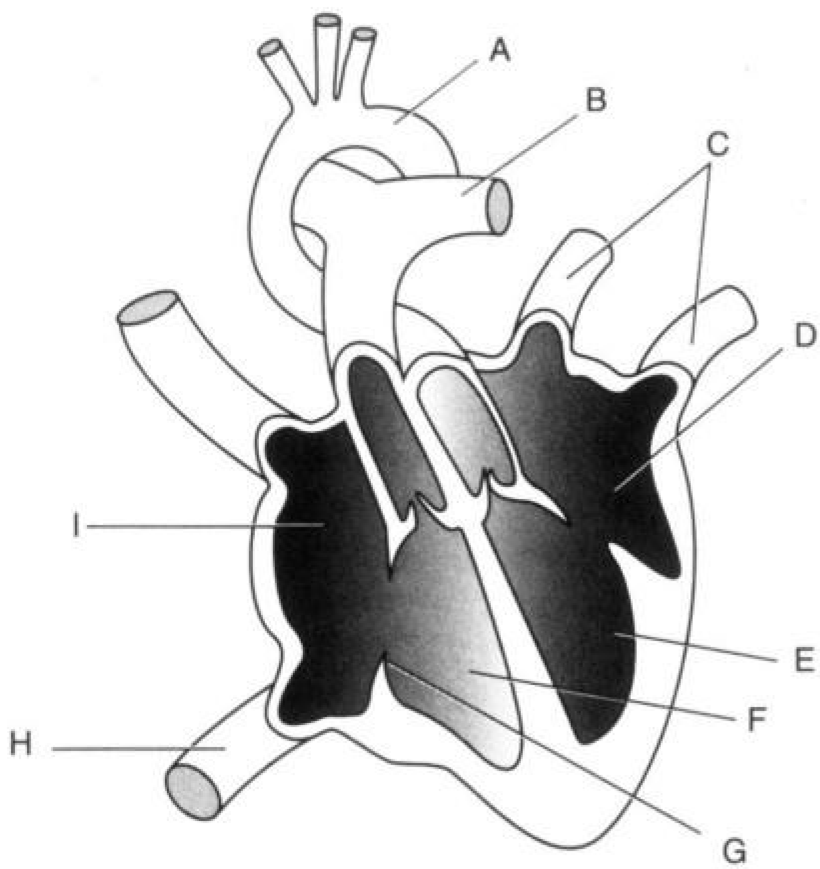
(1) an artery

(2) a vein

(3) a capillary

(4) a lacteal

9-10 Base your answers to questions 9 and 10 on the diagram below of the human heart and on your knowledge of biology.



9. Which structures are most closely associated with the transport of deoxygenated blood?

(1) A, B, and C

(2) B, F, and I

(3) C, D, and E

(4) D, H, and I

10. A structure that prevents the backflow of blood into an atrium is indicated by letter

(1) G

(2) B

(3) C

(4) H

---

11. Which transport structures have specialized regions for filtering out bacteria and dead cells?

(1) arteries

(2) capillaries

(3) veins

(4) lymph vessels

Respiration is the life function by which human beings convert the chemical energy stored in foods to a form that the cells can use more easily. The .production of cellular energy is one of the most essential functions carried on by living things. Organs and tissues specially adapted to promote the absorption of oxygen are important parts of the human respiratory system. The components of this system are as follows.

- Nasal cavity-The nasal cavity is composed of a series of channels through which outside air is admitted to the body interior. The cavity is lined by ciliated cells capable of producing mucus. Hair is also present; it catches dust particles. Air passing through the nasal cavity is moistened, warmed, and filtered in the nasal cavity, making it more compatible with the environment of the lung.

- Pharynx-The pharynx (throat) is the area in the back of the oral cavity where the nasal cavity joins in. In the pharynx, a flap of tissue, the epiglottis, covers the open end of the trachea to prevent food from entering the respiratory tubes.

- Trachea-The trachea (windpipe) is a cartilage-ringed tube used to conduct air from the pharynx deeper into the respiratory system. The cartilage rings maintain the open condition of the trachea at all times. The trachea is lined with ciliated tissues that sweep dust particles up and out of the trachea so they can be swallowed or expelled.

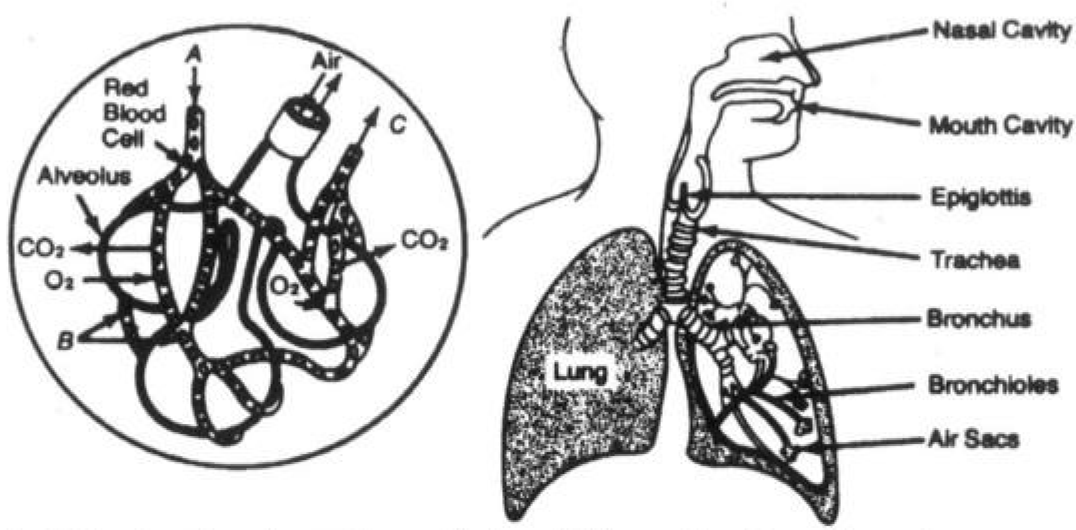
• Bronchi-Two bronchi branch from the the end of the trachea and lead to the two lungs. Like the trachea, the bronchi are ringed with cartilage and lined with ciliated mucous membrane.

• Bronchioles-The bronchioles are highly branched tubules that subdivide from the ends of the bronchi and become progressively smaller as they pass deeper into the lungs. The bronchioles lack cartilage rings.

• Alveoli-The alveoli, tiny air sacs, are found at the ends of each of the bronchioles. The alveoli are lined with cells that constitute the actual respiratory surface of the lung. Hence, the alveoli are the functional unit of the lung. Capillaries surround the alveoli. They carry away the oxygen absorbed in the moist lining so it can be transported to body tissues.

• Lungs-The lungs are composed of the bronchi, bronchioles, alveoli, and their supporting tissues. The functional unit of the lung is the alveolus (alveoli, plural), whose function is described above.

Breathing is a mechanical process used to to move air into the lungs as efficiently as possible. This process involves muscular movements of the diaphragm and rib cage, which raise and lower pressures within the chest cavity. As the pressure reduces, air is forced into the lungs by atmospheric pressures. As the pressure increases, the process is reversed, allowing gases (carbon dioxide and water vapor) to be expelled. The breathing rate is regulated by the nervous system as it monitors the concentration of carbon dioxide dissolved in the blood.



Deoxygenated blood enters through capillaries *(A)* branching from the pulmonary artery. As the blood passes through the capillary network *(B)* surrounding the alveoli, oxygen diffuses into the blood and carbon dioxide diffuses out of the blood. Oxygenated blood then returns to the heart via capillaries *(C)* leading to the pulmonary veins.

Adaptations for Human Respiration

Gas exchange in the alveoli is accomplished by simple diffusion. Oxygen in the bloodstream combines with hemoglobin to form oxyhemoglobin. In a reversal of the process that forms oxyhemoglobin, oxygen is released into the cells, where it is used in the chemical process of aerobic respiration. At the cells, carbon dioxide formed as a waste product of cellular respiration diffuses into the blood and is carried in the plasma in the form of the bicarbonate ion. Carbon dioxide and water vapor are released from the blood into the alveoli for removal from the body.

At the cellular level, food molecules are broken down chemically into energy and certain waste products. When this process occurs in the absence of molecular oxygen, the process is known as anaerobic respiration. When this process occurs in the presence of molecular oxygen, the process is known as aerobic respiration. Chemical respiration, both anaerobic and aerobic, are discussed in detail on pages 172-174.

Excretion is how human beings remove metabolic wastes from their cells and release them into the environment. The by-products of metabolic activity in humans may be harmful to the human body if they are not removed from where they are produced. Excretion is carried out by a set of specialized excretory tissues and organs, with the help of the transport system. The organs that assist the process of excretion are as follows.

- Lungs-The lungs are responsible for the excretion of carbon dioxide and water vapor, which result from the process of aerobic respiration. These materials diffuse out of the blood into the alveoli and are expelled in the breathing process when exhaling.

- Liver-The liver's role in excretion includes the recycling of worn-out red blood cells and the production of urea, which results from the breakdown of amino acids. The chemical breakdown of amino acids is known as deamination.

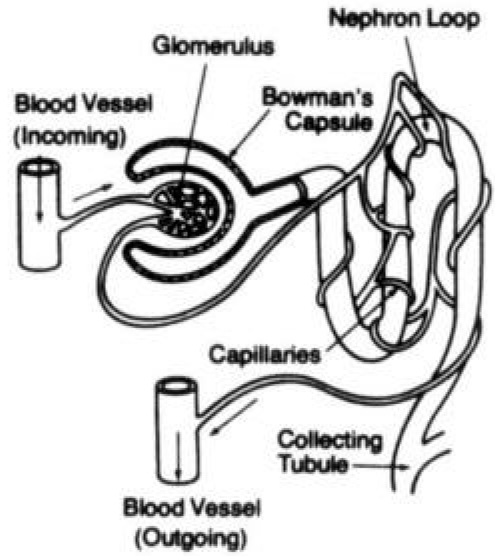
- Sweat glands-The sweat glands of the skin play a role in excretion by removing water, salts, and urea from the blood and excreting them as perspiration. Heat, a by-product of metabolism, is also removed from the tissues by the sweat glands. As water in the perspiration evaporates, it carries with it body heat that would otherwise overheat the cells.

- Kidneys-The kidneys in the urinary system are major excretory organs in human beings. They help regulate the chemical composition of the blood and thereby the chemical composition of the body tissues. Two arteries that branch off the aorta carry blood to the kidneys for filtering. These arteries quickly branch into many capillary networks, each known as a glomerulus. The glomerulus is nested inside a cup-shaped structure, Bowman's capsule, where many soluble blood components (including water, salts, urea, and soluble nutrients) are absorbed from the blood by diffusion. Bowman's capsule is part of a larger structure, known as the nephron, that is the functional unit of the kidney. In a looped portion of each nephron, active transport is used to reabsorb most of the soluble nutrient molecules, certain mineral ions, and some water. These reabsorbed components are returned to the blood flowing out of the kidney by way of veins to the vena cava. The concentrated mixture of waste materials remaining in the nephron, including water, salts, and urea, is known as urine.

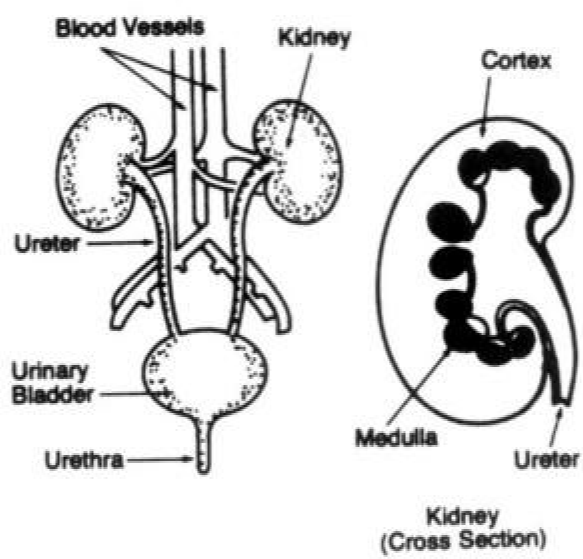
- Ureters-The two ureters, which are small tubes, conduct urine from the kidneys through the lower abdomen to the urinary bladder.

• Urinary bladder-The urinary bladder collects urine from the ureters and stores it for periodic excretion from the body.

• Urethra-The urethra is a small tube that leads from the urinary bladder to the outside of the body. Urine is released to the environment through the urethra.



Nephron (Magnified)



Urinary System

QUESTION SET 2.2-HUMAN PHYSIOLOGY 2 (ANSWERS EXPLAINED, P. 279)

1. When humans exhale, air passes from the trachea directly into the

(1) bronchioles

(2) alveoli

(3) bronchi

(4) pharynx

2. Which human excretory structure aids in the maintenance of normal body temperature?

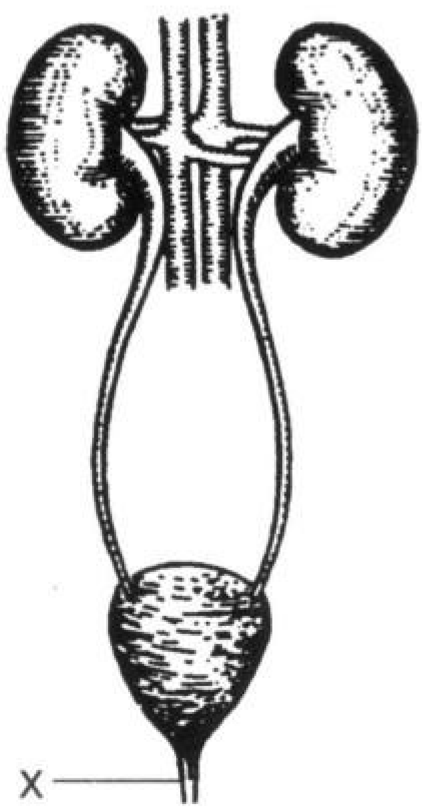
(1) sweat gland

(2) nephron

(3) liver

(4) urinary bladder

3. What is the principal function of structure X represented in the diagram below?



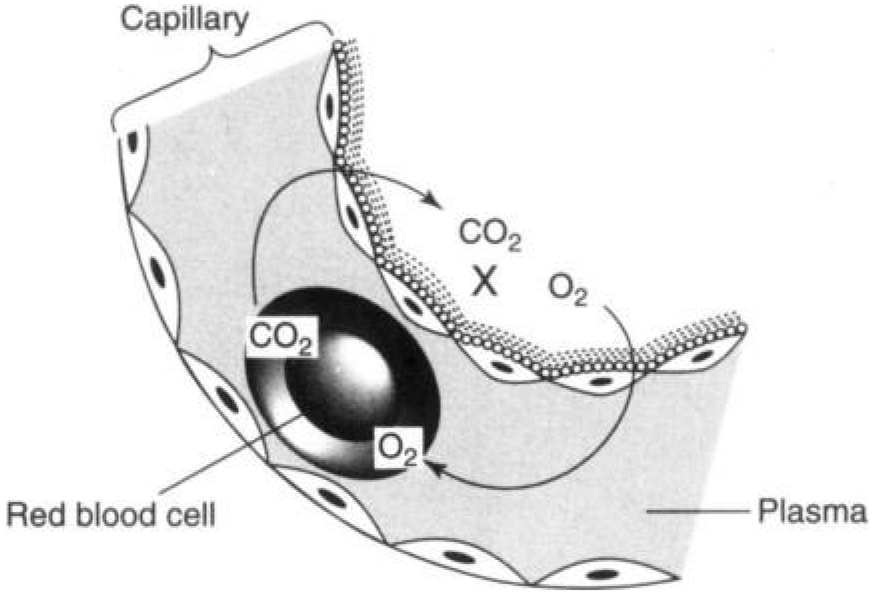
(1) filtration of cellular wastes from the blood

(2) transport of urine out of the body

(3) storage of urine

(4) secretion of hormones

4. The diagram below represents part of a capillary in a specific region of the human body.



The region labeled X represents part of

(1) a glomerulus

(2) an alveolus

(3) a villus

(4) the liver

5. An individual running a marathon may experience periods of oxygen deprivation that can lead to

(1) anaerobic respiration in muscle cells, forming lactic acid

(2) aerobic respiration in muscle cells, generating glycogen

(3) anaerobic respiration in liver cells, producing glucose

(4) aerobic respiration in liver cells, synthesizing alcohol

6. Which structure is lined with a ciliated mucous membrane that warms, moistens, and filters air?

(1) pharynx

(2) alveolus

(3) epiglottis

(4) nasal cavity

7. In humans, the ureter transports urine from the

(1) blood to the kidney

(2) liver to the kidney

(3) kidney to the urinary bladder

(4) urinary bladder to outside the body

8. Which set of symptoms would most likely lead to a diagnosis of asthma?

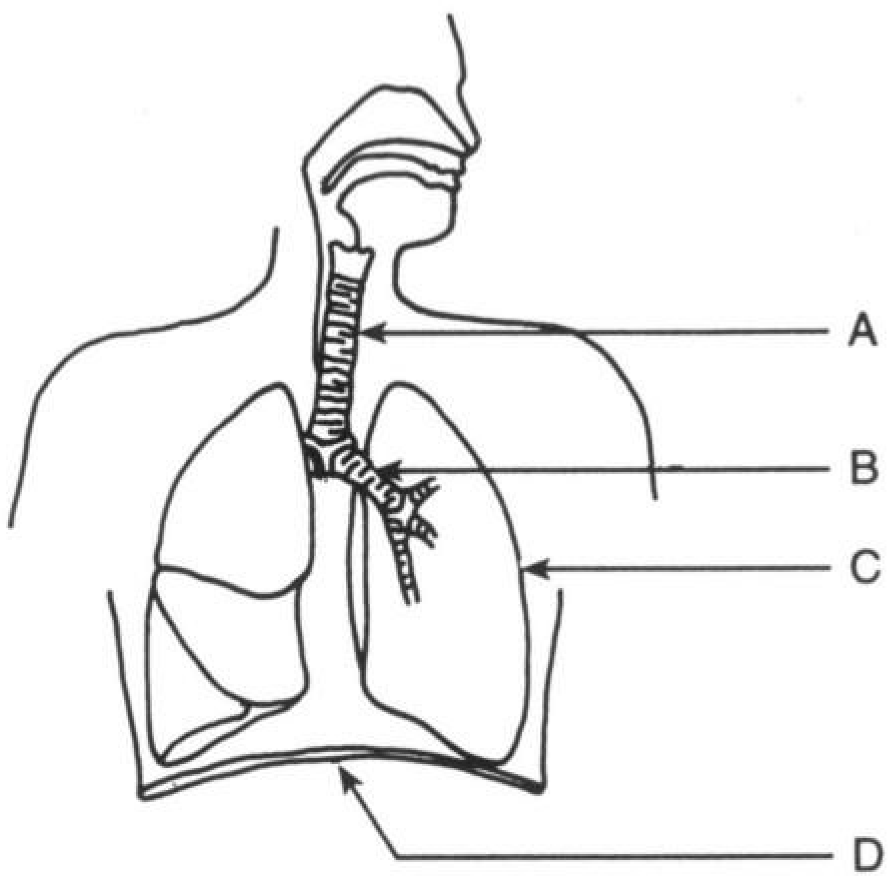
(1) enlargement and degeneration of the alveoli

(2) constriction of the bronchial tubes and wheezing

(3) inflammation and swelling of the epiglottis

(4) constriction of the nasal cavity and watery eyes

9. Which structure shown in the diagram below contracts, causing a pressure change in the chest cavity during breathing?



(1) A

(2) B

(3) C

(4) D

10. What is the function of the nephron?

(1) It breaks down red blood cells to form nitrogenous waste.

(2) It regulates the chemical composition of the blood.

(3) It forms urea from the waste products of protein metabolism.

(4) It absorbs digested food from the contents of the small intestine.

Regulation is the life function by which human beings control and coordinate other life functions to maintain existence. Regulation involves both nerve control and chemical (endocrine) control. The nervous system and the endocrine system are similar in that both are responsible for helping to regulate the body's activities. To do this, both systems use chemical messengers that affect other living tissues. However, the systems work at different rates and over different time periods. Nervous responses occur very rapidly and have a very short duration. Endocrine responses take longer to initiate, but their effect lasts longer.

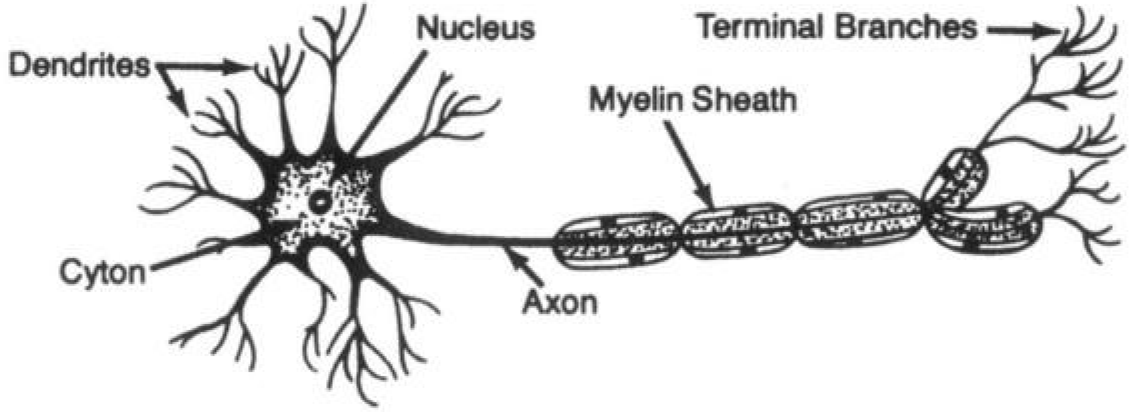
Nervous System Regulation-Nervous system regulation is carried out by a set of specialized tissues and organs. The organs that assist the process are as follows:

- Neurons- Neurons are the basic functional units of the human nervous system. They transmit nerve impulses from place to place in the body. They initiate and conduct electrical discharges, known as nerve impulses, along their membranes. Impulses are transmitted from cell to cell by means of neurotransmitter chemicals. These are secreted by one neuron and stimulate an impulse in a second neuron. Three structurally and functionally different types exist.

  > Sensory neurons-Sensory neurons receive stimuli from the environment and transmit this information to the central nervous system for interpretation. Sensory neurons are normally concentrated in organs specially designed to receive specific types of stimuli. These sensory receptor organs include the eyes, ears, nose, tongue, and skin.

  Interneurons-Interneurons exist primarily in central nervous system organs, although they may also be found in nerve centers in other parts of the body. The interneurons are responsible for interpreting sensory impulses brought to them by the sensory neurons. Interneurons also transmit commands to those motor neurons leading back to the body's effector organs (muscles or glands).

  > Motor neurons-Motor neurons carry impulses from the command center in the central nervous system to effector organs (muscles or glands), where an appropriate response is initiated.

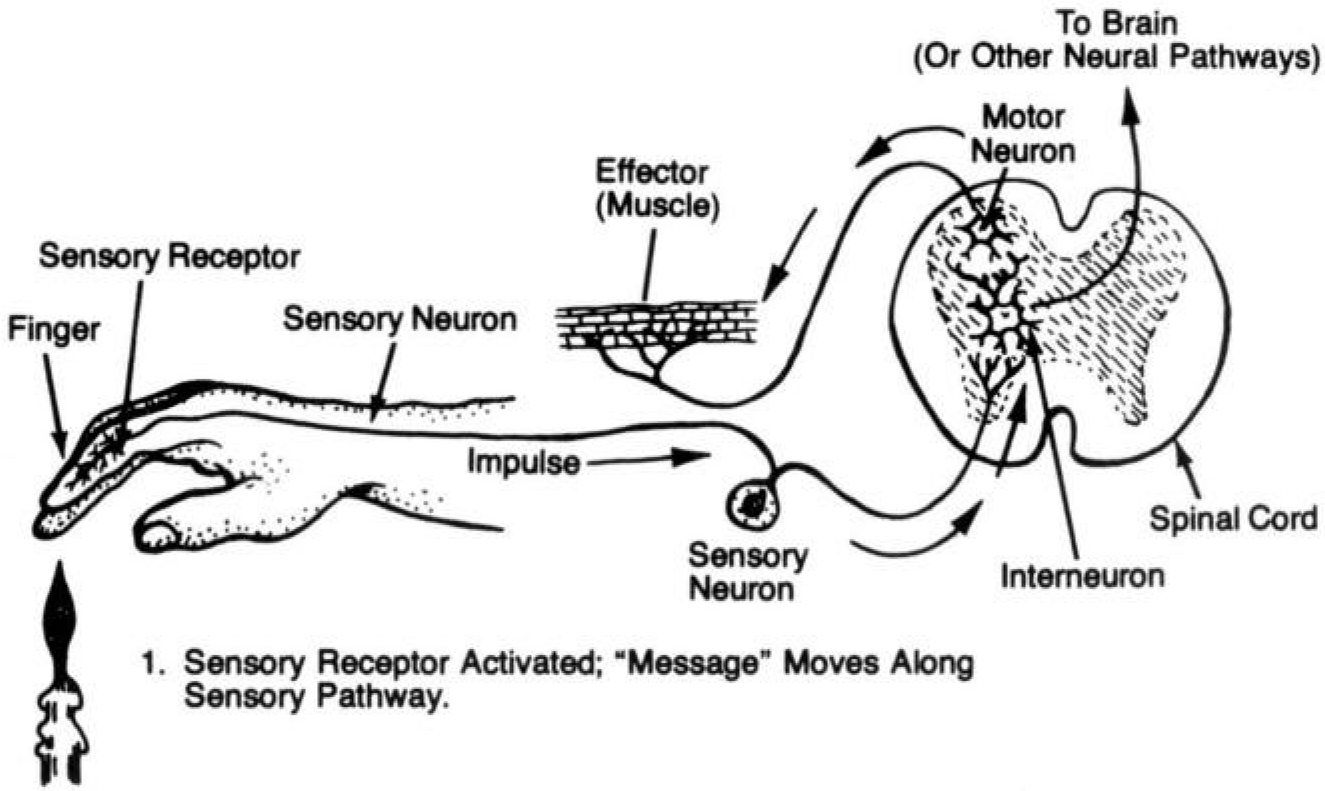


Vertebrate Neuron

- Nerves-Nerves are bundles of neurons that may contain a single type of neuron (sensory or motor nerves) or two separate types (mixed nerves). A fatty sheath protects the neurons in a nerve from coming into contact with each other and short-circuiting the impulses they carry. Nerves are specialized for conducting impulses over comparatively long distances at high rates of speed.

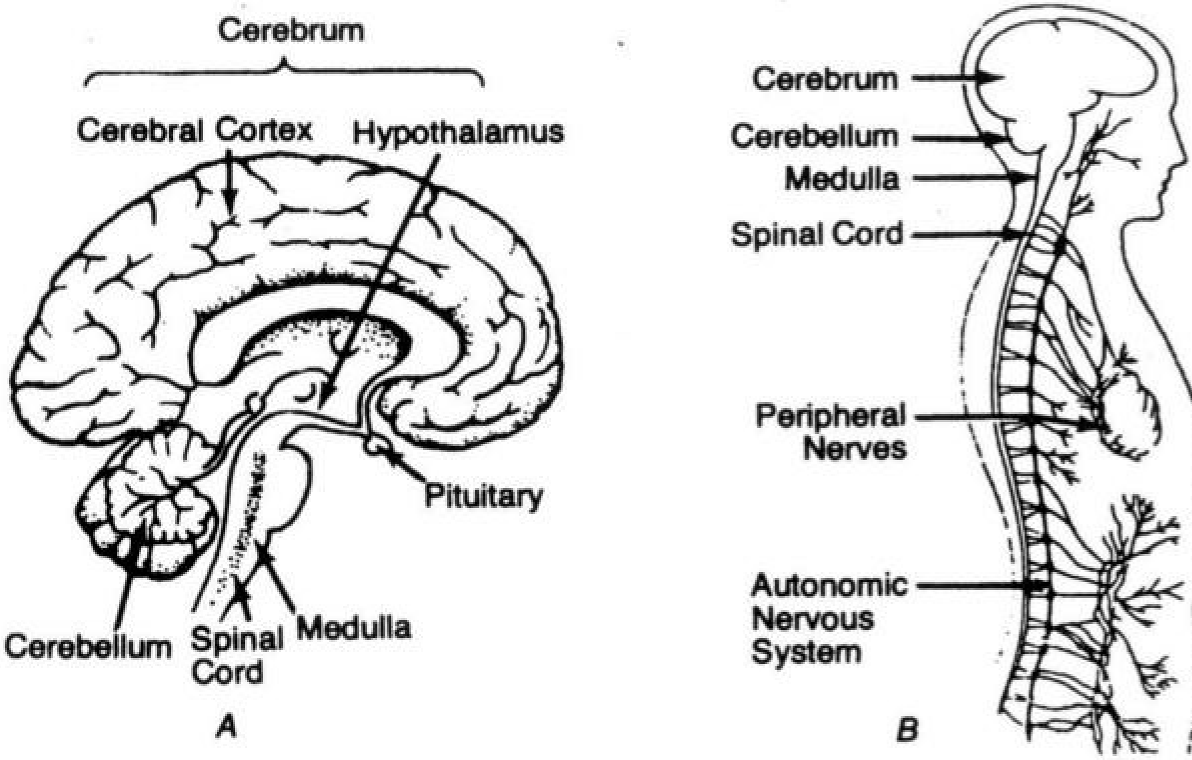
- Brain-The brain is a large organ composed of a mass of interneurons located within the cranial cavity in humans. The brain is one of the most highly specialized parts of the human body. It is responsible for regulating everything from the simplest to the most complex human activity. The brain is subdivided into three major regions, each responsible for a specific aspect of human behavior. The cerebrum is responsible for conscious thought, memory, sense interpretation, reasoning, and other voluntary activities. The cerebellum is responsible for coordinating muscular activities and helping the body maintain physical balance relative to its surroundings. The medulla oblongata is responsible for the regulation of automatic activities including heartbeat, breathing, blood pressure, and peristaltic activity.

- Spinal cord-The spinal cord is continuous with the brain. It extends downward from the base of the brain along the dorsal surface of the body. It is encased within the bony vertebral column, which protects it from mechanical damage. The major functions of the spinal cord include connecting the brain to the peripheral nerves and coordinating the reflex response. Reflexes are simple, inborn, involuntary patterns of behavior that permit immediate, unthinking responses to potentially dangerous situations.



Reflex Arc

- Peripheral nervous system-The peripheral nervous system consists of all types of nerves that branch through the body from the central nervous system. The peripheral nervous system is organized into two divisions. The somatic nervous system includes the nerves that control the actions of the voluntary skeletal muscles. The autonomic nervous system consists of nerves regulating automatic functions such as the actions of glands and involuntary muscle.



Central Nervous System

Endocrine Regulation-Endocrine regulation is carried out by a set of specialized tissues and organs, with the help of the transport system. The endocrine system consists of a number of discrete glands located at various points in the body. These glands lack ducts to carry their secretions to the target tissues and are therefore known as ductless glands. The endocrine glands deliver their secreted hormones throughout the body by way of the bloodstream. Negative feedback controls many aspects of endocrine regulation. Negative feedback and other self-correcting mechanisms are discussed in further detail below. The organs that assist the process of endocrine regulation are as follows.

- Hypothalamus-The hypothalamus is a small gland located within the brain. It produces secretions that affect the operation of the pituitary gland.

- Pituitary gland-The pituitary gland, which is located under the brain, is sometimes referred to as the master gland because of the large number of hormones it produces. Many of them control the activities of other endocrine glands. These hormones include growth-stimulating hormone (affecting the growth of long bones in the body), thyroidstimulating hormone (affecting the thyroid gland), and folliclestimulating hormone (affecting the ovaries in females).

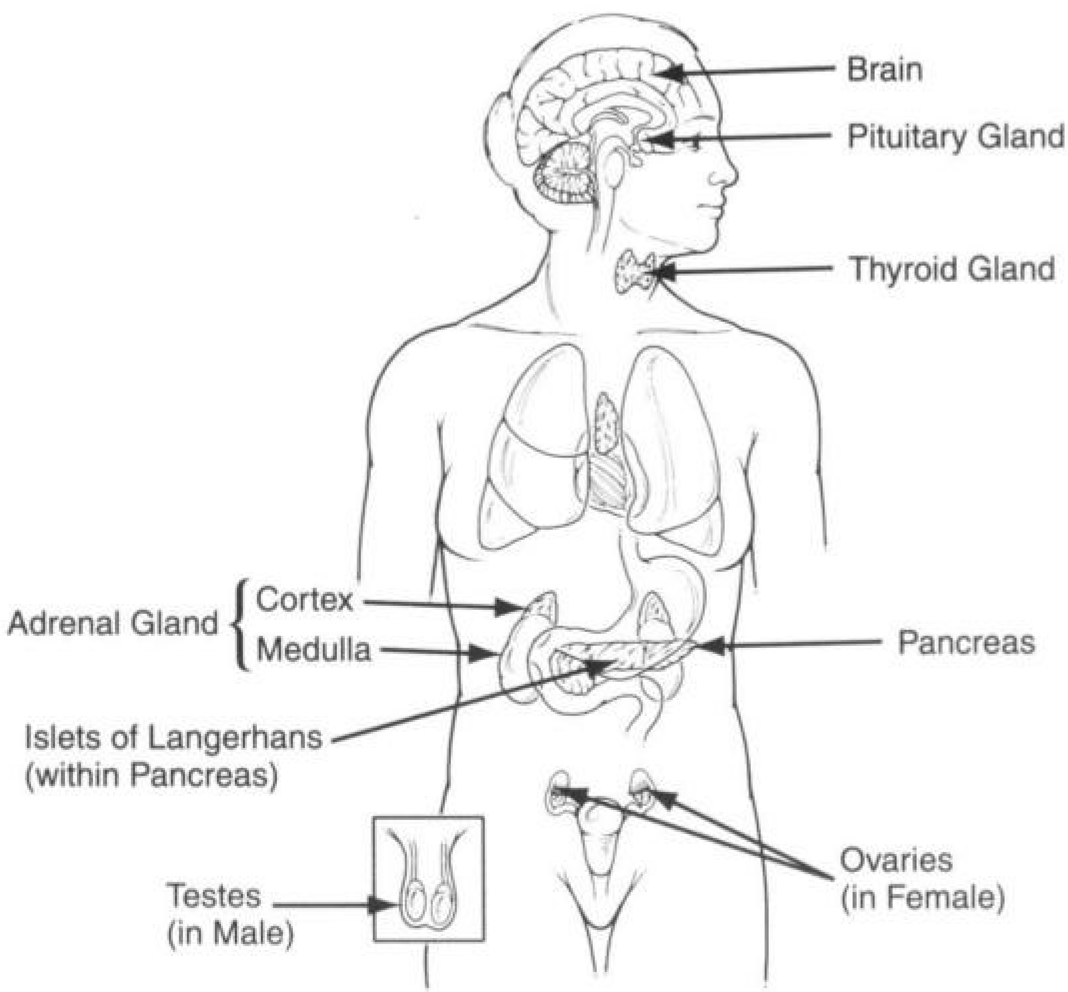
- Thyroid gland-The thyroid gland is located in the neck region, surrounding the trachea. Its principal hormone is thyroxin (affecting the general metabolic rate of the body).

- Parathyroid gland-The parathyroid glands are embedded within the thyroid gland. The hormone produced by the parathyroids is parathormone (affecting the metabolism of calcium in the body).

- Adrenal gland-The adrenal glands, located on the kidneys within the abdomen, consist of two separate regions, the cortex (outer region) and the medulla (inner region). The adrenal cortex secretes steroid hormones that regulate water balance and blood pressure as well as the conversion of complex protein and fat molecules into simpler glucose. The adrenal medulla secretes the hormone adrenaline. It increases the rates of metabolism, heartbeat, and breathing and stimulates the conversion of complex glycogen molecules into simpler glucose.

- Islets of Langerhans-The islets of Langerhans, small groups of glandular tissue scattered throughout the pancreas, produce the hormones insulin and glucagon. These two hormones have opposite effects on the storage of sugar in the liver and muscles of the body. Insulin promotes the storage of excess blood sugar as glycogen, thus lowering blood sugar levels. Glucagon stimulates the conversion of glycogen back into glucose, thus raising blood sugar levels.

- Gonads-The gonads (sex glands) differ in men and women. In males, the testes produce the hormone testosterone, which is important in the promotion of male secondary sex characteristics. In females, the ovaries secrete estrogen, which influences various aspects of the female secondary sex characteristics.

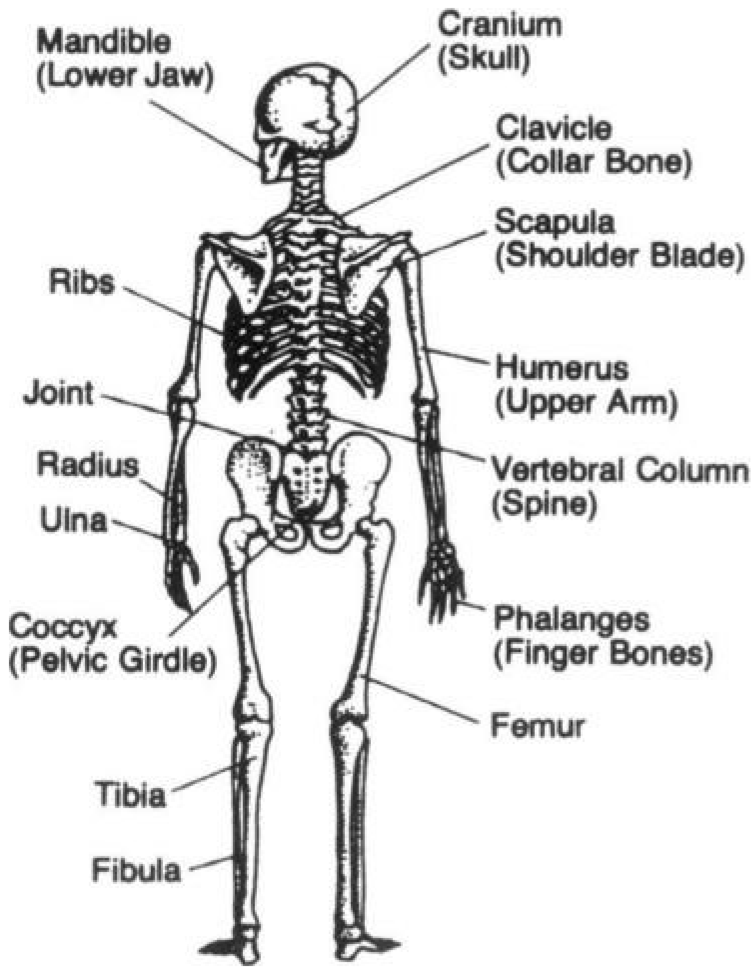


Endocrine Glands

Locomotion is how human beings move from place to place within their environment. As with most animal species, humans are well adapted to move from place to place in their immediate environment. The skeletal system and its muscle attachments make this movement possible.

Locomotion is carried out by a set of specialized tissues and organs. The organs that assist the process of locomotion are as follows.

- Bones-Bones provide mechanical support and protection for the body and its internal organs. These bones are arranged into an internal skeleton (endoskeleton), which gives human beings their characteristic body shape. The human skeleton is made up of over 200 bones of varying shapes, sizes, and functions. The point at which one bone comes into contact with another bone is known as a joint. Other functions of the bones include protection of soft tissues and organs, anchorage sites for muscles, leverage for movement, and production of blood cells in the bone marrow.



Skeletal System

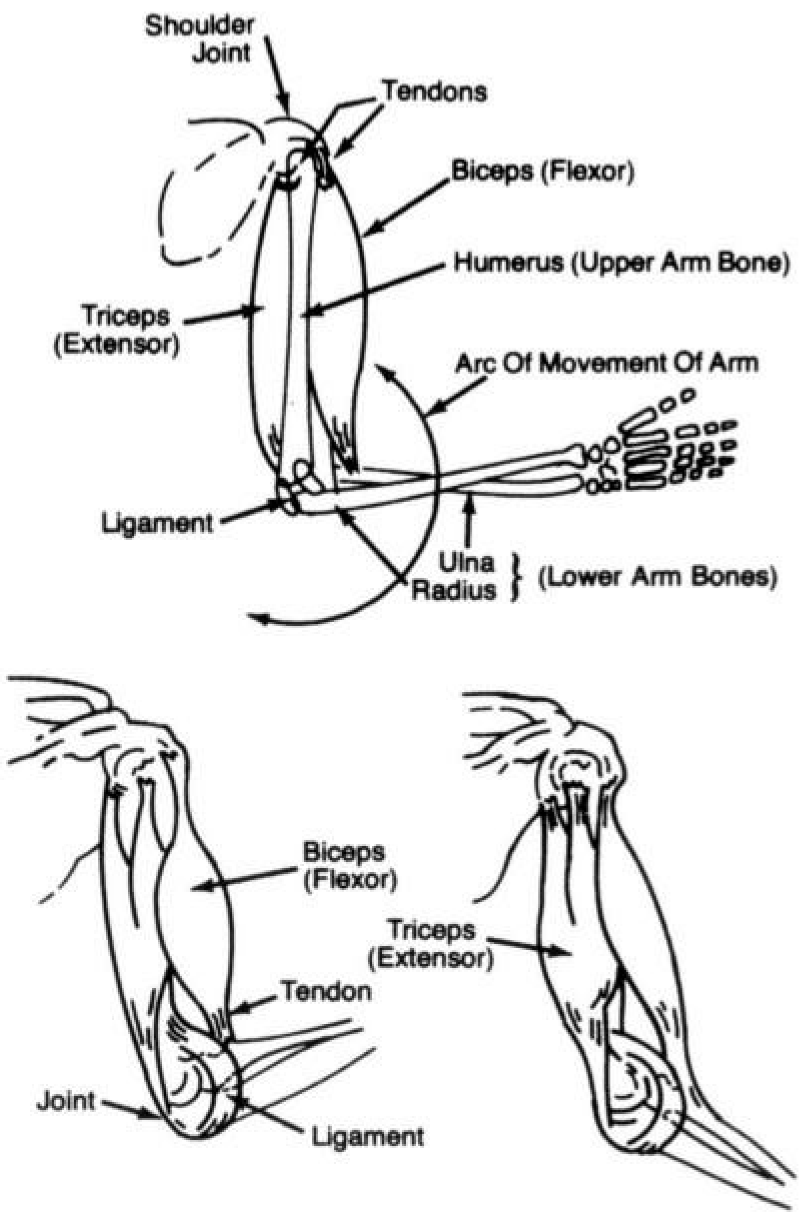
- Cartilage-Cartilage is a flexible, fibrous connective tissue that pads the joints between bones. Cartilage is found in many of the flexible parts of the body, including the outer ear and the nose. In embryos and very young children, cartilage is abundant, making up the major portion of the skeleton. In adults, it is much reduced, being found only at bone ends and in flexible portions of the body such as the trachea.

- Muscles-Muscles in the human being are of three types. Visceral and cardiac muscles are involuntary muscles controlled primarily by the autonomic nervous system. Skeletal muscles are voluntary and are those most directly involved in human locomotion. Skeletal muscles normally work in opposing pairs, each pulling a joint in a different direction. By coordinating these muscle pairs, the body is able to move skeletal levers to accomplish movement from place to place. In opposing pairs, muscles that extend (open) joints are known as extensors, while muscles that flex (close) joints are known as flexors.

Muscles require energy in order to contract. During heavy exercise, oxygen supplies may not be sufficient to release energy to the muscle cells by aerobic means. At such times, the muscle cell has the capacity to use lactic acid fermentation to supply additional energy. The buildup of lactic acid in the muscle tissues is known as muscle fatigue.

- Tendons-Tendons are responsible for attaching muscles to the bones of the skeleton. They are composed of tough, inelastic connective tissue.

- Ligaments-Ligaments attach bones to other bones at the skeletal joints and are composed of tough, elastic connective tissues that are able to stretch as the joints flex.



Elbow Joint

QUESTION SET 2.3-HUMAN PHYSIOLOGY 3 (ANSWERS EXPLAINED, P. 282)

1. During a race, the body temperature of a runner increases. The runner responds by perspiring, which lowers body temperature. This process is an example of

   (1) maintenance of homeostasis

   (2) an antigen-antibody reaction

   (3) an acquired characteristic

   (4) environmental factors affecting phenotype

2. Which substances are secreted at the endings of nerve cells?

(1) antibodies

(2) antigens

(3) neurotransmitters

(4) lipids

3. Which row in the chart below contains the words that best complete this statement?

   "The I glands produce II , which are transported by the III system."

Row	I	II	III
A	Digestive	Hormones	Circulatory
B	Endocrine	Enzymes	Lymphatic
C	Endocrine	Hormones	Circulatory
D	Digestive	Enzymes	Lymphatic

(1) A

(2) B

(3) C

(4) D

4. All living things carry out a variety of life functions such as coordination, excretion, digestion, circulation, and synthesis. Select two of the life functions listed. Define the two life functions you selected and explain how they interact to keep an organism alive. [4 points]

____

5. Which statement does not correctly describe a function of cartilage?

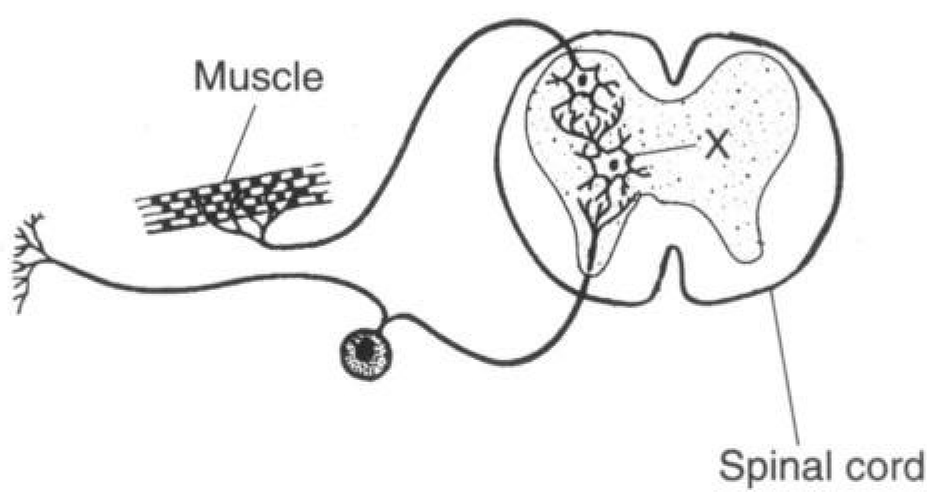
(1) It anchors muscles to bones.

(2) It provides flexibility in an embryo.

(3) It makes up the outer ear.

(4) It cushions bones at a joint.

6. A reflex arc is illustrated in the diagram below.



Structure x represents

(1) an effector

(2) a motor neuron

(3) an interneuron

(4) a receptor

7. One of the functions of the human endoskeleton is to

(1) transmit impulses

(2) produce blood cells

(3) produce lactic acid

(4) store nitrogenous wastes

8. A human skeleton is shown in the photograph below.

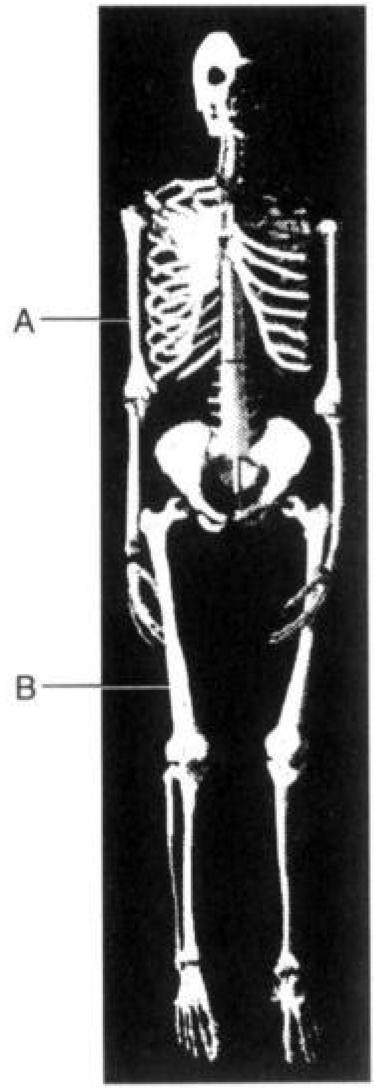
The elongation of structures A and B was stimulated by a hormone produced by the

(1) islets of Langerhans

(2) liver

(3) pituitary gland

(4) striated muscles



9. When a child runs to his/her mother after hearing a clap of thunder, the child is using

(1) the central nervous system only

(2) the peripheral nervous system only

(3) both the central and the peripheral nervous systems

(4) neither the central nor the peripheral nervous systems

10. The humerus, the bone in the upper arm of a human, is directly connected to other bones in the arm

by

(1) cartilage

(2) tendons

(3) extensors

(4) ligaments

11-12 For each phrase in questions 11 and 12, select from the list below the answer best described by that phrase. Then record its number.

Endocrine Glands

(1) thyroid

(2) adrenal

(3) islets of Langerhans

(4) parathyroid

11. Secretes a hormone in times of emergency, accelerating metabolic activities

12. Requires a supply of iodine to synthesize its hormone

II. HOMEOSTASIS

The components of the human body, from organ systems to cell organelles, interact to maintain a balanced internal environment. To accomplish this successfully, organisms possess a diversity of control mechanisms that detect deviations and make corrective actions.

When all components of the human body are functioning at peak efficiency, each helps to establish a balanced set of conditions that supports the continuation of life. This balance, or steady state, is known as homeostasis. In this state, all systems work together to perform their specialized functions. The resulting products are used to perform other life processes. The human body contains sensory tissues that can detect and measure the concentrations of many organic and inorganic compounds. When inappropriate levels of these materials are found in the body, a response is initiated that helps to correct the imbalance and reestablish homeostasis. Many different mechanisms exist to assist in the maintenance of homeostasis. Examples of this mechanism include the following.

- As carbon dioxide builds up in the body tissues as a result of aerobic respiration, it diffuses into the blood for elimination from the body as respiratory waste. Elevated concentrations of dissolved carbon dioxide are detected by the central nervous system. Commands are sent to the breathing mechanisms that increase the breathing rate. The increased breathing rate allows dissolved carbon dioxide to exit the bloodstream at an accelerated pace and introduces atmospheric oxygen into the blood at the same time. As the central nervous system detects a reduced carbon dioxide concentration in the blood, commands are sent that slow the breathing rate to normal levels as homeostatic balance is reestablished once more.

- When human skin comes into contact with a hot surface, the body's tissues may be damaged as a result. A reflex arc consisting of a sensory neuron, interneuron, and motor neuron respond to this danger. The sensory neuron detects the stimulus and identifies it as heat. This information is transmitted to an interneuron in the spinal cord. A command response is then initiated that is sent along a motor neuron to muscles. The muscles are commanded to move the part of the body away from the hot surface. This reflex action is involuntary and very rapid. The quick response helps to protect the skin and underlying tissues from damage and maintain homeostatic balance.

- The mechanism that controls many aspects of endocrine regulation is negative feedback. It operates on the principle that the effects of a particular hormone may inhibit the further production of that hormone but may stimulate the production of another hormone. A good example of negative feedback is the insulin-glucagon feedback loop. Elevated sugar levels in the blood stimulate the production of insulin (which functions to store glucose in the liver) while inhibiting the production of glucagon. As blood sugar levels drop as a result of insulin's action, glucagon production increases. As a result, glucose is released from the liver, while insulin production is inhibited.

- Sensors in the central nervous system are specialized to monitor the temperature of the blood. When this temperature exceeds 98.6°F, by a few tenths of a degree, the central nervous system sends out a series of commands that have various effects. Breathing deepens and quickens, allowing heat to escape from the body by means of exhaled air and water vapor. Sweat glands on the face and body open. Perspiration beads begin to appear on the skin surface, where they can evaporate and cool the skin further. By initiating these responses, the body avoids overheating and damaging sensitive tissues throughout. This protection is important in maintaining overall homeostatic balance.

If there is a disruption in any human system, there may be a corresponding imbalance in homeostasis. When the balance of the body's systems is disrupted, cells, tissues, and their associated organs are affected. This may lead to failure of one or more organs or systems within the body. When such a fail ure occurs, the homeostatic balance of the entire organism can be thrown off. This can lead to illness or death, depending on the severity of the imbalance.

For example, untreated high blood pressure can damage the nephrons, the functional units of the human kidney. If the high blood pressure condition persists for a long period of time, the tissues of the kidneys can become so badly damaged that the kidneys cease functioning altogether. As the kidneys stop functioning to filter the blood of urea and salts, the concentration of these wastes builds up to unsafe levels in the blood. As this unfiltered blood reaches other body tissues, it poisons them and causes them to slow or stop functioning. Eventually, the body's tissues become so badly poisoned with toxic metabolic wastes that they can no longer support life activity. At this point, organs and body systems fail, and the person may die if he/she is not treated. See the section "Disease as a Failure of Homeostasis" for more information about disease as a failure of homeostasis.

III. CELL FUNCTION AND STRUCTURE

The organs and systems of the body help to provide all the cells with their basic needs. The cells of the body are of different kinds and are grouped in ways that enhance how they function together. Each of the body systems and its associated organs mentioned provides a different functional life activity. These systems and organs work together to support life. Life really begins with the biochemical activity of the individual cells that make up a multicelled organism such as the human being. Each living cell in the body needs food, water, and oxygen to function appropriately These cells must also be cleaned constantly to free them of toxic metabolic wastes such as urea and carbon dioxide.

To illustrate, consider how the body's systems work together to provide for the needs of an individual cell living deep inside the body of a human being. The digestive system provides food for this cell by breaking down the complex structure of ingested foods into soluble components that can be absorbed by the cell. Oxygen needed by the cell for respiration is absorbed from the atmosphere by the respiratory system. The circulatory system absorbs these soluble food and oxygen molecules from their respective points of entry into the body. It moves them near the cell so the molecules can be absorbed through the cell membrane. The cell metabolizes these molecules, producing cell components and energy needed to support the cell's life activities. The cell also produces a variety of waste materials, including carbon dioxide, salts, and urea, that must be removed from the cell and from its immediate environment. Once again, the circulatory system assists by absorbing these waste molecules and moving them to organs that specialize in the release of wastes to the outside environment. Carbon dioxide is removed from the blood in the respiratory system, while salts and urea are filtered out of the blood by the excretory system. Meanwhile, all these systems are being coordinated by the regulatory system. As a result, a homeostatic balance is struck. All systems operate in a coordinated fashion to sustain life.

Tissues

Each cell in the body is a part of the complex fabric of the organism. Cells are specialized to perform specific functions in the body. Groups of such specialized cells are known as tissues. They are often found clustered together within organs where they carry on their specialized activities with great efficiency. Examples of human body tissues include:

- skin tissues that provide an impervious layer surrounding and protecting interior organs;
- bone tissues that secrete bone mineral and maintain the body's endoskeleton;
- blood tissues that transport oxygen and other components as well as protect the body against

disease;

- muscle tissues that move skeletal levers during locomotion and specialize in the physical movement within certain body organs;

- nerve tissues that provide a communication link among all body systems; and

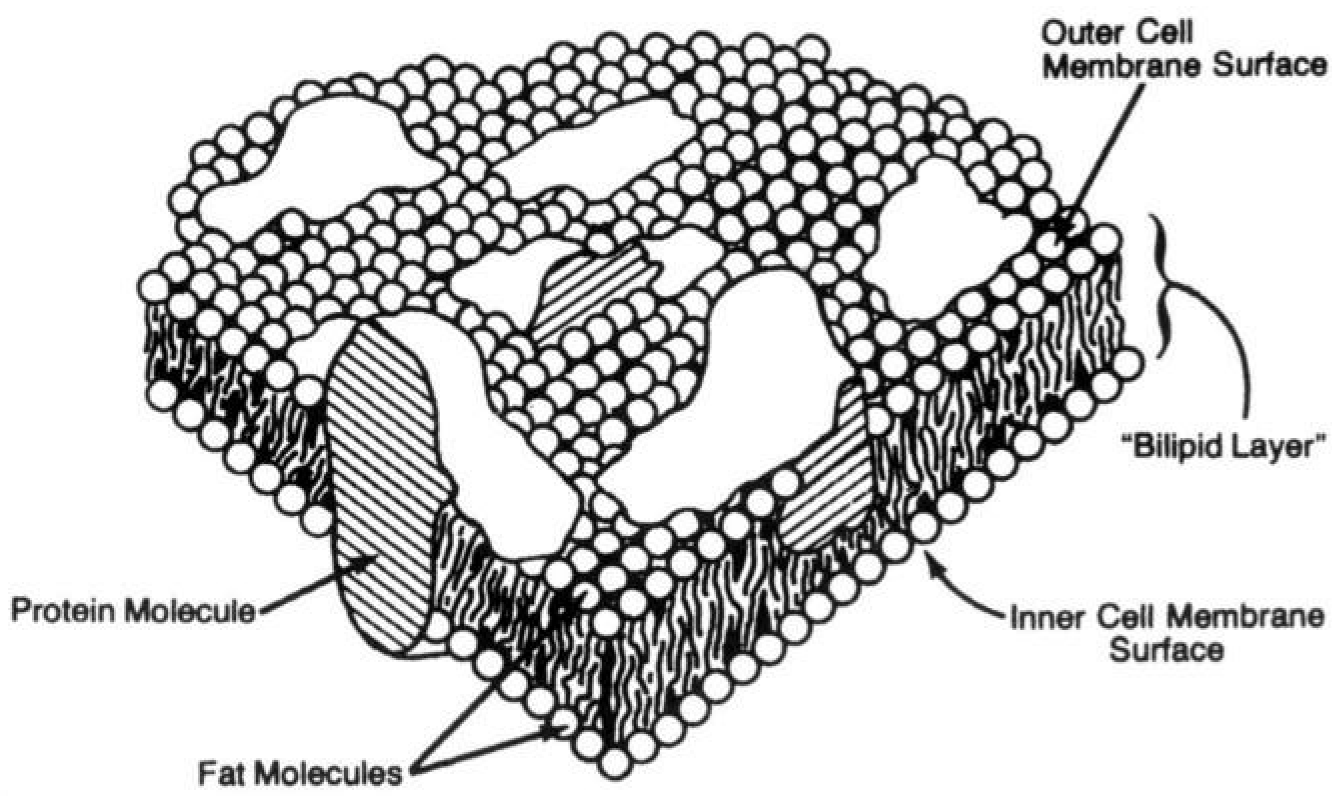
- endocrine tissues that produce a variety of chemical substances that control the functioning of other body tissues.

Many other specific tissues operate within the body. Each of the tissue types listed above can be subdivided into several highly specialized tissues that carry on very narrow roles in maintaining homeostatic balance. For example, the broad category of muscle tissue contains skeletal muscle that moves skeletal levers, visceral muscle that creates internal movements such as peristalsis in the intestines, and cardiac muscle that establishes and maintains rhythmic contractions of the heart and arteries. Blood tissues include red blood cells that carry oxygen, phagocytes that engulf bacteria, lymphocytes that produce antibodies against disease, platelets that specialize to produce clots, and a variety of other cell types, each with its own special function in the body. Nerve tissues are subdivided into sensory neurons that receive environmental stimuli, motor neurons that control muscles and glands, and interneurons that process sensory input and send motor commands.

Cells have particular structures that perform specific jobs. These structures perform the actual work of the cell. Just as systems are coordinated and work together, cell parts must also be coordinated and work together. The cell is extremely complex and is composed of smaller functional parts known as cell organelles. Many of these organelles were unknown to scientists until 20th-century scientific techniques and equipment (electron microscope, ultracentrifuge) made them visible to researchers. Each type of organelle has special work to do that promotes the survival of the cell. In a sense, these tiny structures are similar to organs and organ systems. They provide specialized functions coordinated to establish and maintain homeostasis within the cell. Organelles are specialized to carry on the life functions of nutrition, respiration, circulation, excretion, regulation, reproduction, and locomotion within their particular cell.

Cell Membrane

Each cell is covered by a membrane that performs a number of important functions for the cell. These include separation from its outside environment, controlling which molecules enter and leave the cell, and recognition of chemical signals. The processes of diffusion and active transport are important in the movement of materials in and out of cells. The outer membrane of the cell, which regulates the transport of materials into and out of the cell, is known as the plasma (cell) membrane. The plasma membrane also serves as the interface between the cell interior and its outside environment. Recent research points to the plasma membrane's function as a site of cellcell recognition, which has important implications for the control of disease, including cancer.



Fluid-Mosaic Model

The structure of this membrane has been the subject of study for many years. Several models have been developed to describe it. The fluid-mosaic model is the currently accepted model for this structure. This model shows the principal component of the plasma membrane to be a double layer of lipid molecules with many embedded proteins, known as receptors. This structure allows the passage of small, soluble molecules such as monosac charides, amino acids, and dissolved gases while preventing the passage of larger molecules (for example, starches and proteins). Current research indicates that size may be only one factor affecting the passage of materials through the cell membrane. Evidently, chemical recognition factors are also important.

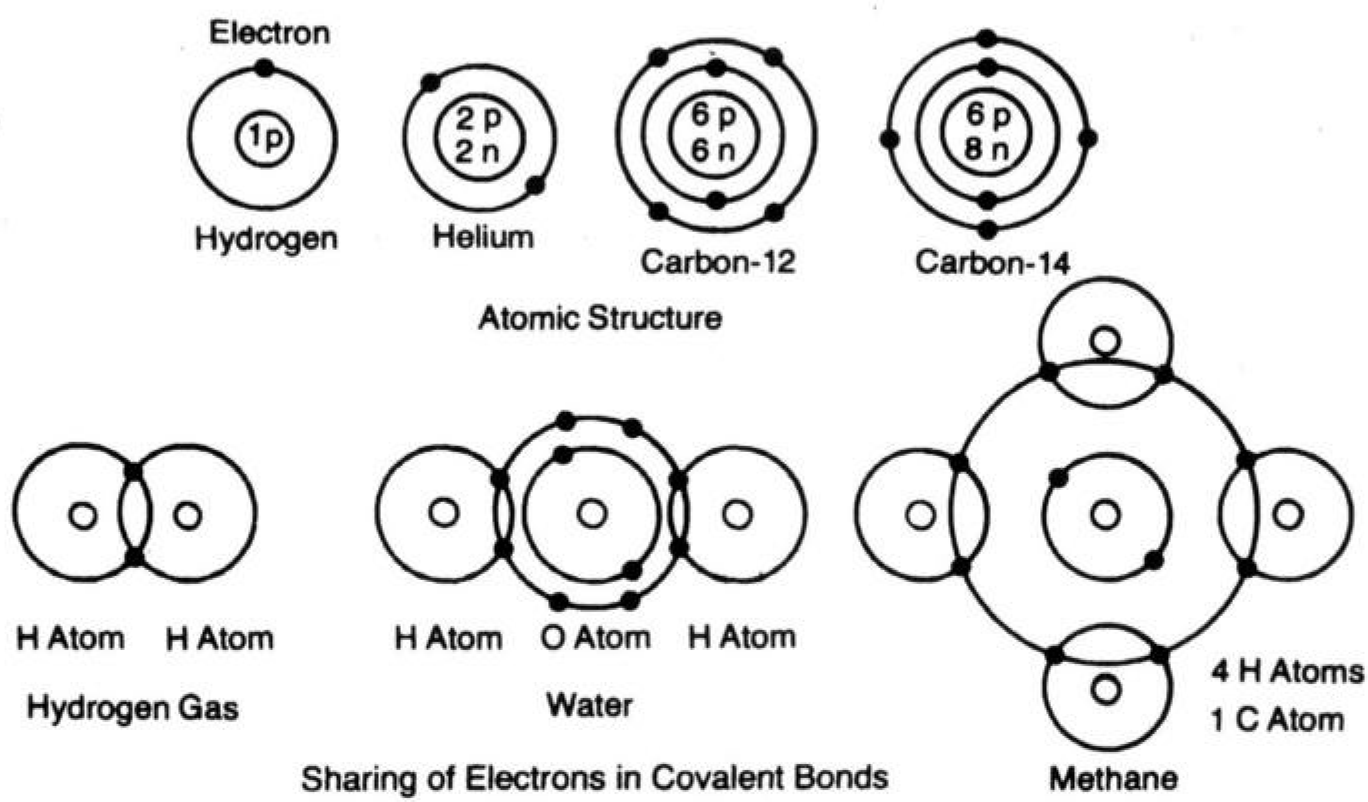
Cellular Energy

All particles in the environment of the cell contain energy of motion (kinetic energy). As these particles collide with the plasma membrane, they may pass through by slipping between the lipid molecules making up the membrane. Because no cellular energy is expended in this absorption process, it is known as passive transport. Diffusion is a form of passive transport in which a dissolved substance passes through the plasma membrane from a region of higher relative concentration to a region of lower relative concentration of that substance. The diffusion of water molecules into or out of the cell (through the plasma membrane) is known as osmosis.

Some cells are capable of expending cellular energy in order to pump materials into (or out of) themselves from regions of lower relative concentration to regions of higher relative concentration. Because cellular energy must be expended to accomplish this process, it is known as active transport. The plasma membrane may be involved in active transport through the use of special carrier proteins embedded in the membrane's lipid layers. These carrier proteins take advantage of the specific chemical nature of desired components by attaching to them and carrying them through the membrane to the cytoplasm.

IV. CHEMISTRY OF LIVING ORGANISMS

Many organic and inorganic substances dissolved in cells allow necessary chemical reactions to take place in order to maintain life. Large organic food molecules such as proteins and starches must initially be broken down (digested to amino acids and simple sugars, respectively) in order to enter cells. Once nutrients enter a cell, the cell will use them as building blocks in the synthesis of compounds necessary for life. The same chemical elements that comprise the Earth's crust, water, and atmosphere also make up the bodies of living things. However, the proportion of elements in living matter is different from the proportion of elements in nonliving matter. Living things are made up of relatively large percentages of the elements carbon (chemical symbol C), hydrogen (chemical symbol H), oxygen (chemical symbol 0), and nitrogen (chemical symbol N). Elements found in lower percentages include sulfur (chemical symbol S), phosphorus (chemical symbol P), magnesium (chemical symbol Mg), iodine (chemical symbol I), iron (chemical symbol Fe), calcium (chemical symbol Ca), sodium (chemical symbol Na), chlorine (chemical symbol Cl), and potassium (chemical symbol K).



Atomic Structures and Covalent Bonding

Compounds

Compounds are substances composed of two or more different elements bound together chemically. The bonds holding these compounds together may be ionic (involving the transfer of electrons between atoms) or covalent (involving the sharing of electrons between atoms). [Note: The chemistry of bonding is not a required understanding for Biology-The Living Environment. For details on this topic, consult a chemistry textbook.]

Two broad categories of compounds exist in nature: inorganic and organic compounds. All organic compounds contain the elements carbon and hydrogen. Inorganic compounds may contain any of Earth's elements but rarely contain carbon and hydrogen together. Living things are composed of both inorganic and organic compounds.

Inorganic Compounds

Inorganic compounds commonly found in living things include the following.

- Water-Living things consist of 60 to 98 percent water, which acts as a medium for transport and for chemical activities within the cell.

- Salts-Salts are chemicals composed of metallic and nonmetallic ions combined by ionic bonds. They are important for maintaining osmotic balance in the cell and for supplying ions necessary for many of the cell's chemical reactions.

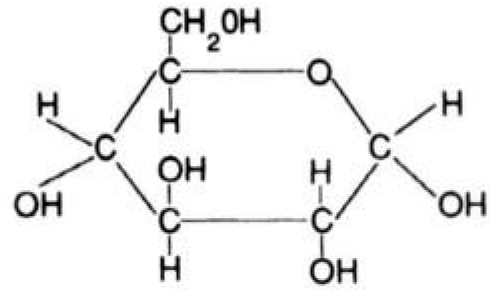
- Acids and bases-These compounds are important for maintaining the proper balance of hydrogen ion concentration (acidity/alkalinity) in the cell.

Organic Compounds

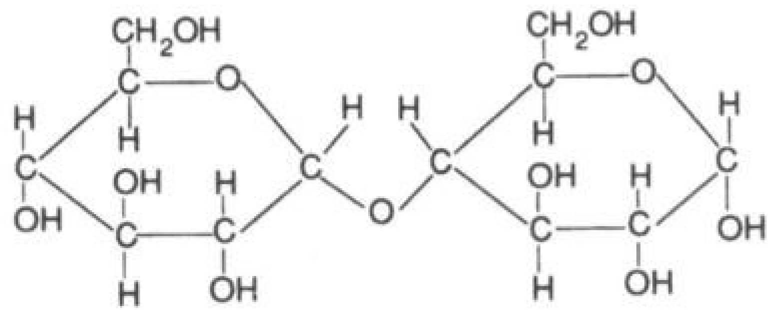
Organic compounds commonly found in living things include the following.

- Carbohydrates are organic compounds and so contain the elements carbon and hydrogen. In addition, they contain the element oxygen. Carbohydrates generally contain hydrogen and oxygen in the ratio of 2:1. This ratio differs from that found in other organic compounds. Like many organic compounds, carbohydrates are actually formed around a skeleton of carbon atoms linked together in a chain. Some chains are quite short (six or fewer carbon atoms), while others are very long (thousands of carbon atoms).

  The simplest stable carbohydrate is the monosaccharide (simple sugar). Monosaccharides form around a chain of 5 or 6 carbon atoms. An example of a monosaccharide is the simple sugar glucose, whose chemical formula is C6H1206. Glucose is the basic chemical unit of nearly all the more complex carbohydrates. A more complex form of carbohydrate is the disaccharide (double sugar), composed of two chemically linked monosaccharide molecules. Disaccharides are commonly formed around a chain of 12 carbon atoms. The chemical process by which this linkage occurs is dehydration synthesis. The atoms making up water molecules are removed from the monosaccharide molecules and the two monosaccharides join to form a single disaccharide molecule. Examples of disaccharides are maltose and sucrose. A complex form of carbohydrate is known as a polysaccharide (many sugar). It forms by chemically combining many monosaccharide molecules via dehydration synthesis. The chain of monosaccharide units forming a polysaccharide may be thousands of units long and may be highly branched. Starch (amylose), glycogen, and cellulose are examples of polysaccharides.

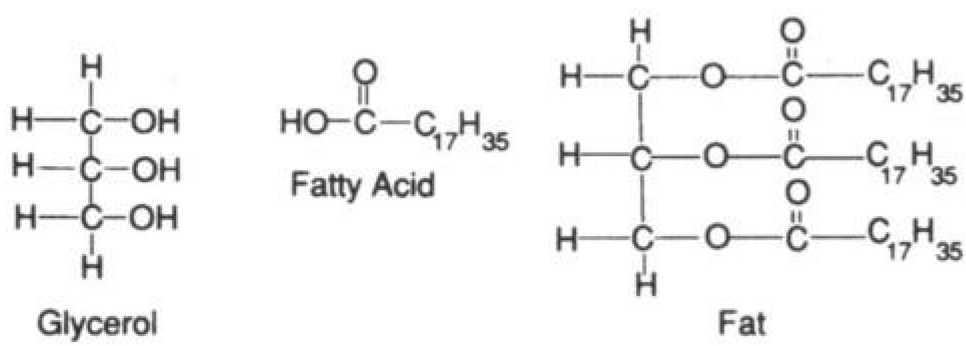


Structural Formula: Glucose



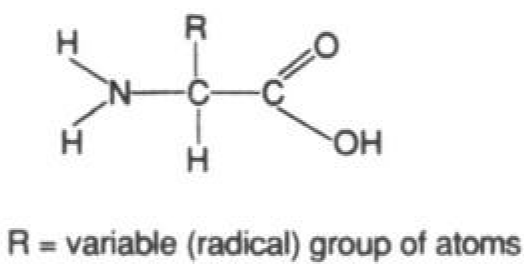
Structural Formula: Maltose

• Lipids are composed of the elements carbon, hydrogen, and oxygen. Many of the more common lipids, known as triglycerides, are constructed of a unit of glycerol (a three-carbon alcohol) combined chemically via dehydration synthesis with three molecules of fatty acid (a hydrocarbon chain with an attached carboxyl group). Examples of lipids include animal fats, plant oils, and waxes.

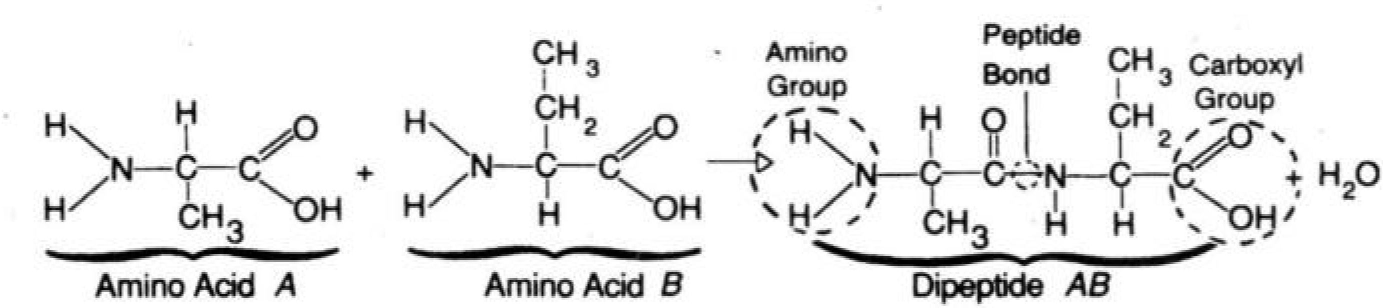


Structural Formula: Lipid

• Proteins contain the elements carbon, hydrogen, and oxygen, as do carbohydrates and lipids. In addition, proteins contain a substantial proportion of nitrogen. Certain proteins may also contain sulfur. Proteins are polymers made up of repeating units of other, simpler compounds known as amino acids. Although there are more than 20 different types of amino acids, they all share a common general structure. All amino acids contain an amino group (-NH2) and a carboxyl group (-COOH) attached to a central carbon atom. A third attached group (radical) varies and gives each type of amino acid its unique properties. Two amino acid molecules may be joined together chemically by dehydration synthesis to form a dipeptide. The term peptide refers to the name of the actual chemical bond between carbon and nitrogen atoms (C-N) that joins the two amino acid units together. As more and more amino acids link together by dehydration synthesis, an amino acid chain, known as a polypeptide, is formed. Polypeptide chains form the basis of protein molecules. Because of the almost endless variations in which amino acids may be arranged in a polypeptide, proteins form in thousands of different forms. The extreme variability of proteins is thought to be responsible for the individual variations in living things. Examples of proteins are structural proteins and enzymes. See below for additional information about the mechanisms of protein synthesis.



Structural Formula: Amino Acid

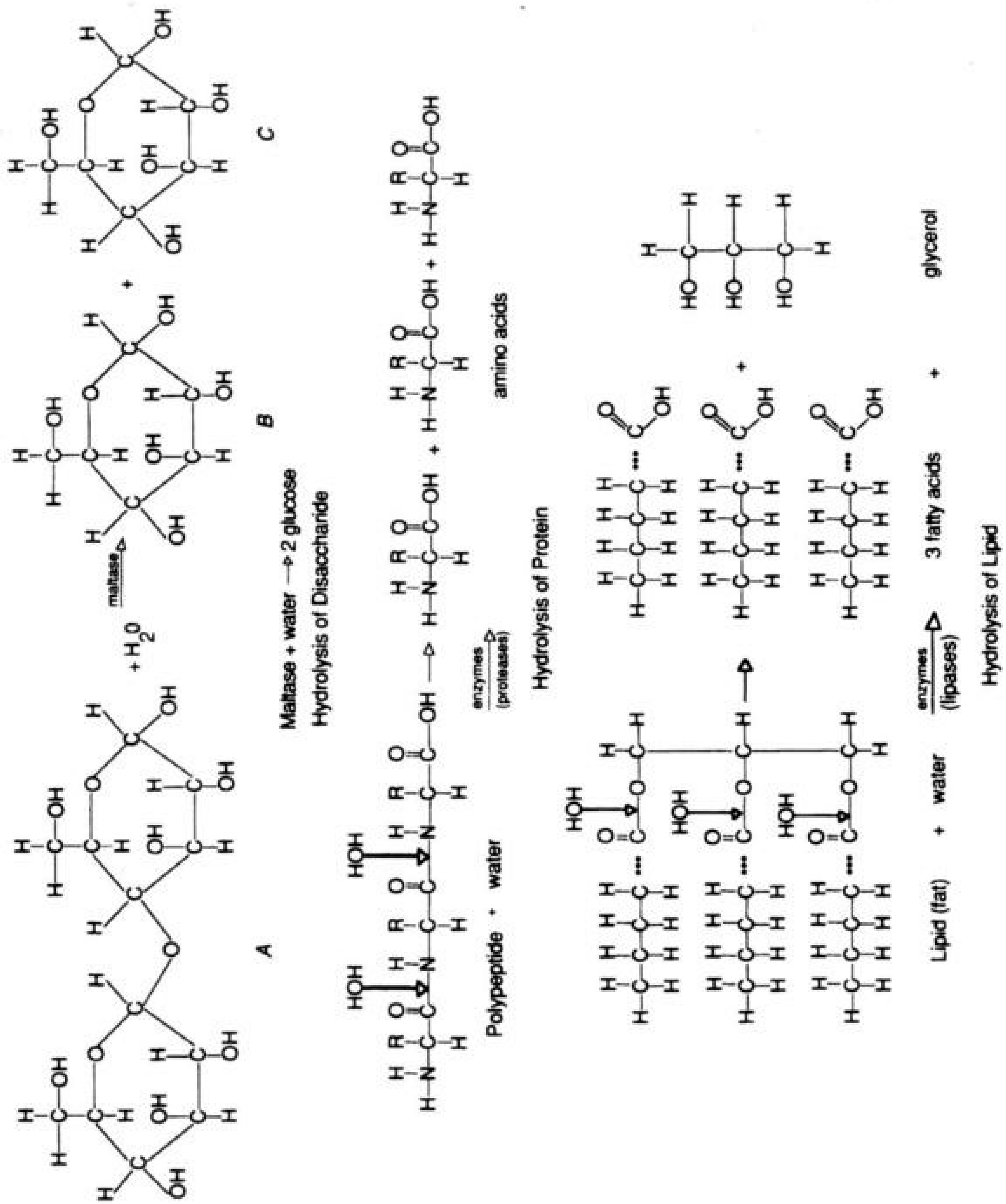


Structural Formula: Dipeptide Formation

- Nucleic acids are extremely complex polymers that function to determine the characteristics of individual cells and thereby the characteristics of the entire organism of which they are a part. Principal nucleic acids include deoxyribonucleic acid (DNA) and ribonucleic acid (RNA). Nucleic acids are polymers composed of a simpler chemical subunit known as a nucleotide. Thousands of these units comprise a single DNA molecule, making DNA one of the largest and most complex of all organic compounds. DNA exists in hundreds of thousands of different forms, depending on the precise arrangement of nucleotides in the molecule. Its variability and its role in protein synthesis are the keys to genetic variation in living things. DNA nucleotides themselves are quite complex. They are composed of three separate subunits: phosphate group, deoxyribose, and one of four nitrogenous bases, including adenine, thymine, cytosine, and guanine. DNA's function in the cell is to code for the production of specific protein types in the cell. This function is discussed in more detail in the section "Genetic Material."

When taken into the body as food, complex food molecules such as starches, proteins, fats, and nucleic acids must be broken down into their simpler chemical subunits before they can be used by the living cell. These large molecules cannot pass readily through the plasma membrane, but their smaller, soluble subunits can. The act of breaking down these complex molecules is known as chemical digestion and is accomplished by the chemical process of hydrolysis. Hydrolysis (splitting with water) involves replacing existing chemical bonds within a complex molecule with the atoms comprising a water molecule, thereby breaking the complex molecule apart at those points and producing simpler molecules. The following word equations will illustrate this process:

$$\begin{aligned}
&\text{starch} + N\ \text{water} \longrightarrow N\ \text{glucose}\\
&\text{maltose} + \text{water} \longrightarrow 2\ \text{glucose}\\
&\text{lipid} + 3\ \text{water} \longrightarrow \text{glycerol} + 3\ \text{fatty acids}\\
&\text{protein} + N\ \text{water} \longrightarrow N\ \text{amino acids}
\end{aligned}$$



Hydrolysis

The end products of hydrolysis are as follows:

Complex Food Molecules	**Molecular End Products**
Carbohydrates (starches, double sugars)	Simple sugars
Lipids (fats, oils)	Fatty acids and glycerol
Proteins	Amino acids
Nucleic acids	Nucleotides

Cell Organelles

Inside the cell, a variety of specialized structures, formed from many different molecules, carry out the transport of materials (cytoplasm), extraction of energy from nutrients (mitochondria), protein building (ribosomes), waste disposal (cell membrane), storage (vacuole), and information storage (nucleus). Living cells are extremely complex structural and functional units. The major cell organelles and their functions are described below.

- Plasma (cell) membrane-the outer membrane of the cell, which regulates the transport of materials into and out of the cell. The cell membrane serves as the interface between the cell and its environment, and ultimately controls the nature of the cell's internal environment. See pages 99-100 for additional information concerning the structure and function of the plasma membrane.

- Cytoplasm-a watery medium for the suspension of cell organelles and the circulation of soluble material throughout the cell. The cytoplasm also serves as the site for many of the cell's chemical reactions.

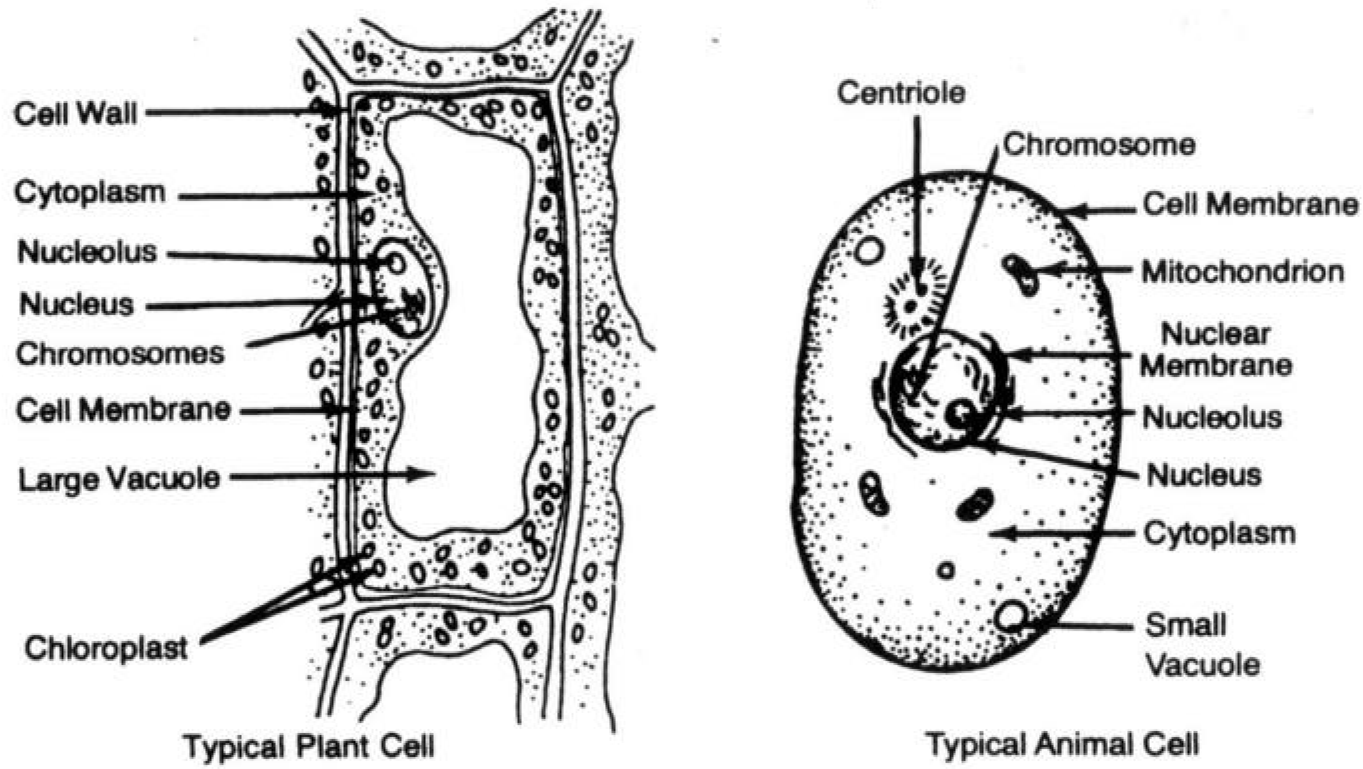
- Nucleus-a spherical organelle, usually located near the center of the cell, that contains the cell's genetic information in the form of chromosomes. The nucleus allows the free transfer of that genetic information during synthesis and reproduction.

- Ribosome-a small, dense organelle that serves as a site for the manufacture of protein molecules within the cell. The ribosome may be attached to the endoplasmic reticulum or may be floating free in the cytoplasm.

- Mitochondrion-a small organelle that contains the enzymes necessary to allow the cell to perform certain aspects of chemical respiration.

- Vacuole-a membrane-bound organelle containing water, enzymes, and other substances. The vacuole may serve to store food molecules, nonremovable wastes, or secretion products.

- Nucleolus-a small organelle, located within the nucleus, that functions in the cell's synthesis mechanism. It forms ribosomes involved in the manufacture of proteins.



Plant Versus Animal Cells

- Endoplasmic reticulum-a series of intracellular membranes that functions in the cell's synthesis mechanism. It houses ribosomes, accepts manufactured proteins, and transports these proteins to the plasma membrane for incorporation into the membrane or for secretion to the cell exterior.

- Golgi complex-a series of membrane-bound organelles that functions in the cell's synthesis mechanism. It accepts manufactured proteins and transports these proteins to the plasma membrane for incorporation into the membrane or for secretion to the cell exterior.

- Lysosome-a specialized vacuole that aids nutrition by carrying digestive enzymes and by merging with food-containing vacuoles. The lysosome may also help to recycle aging or defective cells.

- Centriole-a cylindrical structure, found primarily in animal cells, that apparently functions in the process of cell division.

- Chloroplast-a chlorophyll-containing structure, found primarily in plant and algae cells, in which the chemical reactions of photosynthesis occur.

- Cell wall-a structure, found primarily in plants, that provides mechanical support and protection for the cell.

Cellular Interaction

Receptor molecules play an important role in the interactions between cells. Two primary agents of cellular communication are hormones and chemicals produced by nerve cells. If nerve or hormone signals are blocked, cellular communication is disrupted and the organism's stability is affected.

Receptor molecules are specialized proteins embedded in the plasma membrane. These receptor proteins are able to capture specific types of molecules that come into contact with the membrane and move them to the cell interior. Once inside the cell, these captured molecules can affect the behavior of the cell if they have the capacity to do so. Two types of molecules that have this capacity are hormones and neurotransmitters.

- Hormones are biochemicals produced and secreted by endocrine glands. Each hormone exerts its effect on specific target tissues in the body. In order to be absorbed by the individual cells of a target tissue, these neurotransmitters must be captured by receptor molecules and moved into the cell interior. Endocrine glands are located far from the tissues that they affect, and they have no tubes to connect them to these tissues. For this reason, endocrine glands are known as ductless glands. Since no ducts carry them, hormones are distributed to other parts of the body by means of the circulatory fluid.

- Neurotransmitters are biochemicals produced and secreted by the neuron's terminal branches. They carry the nerve impulse from one neuron to the next. An example of such a neurotransmitter is acetylcholine. In order to be absorbed by the dendrites of a subsequent neuron, these neurotransmitters must be captured by receptor molecules and moved into the cell interior.

Because these chemicals function in controlling the body's metabolic processes, they are essential in maintaining homeostatic balance. When an endocrine gland fails to produce its hormone in appropriate quantities, the life process controlled by it does not operate properly. This can lead to organ or system failure. It may even threaten the survival of the entire organism. For example, if the pancreas malfunctions and causes insulin production to cease, then blood sugar is not converted to glycogen. This will cause the sugar concentration to build in the blood until it reaches dangerous levels. Tissues throughout the body may be affected, but some, such as kidney tissues, may be destroyed and cease to function. If the kidneys fail, then the bloodstream has no way to cleanse itself, and all the body's tissues will be damaged or destroyed.

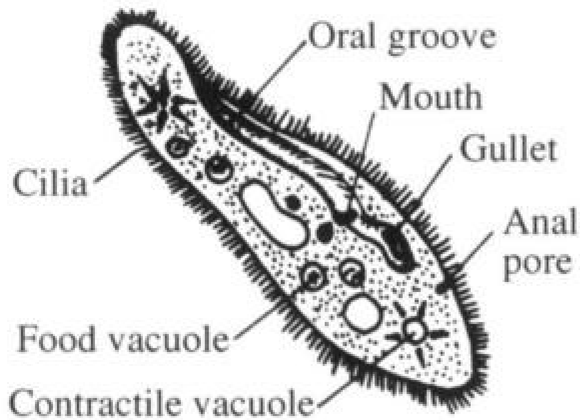
Unicellular Life Forms

Performance Indicator 1.3 The student should be able to explain how a one-celled organism is able to function despite lacking the levels or organization present in more complex organisms.

The structures present in some single-celled organisms act in a manner similar to the tissues and systems found in multicellular organisms. This enables single-celled organisms to perform all of the life processes needed to maintain homeostasis. Some organisms are simple unicellular protists. Their physical structure is made up of a single cell that is able to function independently by carrying on all the life functions. While these protists exist in nature in the millions, a few species are well-known to scientists. These include the paramecium and the ameba. The paramecium is a slippershaped protist that inhabits freshwater environments. One of the largest of the paramecia, at nearly 400 micrometers

(400 millionths of a meter), is Paramecium caudatum. Its organelles function efficiently to allow the organism to thrive in its environment.

- Nutrition depends on the oral groove and food vacuoles. The oral grooves allow the paramecium to ingest food particles. The food vacuoles permit the digestion of these particles to a simple chemical form that can be used by the cell. Egestion is accomplished by means of the anal pore.



Paramecium

- Transport is accomplished by means of the plasma membrane and the cytoplasm, which permit the absorption and circulation of materials.

- Respiration takes place in the mitochondrion, which contains the enzymes needed to release energy from food molecules.

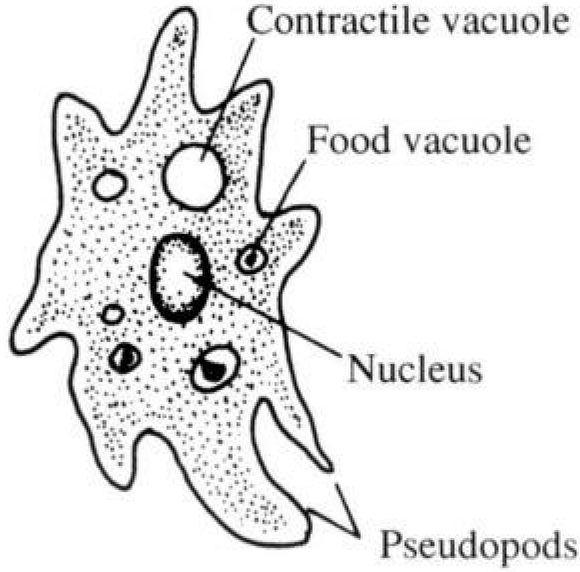
- Excretion of metabolic wastes occurs directly though the plasma membrane. A specialized organelle, the contractile vacuole, expels excess water from the cell.

- Regulation is the function of the nucleus, which manufactures proteins that control the cell's metabolic activities.

- Locomotion is accomplished in paramecia by cilia that sweep in a coordinated motion to propel the cell through the watery environment.

The ameba is also a relatively large freshwater protozoan but lacks a defined shape. The ameba is also successful in its environment because it contains structural adaptations on the organella level that allow it to carry on the basic life functions efficiently.

- Nutrition is aided by the pseudopods and food vacuoles. The pseudopods allow the ameba to ingest food particles. The food vacuoles permit the digestion of these particles to a simple chemical form that can be used by the cell. Egestion is accomplished by means of reverse pinocytosis at the cell membrane.



Ameba

• Transport is accomplished by means of the plasma membrane and the cytoplasm, which permit the absorption and circulation of materials.

• Respiration takes place in the mitochondrion, which contains the enzymes needed to release energy from food molecules.

• Excretion of metabolic wastes occurs directly though the plasma membrane.

• Regulation is the function of the nucleus, which manufactures proteins that control the cell's metabolic activities.

• Locomotion is accomplished in ameba by the use of pseudopods, which flow forward on a solid surface to propel the cell through its environment.

QUESTION SET 2.4-CELL ORGANELLES, BIOCHEMISTRY, UNICELLULAR LIFE FORMS (ANSWERS EXPLAINED, P. 285)

1. Which structures could most likely be observed in cells in the lowpower field of a compound light microscope?

   (1) cell walls and chloroplasts

   (2) ribosomes and endoplasmic reticula

   (3) lysosomes and genes

   (4) nucleotides and mitochondria

2. What would most likely happen if the ribosomes in a cell were not functioning?

(1) The cell would undergo uncontrolled mitotic cell division.

(2) The synthesis of enzymes would stop.

(3) The cell would produce antibodies.

(4) The rate of glucose transport in the cytoplasm would increase.

3. Which activity is illustrated in the diagram below?

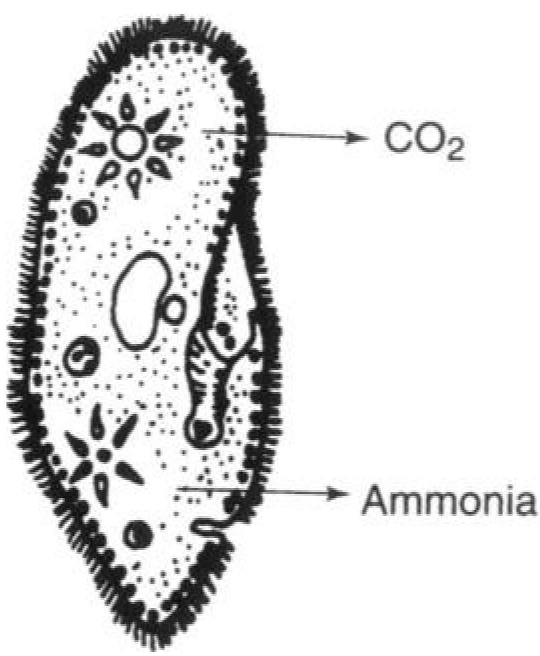
(1) a virus destroying a cell by extracellular digestion

(2) a member of the bryophyte phylum performing intercellular digestion

(3) a protozoan ingesting food during heterotrophic nutrition

(4) a lysosome egesting a food particle into the cytoplasm

4. Which activity is represented by the arrows in the diagram below?



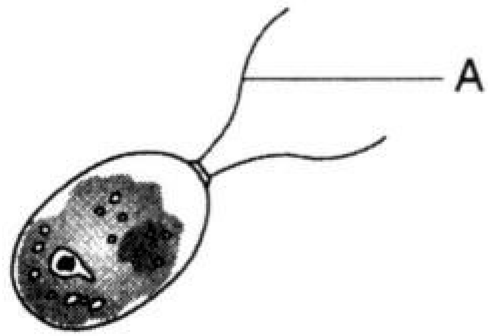
(1) anaerobic respiration

(2) autotrophic nutrition

(3) deamination of amino acids

(4) excretion of metabolic wastes

5. The diagram below represents a green alga.



Which process is most closely associated with structure A?

(1) excretion

(2) transport

(3) locomotion

(4) reproduction

6. Which formula represents an organic compound?

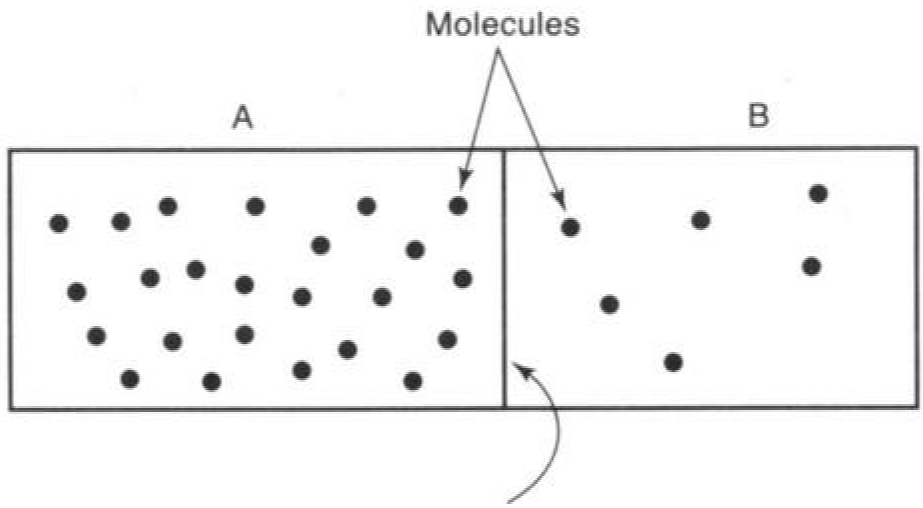
(1) Mg(OH)2

(2) NaCl

(3) C12H22011

(4) NH3

7. The diagram below shows the same type of molecules in area A and area B. With the passage of time, some molecules move from area A to area B.



Selectively Permeable Membrane

The movement is the result of the process of

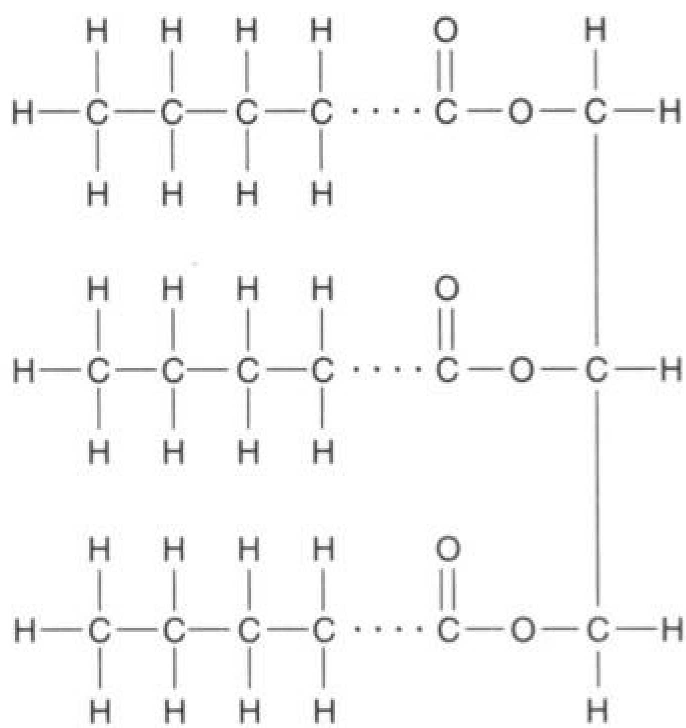
(1) phagocytosis

(2) pinocytosis

(3) diffusion

(4) cyclosis

8-9 Base your answers to questions 8 and 9 on the structural formula of a molecule below and on your knowledge of biology.



8. Which statement best describes this molecule?

(1) It has the ability to control heredity.

(2) It has the ability to control reactions.

(3) It has a high energy content.

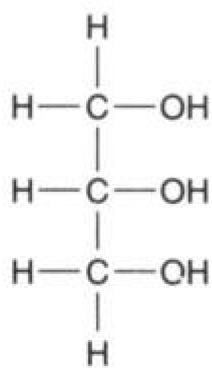
(4) It is involved in photosynthesis.

9. Which formula represents an end product derived from the chemical digestion of this molecule?

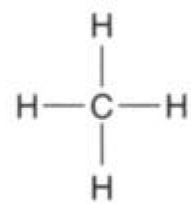
(1) O=C=O

(3) H—O—H

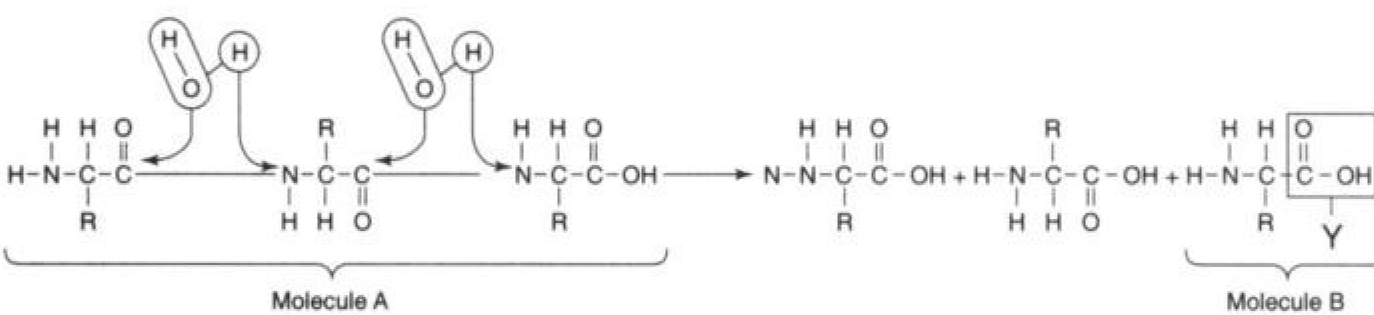
(2)



(4)



10-11 Base your answers to questions 10 and 11 on the diagram below and on your knowledge of biology.



10. In molecule B, what type of group is contained in box Y?

(1) an amino group

(2) a variable group

(3) a carboxyl group

(4) a peptide group

11. How many peptide bonds are present in molecule A?

(1) 1

(2) 2

(3) 3

(4) 4

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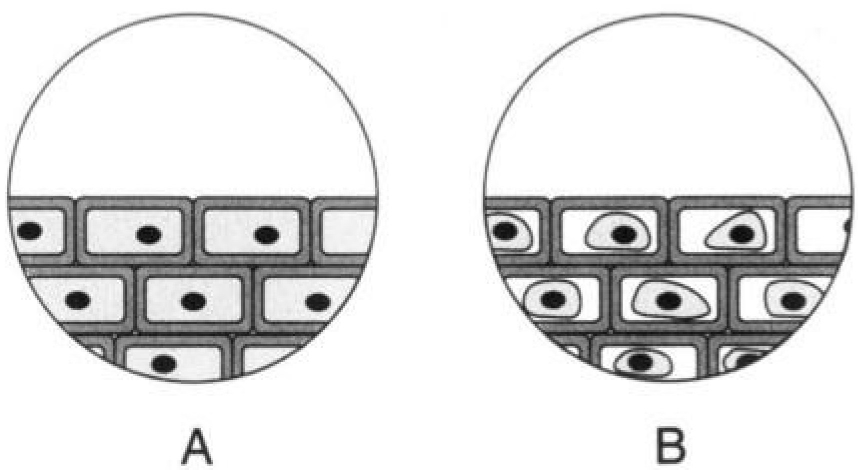
12. A student observed a wet mount of some stained plant cells in the high power field of a compound light microscope. Diagram A represents the general appearance of these cells. The student then added several drops of a liquid to the wet mount and continued the observations. Diagram B represents the general appearance of the cells a few minutes after adding the liquid.



The liquid that the student added to the wet mount was most likely

(1) salt water

(2) distilled water

(3) pond water

(4) tap water

V. GENETIC CONTINUITY

KEY IDEA 2.--GENETIC CONTINUITY Organisms inherit genetic information in a variety of ways that result in continuity of structure and function between parents and offspring.

A significant unifying principle of biology is the concept that all living organisms possess a set of instructions, in the form of genes, that determine the characteristics of the organisms. These instructions are unique to the species. They determine the general physical and biochemical traits of the group. They are also unique to the individual, coding for the specific set of characteristics that sets one individual organism apart from all others of that species. Students should be familiar with the mechanisms by which genetic traits are passed from generation to generation to maintain genetic continuity of the species. You must also gain familiarity with the molecular basis of genetics. You must know how this basis is used to maintain genetic continuity and how it changes through recombination, mutation, and genetic engineering.

You should be familiar with the mechanism by which DNA replicates its structure during normal cell operations and in the process of reproduction. You .must also understand the roles of DNA and RNA in the coding of cell-specific proteins and understand the role of these structural and functional proteins (enzymes, hormones, and other substances) in the operation of the cell.

Humans have long used their understanding of heredity to breed new plant and animal varieties selectively as well as to maintain hybrid varieties. Students should appreciate the economic role that these activities have played over the past centuries as well as the scientific basis of such activities. A relatively new branch of science, genetic engineering, has taken on an increasingly important and visible place in the scientific community. You should understand and appreciate this concept and make informed judgments as to the ethical considerations surrounding such research.

Genetic Material

Performance Indicator 2.1 The student should be able to explain how the structure and replication of genetic material results in offspring that resemble their parents.

Genes are inherited, but their expression can be modified by interactions with the environment. Genetic traits are determined largely through the precise information found in the cell's gene structure. Although this information provides a basis for each individual organism's characteristics, it is not the only force at work in shaping the actual phenotype. Another major force in shaping the final phenotype is the environment in which the gene has to operate. A variety of factors in the environment can actually alter the effects of a particular gene. Some examples of this effect are as follows.

- Effect of light on chlorophyll production-Although most plants have the genetic ability to produce chlorophyll, they will do this only in the presence of light. Without light, these plants produce only a light-yellow pigment and therefore appear pale and sickly until they are exposed to sunlight. After a few days of exposure to sunlight, the chlorophyll production mechanism is enabled and green color returns.

- Effect of temperature on hair color in the Himalayan hare-In their native Arctic environment, Himalayan hares have white body hair with black hair on their extremities. However, when raised in warm climates, they are entirely white. In exploring this phenomenon, scientists shaved off some hair from the hare's back (normally white) and strapped an ice pack onto the bare skin. Under these experimental conditions, the hare's hair grew back black, indicating the role of environmental temperature on the production of hair color in this species.

Every organism requires a set of coded instructions for specifying its traits. For offspring to resemble their parents, information must be reliably transferred from one generation to the next. Heredity is the passage of these instructions from one generation to another. As scientists have continued their study of genetics, they have learned more and more of the details of the mechanisms of genetics. In one of the most significant discoveries in genetic science, deoxyribonucleic acid (DNA) was revealed to be the chemically active agent of the gene. As is now known, DNA replicates itself when chromosomes replicate in the early stages of cell division. DNA is passed from generation to generation during reproduction and acts as genetic factors. DNA interacts with the cell's chemical factory and produces the observable effects of the phenotype when genes are inherited by a cell or an organism. DNA regulates the production of enzymes in the cell and thereby enables the cell to perform the complex cellular chemical reactions necessary to sustain life.

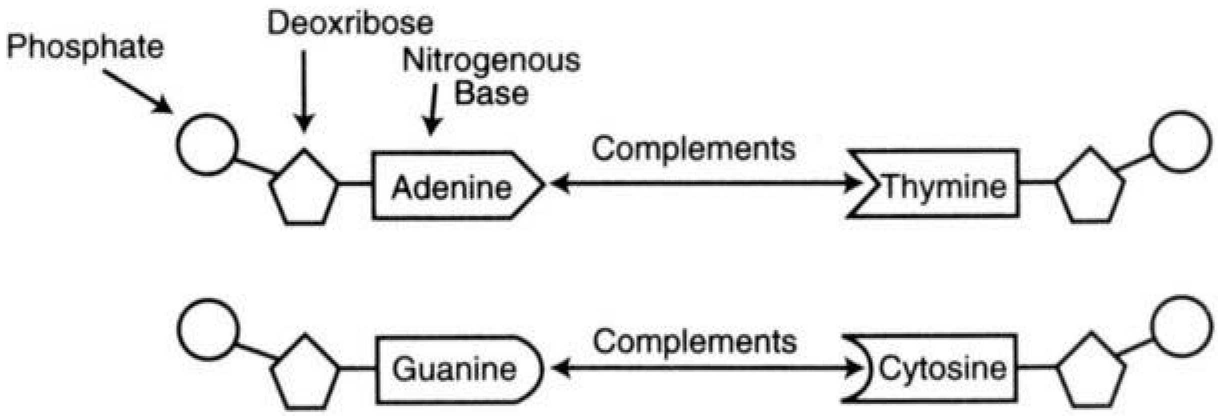
DNA Structure

In order to understand the role of DNA in the maintenance of genetic continuity, you must first understand the currently accepted model of the DNA structure. DNA is a polymer made up of a repeating chemical unit known as the nucleotide. Thousands of these units are known to comprise a single DNA molecule, making DNA one of the largest of all organic compounds. DNA exists in hundreds of thousands, if not millions, of different forms, depending on the precise arrangement of nucleotides in the molecule. Its variability is the key to genetic variation in living things. DNA nucleotides themselves are quite complex, being composed of three separate subunits.

- Phosphate group-a chemical group made up of phosphorus and oxygen.

- Deoxyribose-a five-carbon sugar made up of carbon, oxygen, and hydrogen.

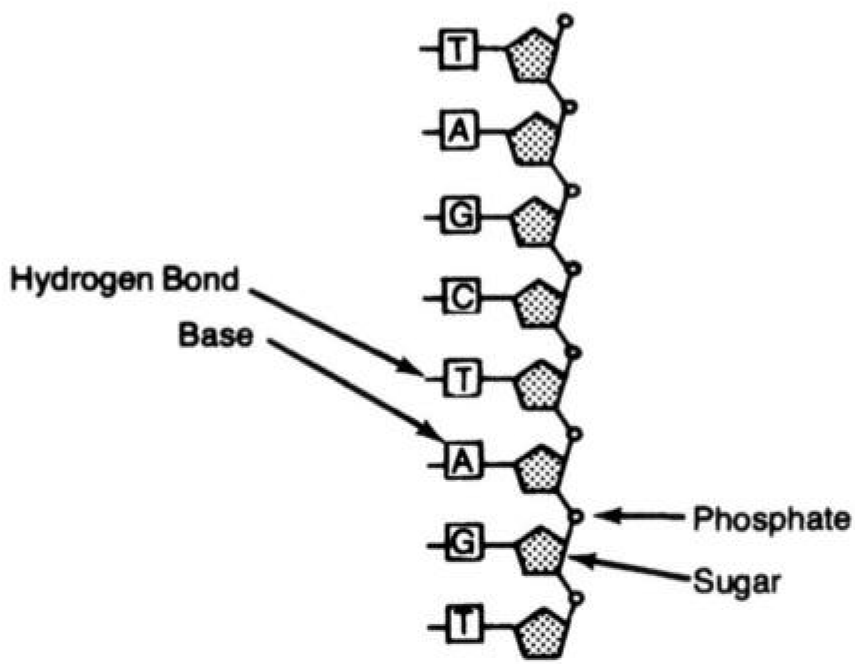
- Nitrogenous base-a chemical unit composed of carbon, oxygen, hydrogen, and nitrogen. Bases found in DNA are adenine (A), thymine (T), cytosine (C), and guanine (G). In chemical terms, the bases A and T are complementary as are the bases C and G.



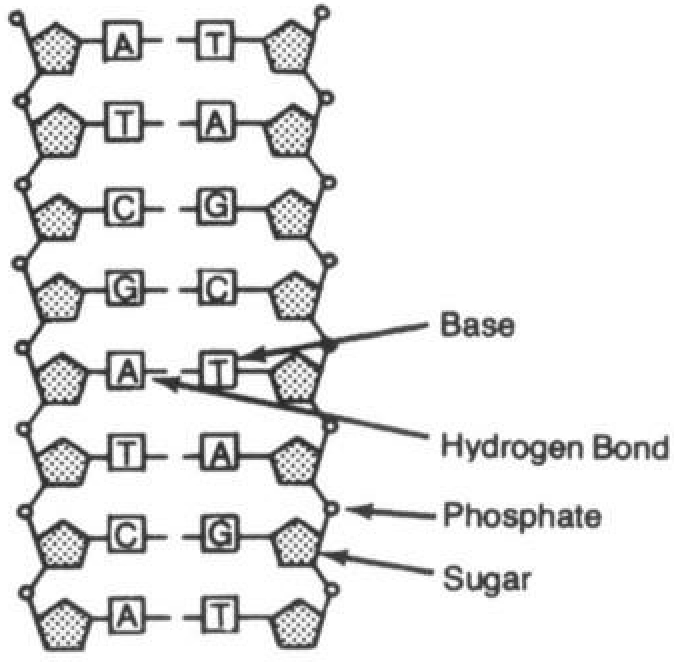
Complementary Nucleotides (DNA)

The Watson-Crick model, developed by James Watson and Francis Crick, is an attempt to describe the physical and chemical structure of DNA in a way that would explain its known characteristics, including its ability to replicate. Watson and Crick's model was developed using the best experimental evidence available at the time and involves the following points.

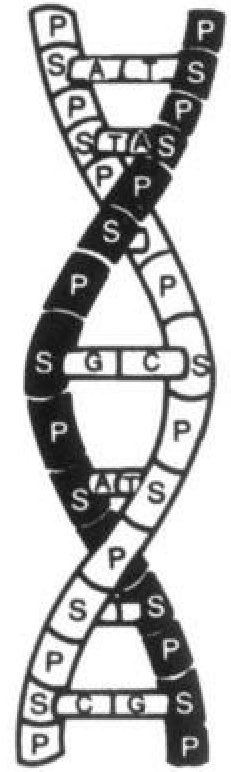
- Nucleotide units are joined end to end, forming a long chain of alternating deoxyribose and phosphate units with nitrogenous bases sticking out on one side of the chain. The specific arrangement of nitrogenous bases on the chain makes up the genetic code.



DNA: Single Strand



DNA Model



DNA Helix

DNA: Double Strand

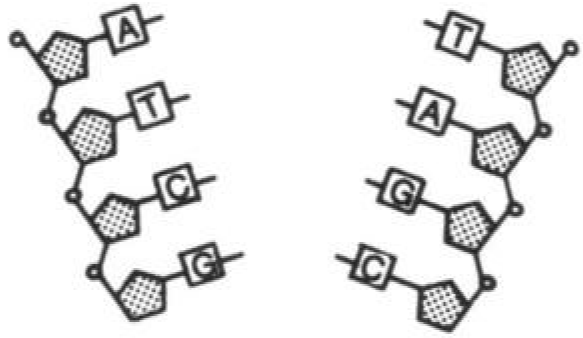
- A second chain, with complementary nitrogenous bases, is aligned with the first, forming a ladderlike molecule. In this formation, the repeating sugar and phosphate units form the uprights of the ladder, while the pairs of linked nitrogenous bases form the rungs connecting the two strands.

- The nitrogenous bases paired to form the ladder rungs are always adenine to thymine (A-T) and cytosine to guanine (C-G). The bases are held together by weak hydrogen bonds.

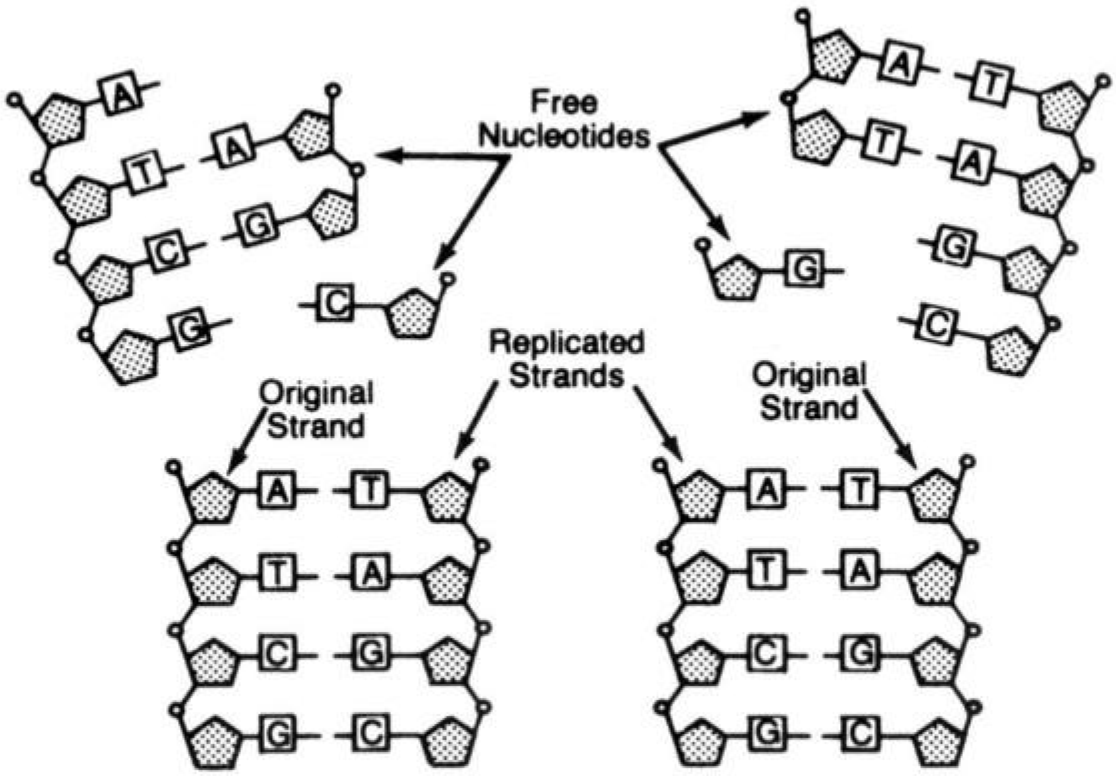
- Finally, the double strands of DNA twist around each other to form a "double helix," or "twisted ladder," shape.

The processes that occur during cell division provide a reliable mechanism for transferring this genetic code from one generation to the next. Of central importance in these processes is the process of DNA replication. Replication is the exact self-duplication of the genetic material in the early stages of cell division. Chromosome replication is actually a function of the replication of the DNA making up the chromosome strand. DNA replication is thought to occur as follows.

- The two strands of the DNA molecule separate by unzipping between pairs of nitrogenous bases.



DNA Replication: Phase I



DNA Replication: Phase II

- Unbound nucleotides floating freely in the cytoplasm are attracted to and incorporated into the unzipped portion of the DNA molecule. In the building process that follows, complementary nucleotides are attracted to each other to ensure that the new strands produced are exact duplicates of the original strands.

- When the unzipping process is complete and all bonding sites are filled with free nucleotides, two identical DNA molecules result; these are free to separate into two chromosome strands.

The Role of Genes in Heredity

Hereditary information is contained in genes, located in the chromosomes of each cell. An inherited trait can be determined by one or by many genes, and a single gene can influence more than one trait. A human cell contains many thousands of different genes in its nucleus. Hereditary factors known as genes are thought to exist as discrete portions (known as loci) of chromosomes. The term "discrete" in this case refers to the concept that genes are always located at the same point (or locus) on a chromosome. It is believed that pairs of homologous chromosomes contain linear, matching arrangements of genes exerting parallel control over the same traits. Pairs of genes that exercise such parallel control over the same traits are known as alleles. The control mechanism used by genes in genetic inheritance is now thought to be chemical in nature and is described in greater detail below.

Genetic characteristics can be extremely complex and may require the actions of several separate genes to be expressed in the adult organism. Examples of traits that require more than a single pair of genes to be expressed are human height and human hair color. Other traits may be controlled by a single pair of genes. Some of these traits may have extreme phenotypes, such as albinism (lack of skin pigment) in humans.

Mapping of the human genome is a project that has intrigued scientists for many years. As of this writing, it has been completed in draft form, with many years of research still necessary to confirm the locations and actions of all human genes. Among the pieces of data to be determined from this project is an exact count of the total number of separate genes found on human chromosomes. The number will certainly be in the thousands. Each of these genes codes for the production of a different, unique protein. Each protein has a separate and distinct function to perform in the cell.

Cell Division

In asexually reproducing organisms, all the genes come from a single parent. Asexually produced offspring are normally genetically identical to the parent. Asexual reproduction involves the production of a new organism of a species from a cell or cells of a single parent organism. This is made possible by a type of cell division known as mitotic cell division. In this type of cell division, the nucleus is duplicated, followed by the splitting of a single cell or group of cells. This results in the production of more cells with characteristics identical to those of the single parent organism.

The Cell Theory states that "all cells arise from preexisting cells by cell division." The type of cell division involved is known as mitotic cell division and involves two distinct stages.

- Mitosis is a precise duplication of the contents of the parent cell nucleus followed by an orderly separation of those contents into two new, identical nuclei. The events of mitosis are as follows.

  > Replication (exact self-duplication) of each chromosome strand in the nucleus of the parent cell. This results in the doubling of each chromosome strand to form double-stranded chromosomes. Each of the two strands of a double-stranded chromosome is known as a chromatid. Chromatids are chemically identical to each other and carry identical genetic information. These chromatids are held together by a centromere.

  > Disappearance of the nuclear membrane surrounding the chromosomes.

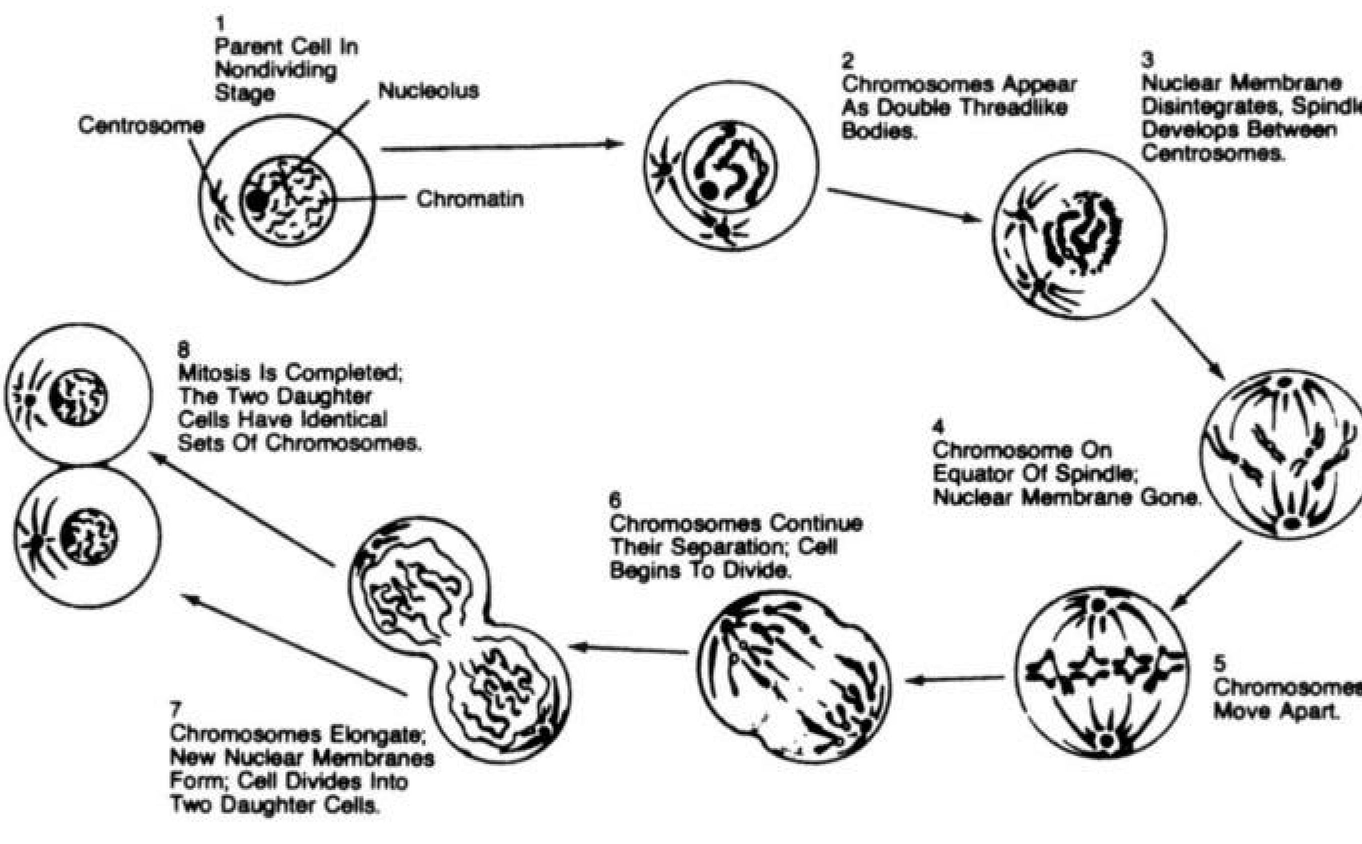
  > Appearance of the spindle apparatus, a series of fibers that attach to the double-stranded chromosomes at the centromere during the early stages of mitosis.

> Replication of the centromere of each double-stranded chromosome. This is followed by separation of the two chromatids of the doublestranded chromosomes to form single-stranded chromosomes.

> Migration of the single-stranded chromosomes along the spindle apparatus toward opposite ends of the cell. The chromatids in each pair separate in this stage of mitosis, allowing a full set of singlestranded chromosomes to migrate to each pole.

> Reformation of the nuclear membrane around the chromosomes grouped at the ends of the cell. These two daughter nuclei are identical to each other and to the parent cell nucleus in terms of the number and type of chromosomes as well as in the particular genetic information found within these chromosomes. The significance of mitosis is the exact duplication of the parent nucleus.

- Cytoplasmic division is the separation of the two new nuclei into two new daughter cells as the cytoplasm of the parent cell divides. After the formation of the daughter nuclei, the cytoplasm of most (though not all) cells is divided into two roughly equal portions, each enclosing one of the daughter nuclei. The daughter cells will grow and eventually go through the cycle of mitotic cell division themselves. The mechanisms governing this cytoplasmic division are not fully understood but are known to occur differently in different types of organisms. For example, in plants and animals, mitosis occurs in much the same way as described above. However, in animals, the centriole is known to function in the formation of the spindle apparatus. In plants, the spindle forms without the presence of a centriole. In animals, cytoplasmic division is accomplished by the formation of a constriction that separates the two daughter cells. In plants, the division of the cytoplasm occurs after the formation of a cell plate.



Mitosis

Reproduction

A common element of asexual reproduction is the fact that offspring produced by this mechanism are genetically identical to the parent organism. See the section "Mechanisms of Reproduction" for additional information on asexual reproductive patterns.

In sexually reproducing organisms, the new individual receives half of the genetic information from its mother (via the egg) and half from its father (via the sperm). Sexually produced offspring often resemble, but are not identical to, either of their parents. Sexual reproduction involves the production of a new offspring organism from the fusion of two sex cells, known as gametes, each of which is contributed by a different parent organism. It is made possible by a special kind of cell division known as meiotic cell division. In this type of cell division, the genetic information is halved. It is restored to its full complement during fertilization.

Diploid and Monoploid Explained

Each body cell of an organism contains a number of chromosomes characteristic of the species. This number is known as the diploid chromosome number. The term "diploid" refers to the fact that the chromosomes in the nucleus are found in pairs with similar structure. These chromosome pairs are known as homologous chromosomes; they carry genes for the same traits. The symbol 2n is used to represent the diploid chromosome number. In gametogenesis (formation of gametes), cells located in the sex organs (gonads) undergo a special type of cell division (meiotic cell division) that results in the formation of sperm cells (in males) or egg cells (in females). In this process, the number of chromosomes is reduced by half. This reduced number of chromosomes is known as the monoploid chromosome number and is represented by the symbol n.

Because each parent contributes 50 percent of the genetic information to the offspring, the offspring resemble, but do not look exactly like, the parents. See the section "Mechanisms of Reproduction" for additional information concerning meiosis, fertilization, and sexual reproduction.

DNA Code

In nearly all organisms, the coded instructions for specifying the characteristics of the organism are carried in DNA, a large molecule formed from subunits arranged in a sequence with bases of four kinds (represented by A, G, C, and T). The chemical and structural properties of DNA are the basis for how the genetic information that underlies heredity is both encoded in genes (as a string of molecular bases) and replicated by means of a template. Recall that DNA is a complex organic molecule composed of thousands of repeating nucleotide molecules and that each free nucleotide carries with it one of four nitrogenous bases. The particular sequence of nitrogenous bases adenine, thymine, cytosine, and guanine (A, T, C, and G) comprising a strand of DNA provides the type of chemical code that is understood by the chemical mechanisms of the cell. The DNA code is used by these mechanisms to manufacture specific enzymes and other proteins through the process of protein synthesis. A DNA strand provides a template (pattern) for the formation of messenger RNA (mRNA). The DNA code is transcribed (read) by mRNA as the latter is synthesized in a pattern complementary to the DNA strand.

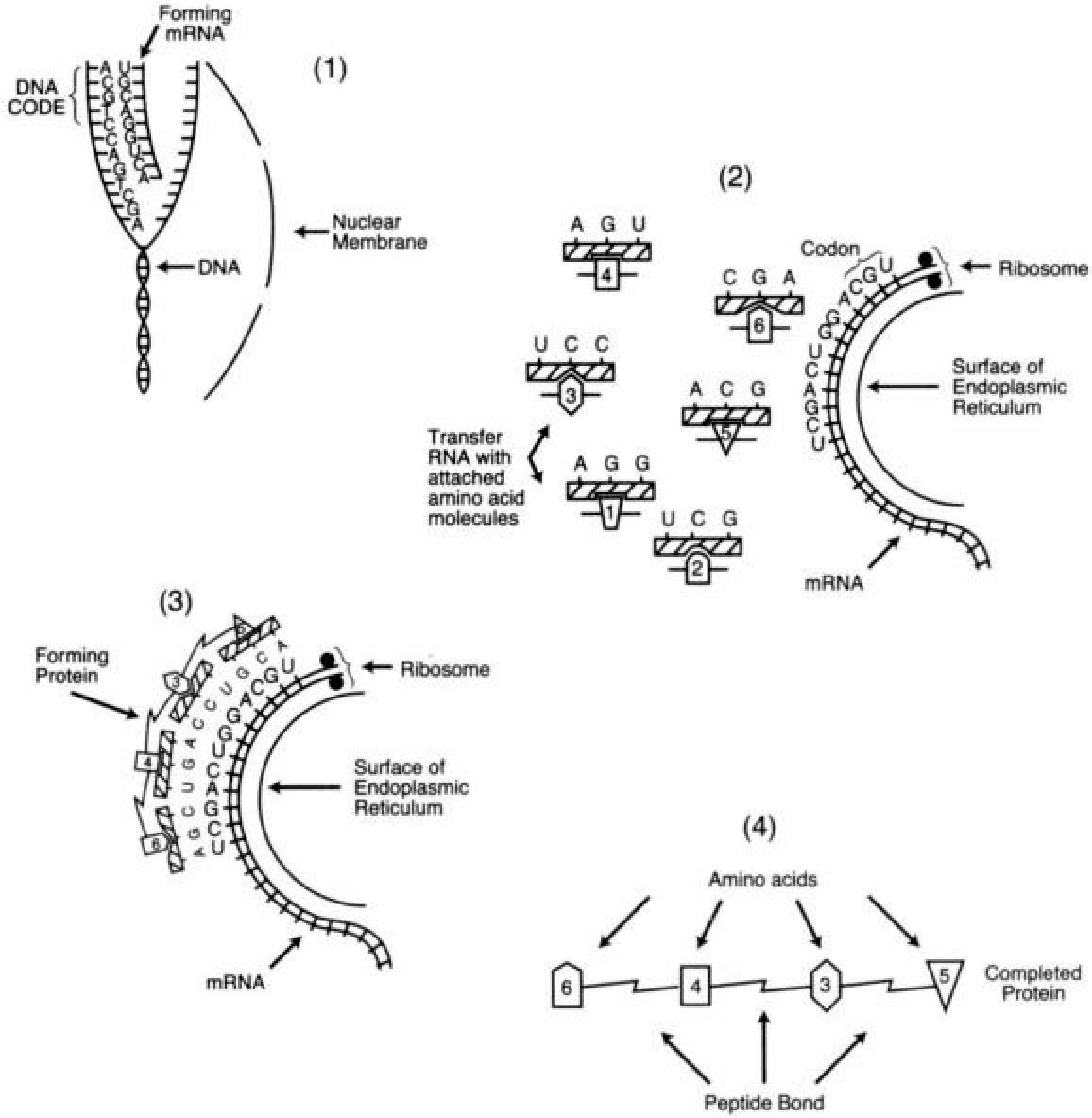
Each group of three nitrogenous bases, known as a triplet codon, provides the information necessary to code for the insertion of a single, specific amino acid into a building protein molecule. The particular sequence of triplet codons on DNA (and transcribed to mRNA) enables amino acids to be linked together in a specific sequence during protein synthesis.

Cells store and use coded information. The genetic information stored in DNA is used to direct the synthesis of the thousands of proteins that each cell requires. The cell contains many thousands of such codes in its chromosomes. Each strand of DNA in the chromosome has the potential to provide the complete chemical code for the manufacture of at least one complete protein. These proteins are highly specific. They result in the expression of some specific trait or portion of a trait in the living cell and, consequently, in the organism of which they are a part.

Protein Synthesis

The actual process of protein synthesis begins when mRNA moves out of the nucleus where it was formed and attaches to a ribosome. The ribosome acts as the site of protein synthesis in the cell. The codon sequence of the mRNA provides a pattern upon which a new polypeptide (protein) strand will be built.

Transfer RNA (tRNA) molecules function by attaching to specific amino acids in the cytoplasm. The tRNA molecules then transport these amino acids to the ribosome for addition to a growing chain of amino acids. Each codon on the mRNA provides the specific information necessary for the placement of each such amino acid in the chain. The result of this process is the synthesis of a particular, specific polypeptide chain.



DNA provides the genetic code to produce new proteins in the cell *(1)*. Messenger RNA (mRNA) reads this code by forming a strand complementary to the DNA strand *(1)*. Once formed, the mRNA travels to the cytoplasm, where it associates with a ribosome *(2)*. Transfer RNA molecules (tRNA), carrying specific amino acid molecules, attach to the mRNA at specific locations, forming a chain of amino acids known as a polypeptide *(3)*. The polypeptide separates from the mRNA, allowing additional copies to be made *(4)*.

Protein Synthesis

One-Gene-One-Polypeptide Hypothesis

Each gene in the cell's nucleus contains the coded information required to synthesize a single polypeptide chain. A particular gene is believed to operate throughout the life of the cell to produce its specific polypeptide and only that polypeptide. This concept is known as the one-gene-one-polypeptide hypothesis. The modern concept of the gene defines it as that sequence of nucleotides and codons in a molecule of DNA necessary to code for a complete polypeptide chain.

Gene Mutations

Genes are segments of DNA molecules. Any alteration of the DNA sequence is a mutation. Usually, an altered gene will be passed on to every cell that develops from it. Gene mutations may be defined as being any changes in the nitrogenous base sequence of a molecule of DNA. When the base sequence of DNA is altered, the amino acid sequence of the polypeptide for which it codes will likewise be altered. Such an alteration may affect the operation of the resulting enzyme, preventing it from properly catalyzing its reaction and thus preventing a trait from being expressed by the cell. The majority of gene mutations are harmful because they result in the cell being impaired from performing some specific task. In most cells, the corresponding allele continues to function, and the cell continues its activities unaffected. In rare cases, a mutation may result in a lethal gene that kills the cell either by producing a substance toxic to the cell or by failing to produce a protein of vital importance to the cell.

Gene mutations are passed on to every cell that arises from the mutated cell. If the mutation occurs in somatic (body) tissues, its effect is limited to the tissues immediately surrounding the mutated cell. If the mutation occurs in a primary sex cell, it can be passed on to the offspring that result from fertilization of or by the gametes produced from that primary sex cell. In the latter case, a mutation can enter the gene pool of a population and be passed on to succeeding generations. This is now known to be a cause of variation in a species.

Amino Acids

The work of the cell is carried out by the many different types of molecules it assembles, mostly proteins. Protein molecules are long, usually folded chains made from 20 different kinds of amino acids in a specific sequence. This sequence influences the shape of the protein. The shape of the protein, in turn, determines its function. Proteins are compounds made up of repeating units of other compounds known as amino acids. Although there are 20 different types of amino acids, they all share a common general structure. All amino acids contain an amino group (-NH2) and a carboxyl group (-COOH) attached to a central carbon atom. A third attached group (radical) varies and gives each type of amino acid its unique properties. Two amino acid molecules may be joined together chemically by dehydration synthesis to form a dipeptide. The term "peptide" refers to the name of the actual chemical bond between carbon and nitrogen atoms that joins the two amino acid units together. As more and more amino acids link together by dehydration synthesis, an amino acid chain, known as a polypeptide, is formed. Polypeptide chains form the basis of protein molecules. Because of the almost endless variations in which amino acids may be arranged in a polypeptide, proteins are formed in thousands of different forms. The extreme variability of proteins is thought to be responsible for the individual variations in living things. Examples of proteins are structural proteins and enzymes.

The functions of proteins may be classified as either structural (forming a part of the cell material) or functional (having a role in the chemistry of the cell). A few common examples of proteins are insulin (a hormone), hemoglobin (an oxygen-carrying pigment in red blood cells), and enzymes (organic catalysts).

Offspring resemble their parents because they inherit similar genes that code for the production of proteins that form similar structures and perform similar functions. We have learned that DNA's principal role in the cell is to code for the production of specific polypeptides. Each enzyme or structural protein synthesized by a cell has a specific function to perform. These functions comprise the characteristics, or traits, of the cell. It follows logically, then, that the individual traits that a cell displays are a function of the particular combinations of DNA found in its cells. The particular combination of these traits gives an organism its individuality that enables us to recognize them as individual organisms. The following diagram will help to illustrate this concept.

DNA → gene → polypeptide → enzyme → reaction → reaction product → trait

Within this individuality, certain traits resemble those of the parent organisms, illustrating the genetic continuity that links one generation to the next. Species traits are similar enough for us to recognize an individual organism as part of a species group but particular enough for us to recognize family similarities and individual characteristics.

Differentiation

The many body cells in an individual can be very different from one another. This occurs even though they are all descended from a single cell and thus have essentially identical genetic instructions. This is because different parts of these instructions are used in different types of cells and are influenced by the cell's environment and past history. All cells in an individual multicellular organism arise by mitotic cell division from a single parent cell, the zygote. All cells in the body therefore receive the same genetic information. Despite this, the body contains many specific tissue types, many highly specialized to perform a narrow range of tasks. The process at work to produce different cells that perform different functions is differentiation. Differentiation is how cells become specialized into tissues to perform the various tasks needed to keep the body functioning. This will be discussed in more depth in the section "Mechanisms of Reproduction." It is mentioned here to illustrate the hypothesis that a gene will operate in the cell only when its polypeptide is required by the activities of the cell and that at other times the gene is switched off. In fact, considerable evidence has accumulated that points to just such a concept. Only the genes specific to the activities of a specific cell type are activated in that cell. This concept maximizes the efficiency of the cell. The cell's protein synthesis mechanisms are not overloaded producing enzymes and structural proteins that have no direct function in the specialized cells in which they operate. For example, human muscle tissues must produce the proteins actin and myosin that make up the muscle cell's contractile apparatus. Therefore, the genes for the production of these proteins are switched on in muscle cells. At the same time, the genes that code for the production of hemoglobin are switched off in muscle cells since hemoglobin, which is required in red blood cells, would not be needed in muscle cells.

Genetic Engineering

Performance Indicator 2.2 The student should be able to explain how the technology of genetic engineering allows humans to alter the genetic makeup of organisms.

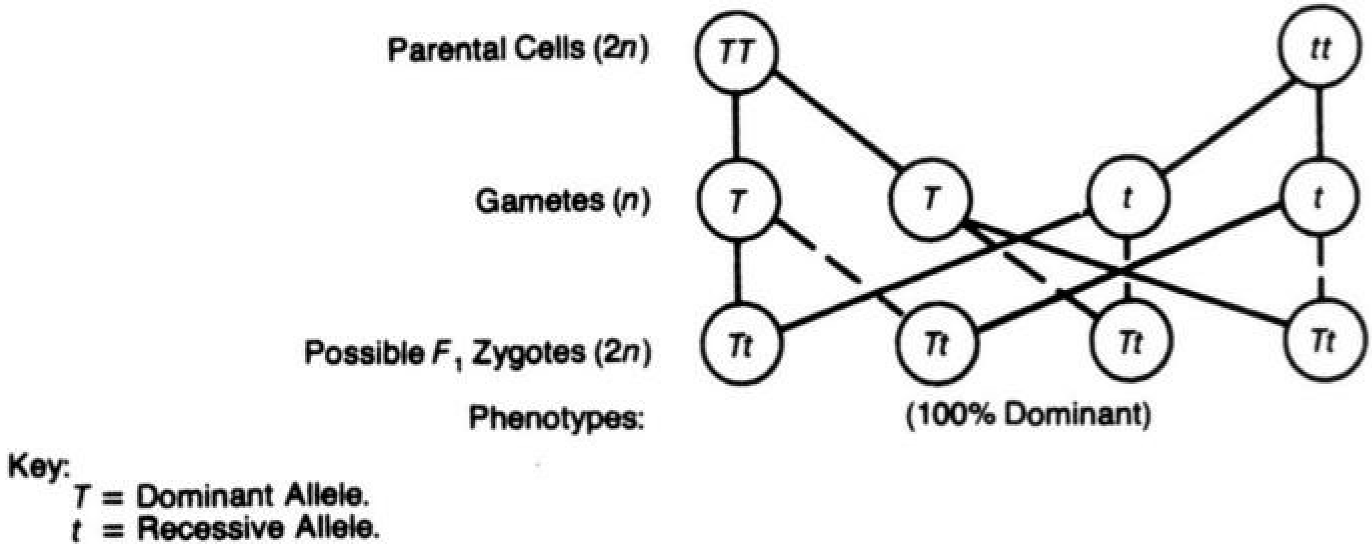
For thousands of years, new varieties of cultivated plants and domestic animals have resulted from selective breeding for particular traits. Geneticists have applied many of the theoretical concepts of the science of genetics to the practical areas of plant and animal breeding. Many of the most productive plant and animal breeds raised for human uses have been developed through careful artificial selection of breeding individuals, crossbreeding (hybridization) between related varieties, and inbreeding of perfected strains to maintain established traits. Such traits as reproductive potential, resistance to disease, adaptability to climate, and productivity, among others, are considered desirable traits for human uses. These and other traits are purposely bred into grains (corn, wheat), flowers (roses, orchids), fruits (apples, oranges), cattle, horses, dogs, and many other species. They are maintained by careful attention to breeding patterns.

In the past, crude methods were used to mate members of a species displaying desirable traits in the hopes that some of the offspring of such a mating would display enhanced characteristics of the desired type. When desirable offspring were obtained, the hybrid animals or plants were crossbred in an attempt to produce a pure-breeding strain of the desired variety.

Genetic Patterns

Students should be familiar with the fundamental principles of genetics. Some of the major genetic patterns are as follows.

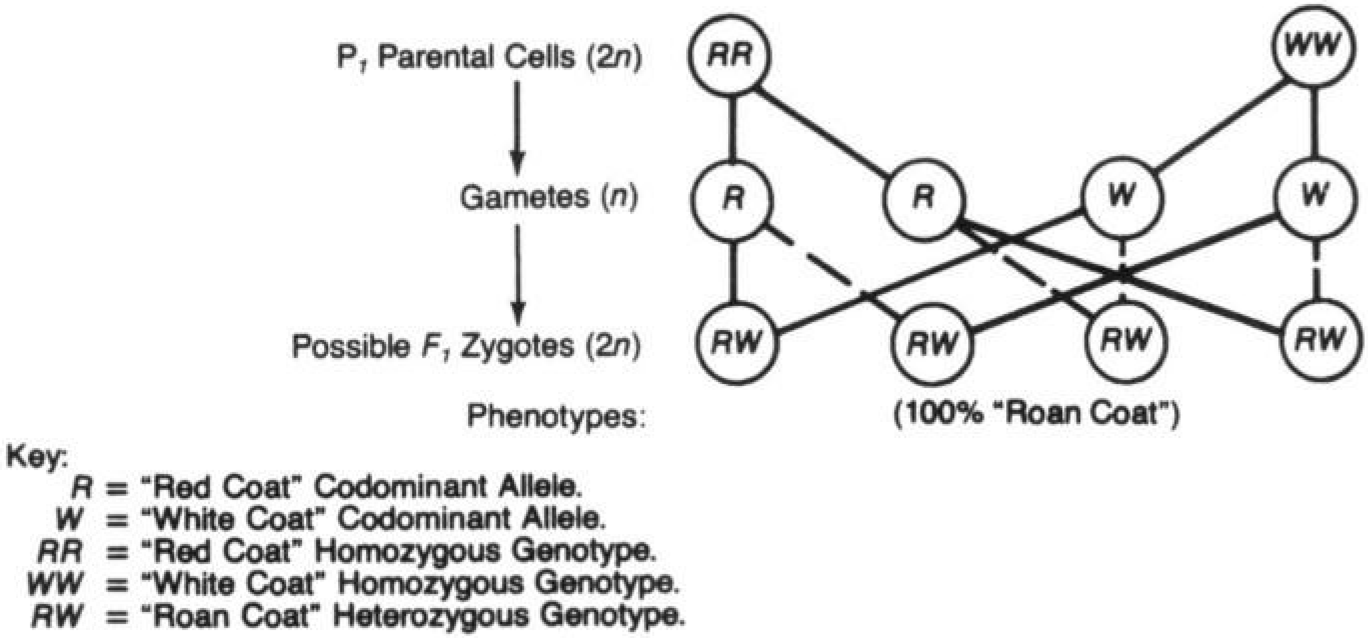
Dominance The principle of dominance was first described by Gregor Mendel in his classic studies of inheritance patterns. When genes of certain allelic pairs have contrasting effects on the same trait, only one may be expressed, while the other is masked. The expressed gene in this case is known as the dominant allele; the masked gene is the recessive allele. Imagining what a gene is like and how it works is sometimes difficult. To make it easier to visualize the gene and to work out problems of genetic inheritance, scientists use symbols to represent genes. In working with genetic problems, certain conventions in the use of these symbols are followed to ensure that that the results are readily understood. In dominance problems, dominant alleles are usually symbolized by a capital italic letter, while the recessive allele for the same trait is normally assigned the same italic letter in lowercase. In the garden pea, the allele for tall stem is dominant over the allele for short stem. The letter commonly designated for the tall allele is T; the letter designation for the short allele is t. When a zygote is formed, inheriting the dominant gene T from one parent and the recessive gene t from the other parent will result in a tall stem in the offspring.



Dominance

Segregation and recombination During meiosis, the chromosomes in each pair of homologous chromosomes separate from each other to form two monoploid sets of chromosomes. The exact pattern formed in this separation is entirely random in each sex cell and represents only one of many possible combinations. As homologous chromosomes separate, the genes in each allelic pair located on these homologous chromosomes also separate. The random separation of alleles into sex cells during meiosis is known as segregation. In the process of fertilization, two monoploid nuclei fuse to form a diploid nucleus. This process recombines pairs of homologous chromosomes and the pairs of alleles located on them that were separated during meiosis. Recombination is also entirely random, bringing together pairs of genes from two different organisms with different histories of genetic inheritance and forming new allelic combinations. The randomness of recombination is an important aspect of variation in sexually reproducing species.

Intermediate inheritance Certain genetic traits do not show a clear pattern of dominance or recessiveness but rather a blending of phenotypes of the parents. Such traits are classified as intermediate inheritance traits. One type of intermediate inheritance is codominance, As its name implies, this results from the simultaneous expression of two dominant alleles. Since neither allele is recessive, neither can be easily masked. So both are expressed in the phenotype of the offspring. If the parents of such a codominant individual are homozygous (contain two identical alleles for the trait in question) and show contrasting phenotypes for the trait, then all their offspring will be heterozygous (contain two different alleles for the trait in question) and display an intermediate phenotype.



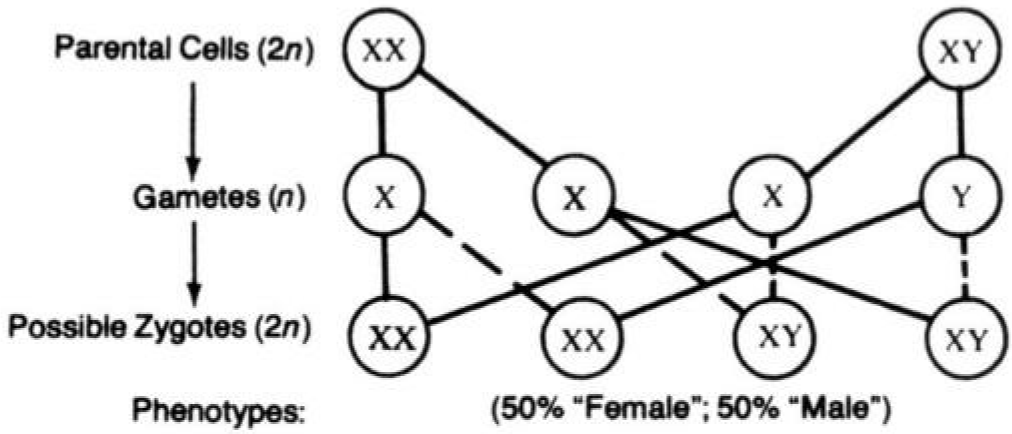
Intermediate Inheritance

Independent assortment Genes located on different (nonhomologous) chromosomes are free to separate from each other in a random fashion during meiosis. Traits controlled by genes located on separate chromosomes are inherited independently of each other in the same random fashion. This mechanism, known as independent assortment, is a major source of genetic variation in living things.

Gene linkage When genes for different traits are located on the same chromosome, they are normally inherited together and so are referred to as being linked. Gene linkage accounts for the fact that such traits as red hair and freckles are frequently found to be inherited together.

Multiple alleles Some traits have hereditary patterns that do not seem to fit the rules of simple two-gene inheritance. Some may be described by a model of gene action involving three or more alleles for the trait in question. This genetic pattern is known as multiple alleles. In such a pattern, only two of .the three alleles may be present in any one cell. This must be true since such cells would have been formed by normal fertilization, involving fusion of two monoploid nuclei, each containing only one type of each allele. For example, the ABO blood group is controlled by the alleles IA, IB, and i.

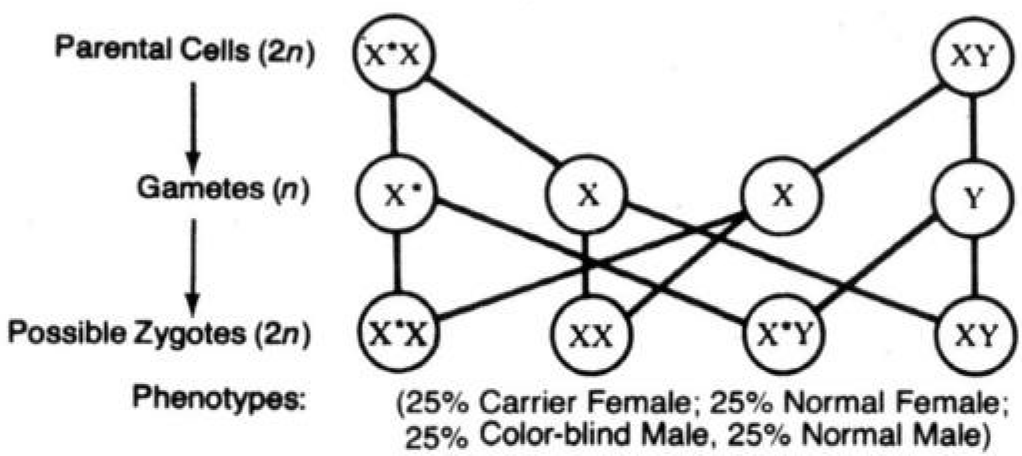
Sex determination The diploid cells of most sexually reproducing species contain two different types of chromosomes. The chromosomes that contain genes controlling most body traits are known as autosomes. One pair is known to contain the genes controlling traits having to do with sex differences (maleness and femaleness). These chromosomes are known as sex chromosomes. In human beings, the diploid number of chromosomes is 46 (23 homologous pairs). Of these, 22 pairs are autosome pairs. The remaining pair is a pair of sex chromosomes known as the X and Y chromosomes. Normally, each diploid human cell contains two of these chromosomes. Females have XX, males have XY. (Note that the combination YY cannot occur.)



Key:
X = X Sex Chromosome.
Y = Y Sex Chromosome.
XX = Female Homologous Chromosome Pair.
XY = Male Homologous Chromosome Pair.

Sex Determination

Sex linkage Some genetic traits are controlled by alleles located on the X sex chromosome only. No corresponding allele can be found on the Y sex chromosome. Such traits are known as sex-linked traits and display a unique inheritance pattern. The relative frequency of sex-linked recessive traits in human males is due to the fact that no normal dominant gene is present on the Y chromosome to mask the effects of the recessive gene. Therefore, males who inherit the single recessive gene will display the trait, whereas the females who inherit only a single recessive gene will not display the trait. Such female individuals are known as carriers of the trait.



Key:
X = Normal X Sex Chromosome.
X* = Carrier X Sex Chromosome.
Y = Normal Y Sex Chromosome.
XX = "Normal Female" Homologous Chromosome Pair.
X*X = "Carrier Female" Homologous Chromosome Pair.
XY = "Normal Male" Homozygous Chromosome Pair.
X*Y = "Color-blind Male" Homologous Pair.

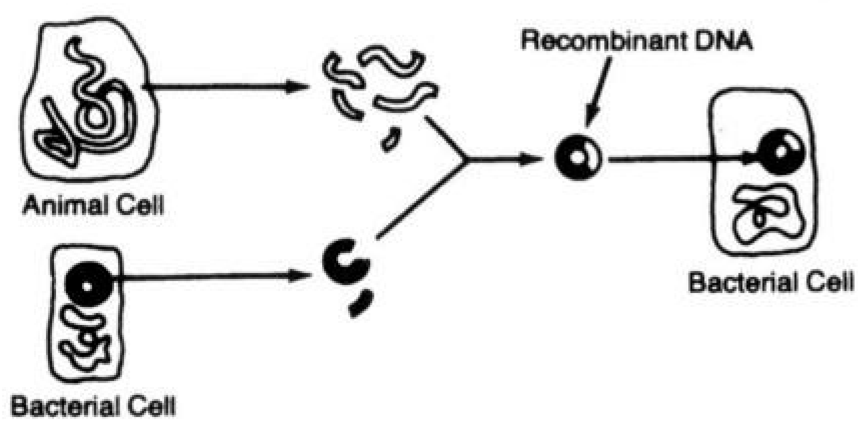
Sex Linkage

Genetic Manipulation

In recent years, new varieties of farm plants and animals have been engineered by manipulating their genetic instructions to produce new characteristics. Modern methods of gene manipulation have been developed that make isolating and inserting specific genes for particular traits within the genome of a species possible. Once inserted, perpetuating the desired trait through traditional methods of hybrid crosses is possible. Genetic engineering refers to the series of techniques used to transfer genes from one organism to another. It involves removing a small piece of DNA from a cell and adding it to the gene structure of another cell. The new DNA that results is known as recombinant DNA. The spliced gene in the recombinant DNA will continue to produce its polypeptide product in the new cell, thus transferring to that cell a genetic ability it lacked before.

These techniques have been used to produce new, improved varieties of certain farm plants (wheat, coffee) and animals (cattle, fish). Some of these species have been bred to display enhanced characteristics such as resistance to disease. Others have been bred to produce human proteins needed for research or for medical applications.

Different enzymes can be used to cut, copy, and move segments of DNA. Characteristics produced by the segments of DNA may be expressed when these segments are inserted into new organisms, such as bacteria. In the mid20th century, research with certain bacteria lead to the discovery of enzymes capable of snipping DNA molecules at particular nitrogenous base sequences. Such enzymes are known as restriction enzymes. This knowledge was used to develop laboratory methods by which the desirable genes of one species may be snipped out of the genome of that species and inserted into the genome of a different species. Once part of the genome of the host species, the gene can function to produce the hormone or other protein coded by the inserted gene. In this way, it is possible for a human trait to be displayed by a different species, including bacteria. The DNA that is altered by this method is known as recombinant DNA.



Genetic engineering involves removing a desirable gene from a cell, adding it to the gene structure of a bacterial cell, and replacing the recombinant DNA into the bacterial cell. The bacteria then have the capability to produce the protein produced by the original animal or plant cell.

Genetic Engineering

Inserting, deleting, or substituting DNA segments can alter genes. An altered gene may be passed on to every cell that develops from it. Any altered sequence of DNA in a living cell can be passed along to succeeding generations of the cell by means of mitotic cell division. Like mutation, genetic engineering can result in altered sequences of nitrogenous bases on a molecule of DNA. When nitrogenous base sequences are added, deleted, or substituted in a DNA molecule, these changes are inheritable. If the genetically engineered cell is a primary sex cell, the gametes resulting from that primary sex cell may inherit the altered gene sequence, leading to the possibility that an artificial gene may be passed along from generation to generation in a host species that does not normally display the characteristic associated with the species.

Gene Therapy

Knowledge of genetics is making possible new fields of health care. For example, finding genes that may have mutations that can cause disease will aid in the development of preventive measures to fight disease. Substances, such as hormones and enzymes, from genetically engineered organisms may reduce the cost and side effects of replacing missing body chemicals. The term gene therapy has become a commonly used term in biomedical research. This process involves the splicing of functional genes into cells that contain defective, nonfunctional genes for a particular trait. The clinical techniques used to accomplish gene therapy are still being worked out. However, they involve research into methods of introducing the functional genes into the person or organism affected by the defective gene. Cystic fibrosis is one human disorder successfully treated in clinical trials using this technique.

An already successful medical technique that holds great promise for the future is the production of human hormones and other proteins in the bodies of laboratory animals or bacterial colonies. Human genes have been removed from healthy human cells and added to the gene sequences of bacteria that are then cultured in large quantities in the laboratory. The substances produced in this manner are considered to be safer than those produced by traditional methods, including those drawn from human subjects. Some examples of this process are as follows.

- Bacteria colonies have been genetically engineered to produce human insulin, interferon, hepititis B vaccine, and human growth hormone. These proteins were gathered and purified for use in treating various human disorders.

- Potato plants have been altered to produce serum albumin.

- Tobacco plants with spliced human genes produce antibodies and melanin.

QUESTION SET 2.5-GENETIC CONTINUITY (ANSWERS EXPLAINED, P. 290)

1. Living things contain units of structure and function that arise from preexisting units. This statement best describes the

   (1) cell theory

(2) lock-and-key model of enzyme activity

(3) concept of natural selection

(4) heterotroph hypothesis

2. Which statement most accurately compares mitotic cell division in plant and animal cells?

(1) It is exactly the same in plant and animal cells.

(2) The walls of plant cells pinch in, but the membranes of animals do not.

(3) Most plant cells use centrioles, but most animal cells do not.

(4) In both plants and animals, the daughter cells are genetically identical to the original cell.

3. What are the normal chromosome numbers of a sperm, egg, and zygote, respectively?

(1) monoploid, monoploid, and monoploid

(2) monoploid, diploid, and diploid

(3) diploid, diploid, and diploid

(4) monoploid, monoploid, and diploid

4. Which statement describes the work of Gregor Mendel?

(1) He developed some basic principles of heredity without having knowledge of chromosomes.

(2) He explained the principle of dominance on the basis of the genechromosome theory.

(3) He developed the microscope for the study of genes in the garden pea.

(4) He used his knowledge of gene mutations to help explain the appearance of new traits in organisms.

5. In guinea pigs, black fur (B) is dominant over white fur (b) and rough fur (R) is dominant over smooth fur (r). A cross between two guinea pigs hybrid for both traits (BbRr x BbRr) produces some offspring that have rough black fur and some that have smooth black fur. The genotypes of these offspring illustrate the genetic concept of

(1) intermediate inheritance

(2) independent assortment

(3) multiple alleles

(4) codominance

6. The gene for tallness (7) is dominant over the gene for shortness (t) in pea plants. A homozygous pea plant is crossed with a heterozygous pea plant, and 200 seeds are produced. Approximately how many of these seeds can be expected to produce plants that are homozygous dominant?

(1) 0

(2) 50

(3) 100

(4) 200

7. Genes carried on only an X chromosome are said to be

(1) hybrid

(2) codominant

(3) autosomal

(4) sex-linked

8. In which situation could a mutation be passed on to the offspring of an organism?

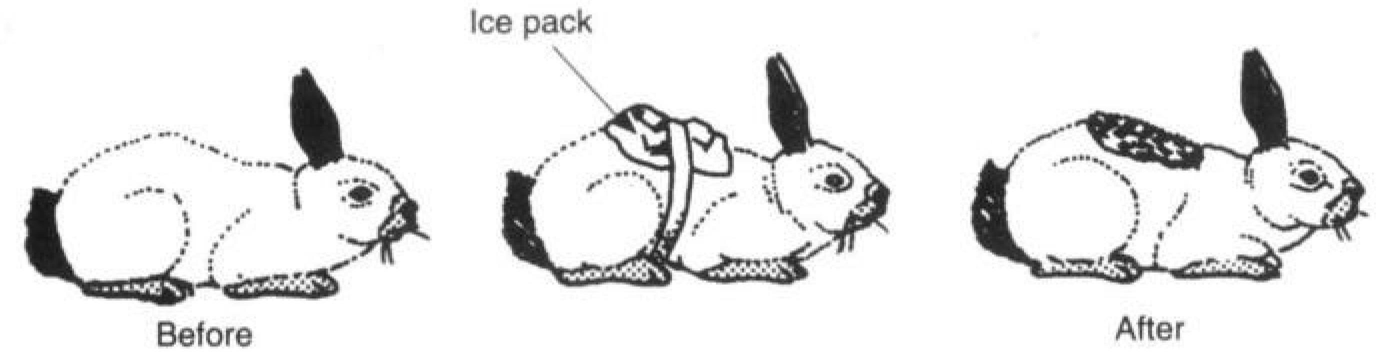
(1) Ultraviolet radiation causes skin cells to undergo uncontrolled mitotic division.

(2) The DNA of a human lung cell undergoes random breakage.

(3) A primary sex cell in a human forms a gamete that contains 24 chromosomes.

(4) A cell in the uterine wall of a human female undergoes a chromosomal alteration.

9. The diagram below illustrates what happens to the fur coloration of a Himalayan hare after exposure to a low temperature.



This change in fur coloration is most likely due to

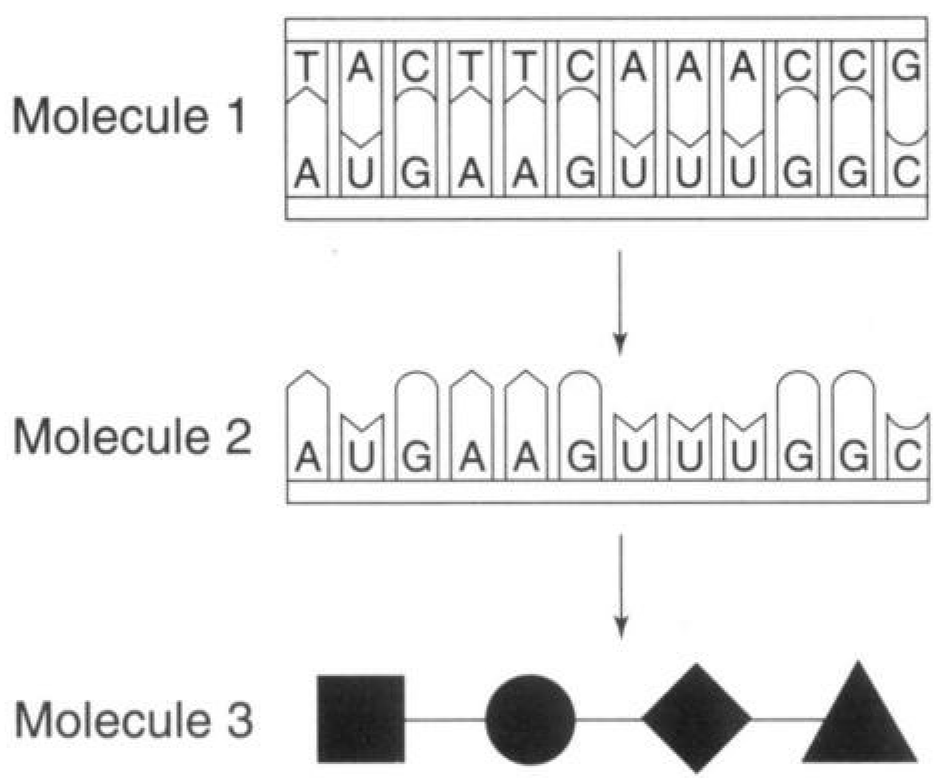
(1) the effect of heredity on gene expression

(2) the arrangement of genes on homologous chromosomes

(3) environmental influences on gene action

(4) mutations resulting from a change in the environment

10-13. Base your answers to questions 10 through 13 on the diagram below and on your knowledge of biology. The diagram represents molecules involved in protein synthesis.



10. In plant cells, molecule 1 is found in the

(1) centriole

(2) nucleus

(3) cell wall

(4) lysosome

11. The building blocks of molecule 3 are known as

(1) amino acids

(2) DNA molecules

(3) fatty acids

(4) RNA molecules

12. Where do the chemical reactions coded for by molecule 2 take place?

(1) in the vacuole

(2) on the plasma membrane

(3) in the lysosome

(4) at ribosomes

13. Molecule 3 is formed as a result of

(1) deamination

(2) dehydration synthesis

(3) enzymatic hydrolysis

(4) oxidation

14-17. Base your answers to questions 14 through 17 on the reading passage below and on your knowledge of biology.

Female or Male, Which Will It Be?

After fertilization, all human embryos begin forming the basic female reproductive structures. These structures are present by the time the embryo has toes, fingers, eyes, and a heart at 35-40 days into gestation. If the egg was fertilized by a sperm containing a Y chromosome, a series of changes occurs that will produce a male.

Recent research has isolated a genetic switching mechanism that is part of the process that determines sex in humans. The Y chromosome contains a trigger factor known as the SRY gene, which activates the male pattern of development after 35-40 days of gestation. The SRY gene causes testes to develop. These, in turn, produce testosterone, which causes the development of male characteristics such as the penis, masculine muscles, and eventually, facial hair.

At this stage of development, the embryo has both male and female potential. However, the SRY gene sends a chemical message to another gene known as MIS. The MIS gene causes the developing female organs in the embryo to disappear. The combined action of the SRY and MIS genes results in the change of the embryo from female to male.

14. During the first five weeks after a human egg is fertilized, the embryo develops

(1) only toes, fingers, eyes, and a heart

(2) male reproductive structures and other organs

(3) female reproductive structures and other organs

(4) male or female reproductive structures depending on whether the egg was fertilized by an X-bearing or a Y-bearing sperm

15. The male pattern of development is activated by the

(1) SRY gene

(2) entire Y chromosome

(3) entire X chromosome

(4) MIS gene

16. The MIS gene is activated by

(1) the X chromosome

(2) a chemical message

(3) the presence of male reproductive structures

(4) the presence of female reproductive structures

17. An embryo is changed from a female to a male by the action of

(1) two X chromosomes

(2) all the genes on a Y chromosome

(3) an MIS gene, only

(4) SRY and MIS genes

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18. The code of a gene is delivered to the enzyme-producing region of a cell by a

(1) hormone

(2) nerve impulse

(3) messenger RNA molecule

(4) DNA molecule

19. Which process could be used by breeders to develop tomatoes with a longer shelf life and to develop cows with increased milk production?

(1) natural selection

(2) sporulation

(3) genetic engineering

(4) chromatography

20. What would most likely result if mitosis was not accompanied by cytoplasmic division?

(1) two cells, each with one nucleus

(2) two cells, each without a nucleus

(3) one cell with two identical nuclei

(4) one cell without a nucleus

21. Which cross would produce a child with type 0 blood?

(1) IAi X IBIB

(2) I^I^ x Pi

(3) I^IB x ii

(4) IN x Pi

22. Breeders have developed a variety of chicken that has no feathers. Which methods were most likely used to produce this variety?

(1) artificial selection and inbreeding

(2) grafting and hybridization

(3) regeneration and incubation

(4) vegetative propagation and binary fission

23. In fruit flies with the curly wing mutation, the wings will be straight if the flies are kept at 16°C but curly if they are kept at 25°C. The most probable explanation for this is that

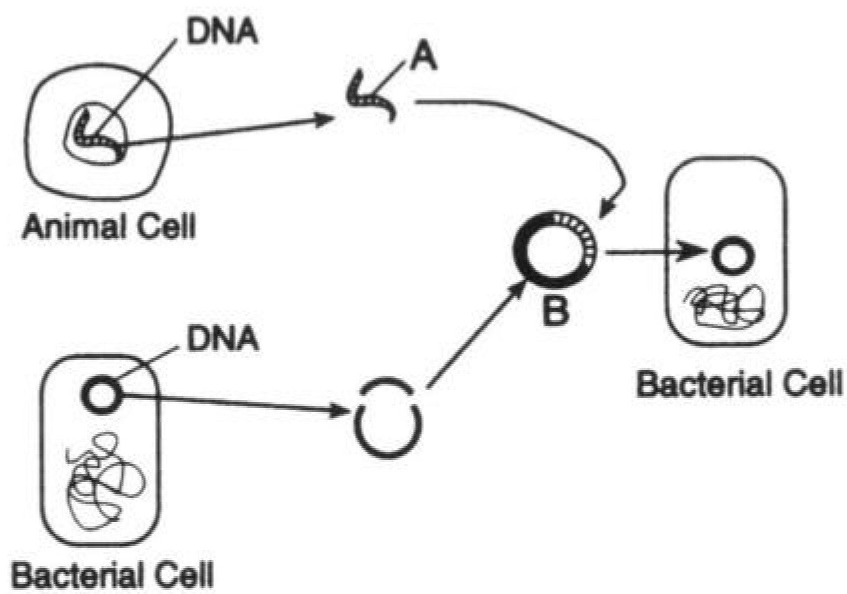
(1) fruit flies with curly wings cannot survive at high temperatures

(2) the environment influences wing phenotype in these fruit flies

(3) high temperatures increase the rate of mutations

(4) wing length in these fruit flies is directly proportional to temperature

24-26. Base your answers to questions 24 through 26 on the diagram below and on your knowledge of biology.



24. Structure A contains a

(1) genetic code

(2) single nucleotide only

(3) messenger RNA molecule

(4) small polysaccharide

25. Structure B represents

(1) a ribosome

(2) transfer RNA

(3) recombinant DNA

(4) a male gamete

26. The technique illustrated in the diagram is known as

(1) cloning

(2) genetic engineering

(3) protein synthesis

(4) in vitro fertilization

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27. Listed below are four prominent scientists whose contributions to the field of biology have been significant. Choose one of these scientists, write his name in the space provided, and write at least one complete sentence summarizing his contribution to biological science.

A. Charles Darwin

C. Francis Crick

B. Stanley Miller

D. Gregor Mendel

VI. ORGANIC EVOLUTION

KEY IDEA 3-ORGANIC EVOLUTION Individual organisms and species change over time.

Little doubt exists that the physical forms of nearly all living things have changed over time. Genetic and environmental factors have combined in the past to make these changes happen. These same forces are still at work, selecting traits that better adapt species to Earth's ever-changing environment. Organic evolution specifically refers to the mechanisms thought to govern the structural, behavioral, and functional changes in living species over geologic time. These changes may include variation within a species or the production of new species.

Theory of Natural Selection

The unifying theory underlying the modern concept of evolution is the theory of natural selection. First advanced by Charles Darwin in the 19th century, this theory is based on scientific observation coupled with an understanding of how living things respond to environmental pressures. The basic features of the theory of natural selection include observations of overproduction of offspring in naturally occurring species, the existence of variation among offspring, and the struggle for survival. The theory also includes logical assumptions concerning the selection of individuals whose variations provide adaptive value and the subsequent survival and reproduction of the best-adapted individuals. To Darwin's original construct has been added a wealth of new observations and a more complete understanding of the genetic basis of variation.

Many scientific observations, some only peripherally related to the science of evolution, have lent support to the concepts embodied in the theory of natural selection. The sciences of geology (study of rocks) and paleontology (study of fossils) have demonstrated the extreme age of the Earth and the existence of fossilized organisms different from, but still similar to, organisms that exist today. The sciences of anatomy (study of structure) and embryology (study of reproduction and development) have enabled scientists to classify organisms based on similarities of structure and developmental patterns. The sciences of cytology (study of cells) and biochemistry (study of chemical reactions in living things) have pointed to the basic similarity of all living things. The relative relatedness of living things shows close structural similarities.

Process of Evolution

Performance Indicator 3.1 The student should he able to explain the mechanisms and patterns of evolution. Evolution is a natural force thought to be responsible for the dizzying array of different life-forms that have inhabited our planet. A survey of living things reveals that approximately 1.5 million different species of every description exist on Earth. Classification provides scientists with the means for sorting and grouping these organisms for easier study. The basis of biological classification is physical structure, although other criteria, such as embryonic, genetic, and biochemical similarities, are also used. Organisms that are similar in their physical traits are usually similar in other ways. Because of this fact, the characteristics of a large grouping of similar organisms can be learned by studying a few representatives of the group. When a new organism is discovered, it can be readily grouped with other, similar organisms when only a few of its characteristics are known. It is assumed that organisms sharing many traits in common are likely to share a common ancestry as well.

Scheme of Classification

The most widely accepted scheme of classification places every known organism into one of five large groupings known as kingdoms. The organisms within a particular kingdom share many broad characteristics in common, although there can be considerable diversity (difference) of form among them. The five kingdoms are as follows.

- Monera-unicellular forms having a primitive cell structure
- Protista-unicellular organisms with plantlike or animal-like characteristics
- Fungi-unicellular, colonial, or multicellular saprophytic organisms
- Plant-multicellular, photosynthetic organisms
- Animal-multicellular, heterotrophic organisms

Within each kingdom, organisms having greater similarity to each other than to the organisms in other groups are classified together into phyla. Therefore, each phylum contains groups of organisms showing characteristics distinctly different from those of other phyla. Phyla are subdivided into still narrower groupings of organisms including classes, orders, and families, and finally into groups showing high degrees of similarity known as genera. The members of each genus are so similar that they might easily be mistaken for each other by most people. Each genus is further broken down into species. The members of a species are so similar biologically that they can share genetic information and reproduce more individuals like themselves. Fertile offspring result from reproductive activities between members of the same species.

Kingdom	Phylum	Characteristics	Examples
Monera	Bacteria Blue-green algae	Have primitive cell structure lacking a nuclear membrane.	*E. coli*
Protista	Protozoa Algae	Are predominantly unicellular organisms with plant-like and/or animal-like characteristics.	Paramecium Ameba Spirogyra
Fungi		Cells are usually organized into branched, multi-nucleated filaments that absorb digested food from their environment.	Yeast Bread mold Mushroom
Plant		Are multicellular, photo-synthetic organisms.	
	Bryophytes	Lack vascular tissues; have no true roots, stems, or leaves.	Moss
	Tracheophytes	Possess vascular tissue; have true roots, stems, and leaves.	Geranium Fern Bean Trees (maples, oaks, pines, etc.) Corn
Animal		Are multicellular, hetero-trophic organisms.	
	Coelenterates	Have two cell layers, hollow body cavity.	Hydra Jellyfish
	Annelids	Have segmented body walls.	Earthworm Sand worm
	Arthropods	Have jointed appendages, exoskeleton.	Grasshopper Lobster Spider
	Chordates	Possess dorsal nerve cord, internal skeleton.	Shark Frog Human being

This classification scheme is used by scientists to organize living things into easily understood groupings. To keep track of the more than 1.5 million different species that have been discovered and classified, a system of naming (nomenclature) has been developed. This system uses two names in much the same way that most people have at least two names to help others tell them apart. This naming system, known as binomial nomenclature (twoname naming), was first devised by Carl Linnaeus in the eighteenth century. The two names are the genus name (always capitalized) and the species name (always written in lowercase). The language used in the system of binomial nomenclature is Latin. Some examples of this system are as follows.

Genus	Species	Common Name
Homo	*sapiens*	human being
Canis	*familiaris*	dog
Canis	*lupis*	wolf
Felis	*domestica*	cat
Felis	*leo*	lion

Evolutionary Assumptions

The basic theory of biological evolution states that the Earth's present-day species developed from earlier, distinctly different species. The currently accepted theories of organic evolution assume that modem life-forms have evolved from previously existing life-forms. One source of this assumption is the logical conclusions drawn from a knowledge that living things arise from other living things by reproduction. Just as present-day organisms have been produced by the generations that immediately proceeded them, so modem-day species must have developed from the ancient species of eons past. In addition to this logical conclusion, a great deal of evidence supports this assumption provided by studies of geology and paleontology.

No direct evidence indicates the exact date of Earth's formation. By studying the indirect evidence drawn from the radioactive dating of the Earth's rocks, however, geologists have estimated the age of the Earth to be between 4.5 and 5.0 billion years. In arriving at this estimation, scientists have assumed that the Earth is at least as old as the oldest rocks so far discovered. Fossils of early life-forms have been found preserved in certain of these rocks and are dated by scientists using various techniques. It is logical to conclude that the fossils are as old as the rock layers in which they are embedded.

Genetic Mechanisms of the Cell

New inheritable characteristics can result from new combinations of existing genes or from mutations of genes in reproductive cells. Mutation and the sorting and recombining of genes during meiosis and fertilization result in a great variety of possible gene combinations. We have already learned that the source of individual traits is found within the genetic mechanisms of the cell. These mechanisms include the cellular processes of mutation, meiosis, fertilization, and protein synthesis.

Mutation is important in providing the new genes that may lead to the production of new genetic traits. Although the majority of such mutations are harmful or neutral, a small percentage may provide significant adaptive advantages to a species. It is important to recognize that in sexually reproducing species, only mutations in gametes can be passed on to succeeding generations. Protein synthesis is the basic chemical process in the cell that results in production of new proteins that function in the cell and result in new variations.

Within the reproductive process, meiosis and fertilization provide the mechanism by which new combinations of both old and new traits may be tried out as new varieties within a species. These can be counted in the millions of possible individual combinations. Successful combinations are perpetuated in the species through the processes of sexual reproduction. Unsuccessful combinations are removed from the population's gene pool by the selective forces of the environment.

Gene Mutations

Mutations occur as random chance events. Gene mutations can also be caused by such agents as radiation and chemicals. When they occur in sex cells, the mutations can be passed on to offspring. If they occur in other cells, the mutations can be passed on to other body cells only. Gene mutations involve changes in the chemical nature of the gene. The active chemical in the gene is DNA. When this material undergoes chemical alteration, its control over cell activities and cell characteristics changes, causing alterations in the phenotype of the organism. Although these changes are likely to be small and difficult to detect, they may occasionally be great enough to be easily noticed or even to cause death. Albinism (lack of skin pigment in humans) is an example of a human trait caused by a single gene mutation whose effects are quite obvious and dramatic. The phenotype (albino) that results from the homozygous recessive allelic combination is characterized by pale white skin, yellow hair, and pink eyes.

Although most gene mutations cause changes that are neutral or harmful, occasionally their effect is beneficial. A beneficial mutation, such as one that produces a needed enzyme, causes a phenotypic change that in some way gives an organism an advantage in its environment over other organisms of the same species. An extremely beneficial gene mutation can cause major shifts in the species' genetic characteristics, a phenomenon considered by many scientists to be a major driving force in evolution.

Gene mutation can occur spontaneously by random chemical alteration of DNA during replication. In addition, a number of naturally occurring and human-produced phenomena are known to cause or accelerate gene mutation. These phenomena include:

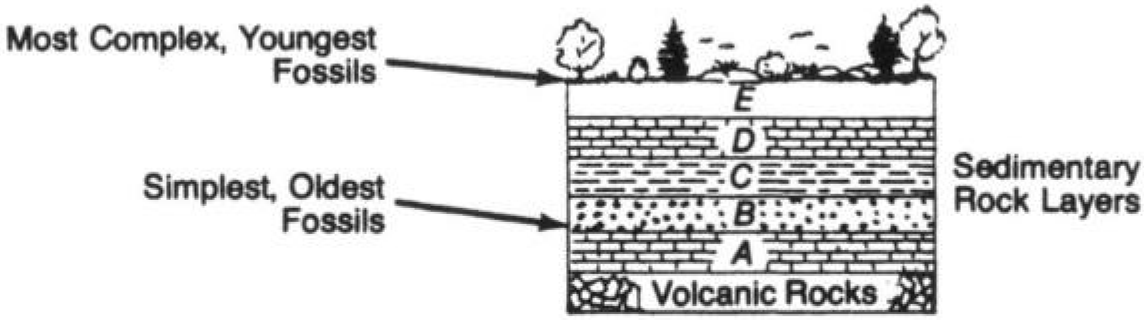
- Radiation-Sources of radiation include cosmic rays, radon, X rays, ultraviolet radiation, radioactive radiation, and electromagnetic radiation; and

- Chemicals-Sources include benzene, formaldehyde, asbestos, dioxin, and tobacco residues.

Geologic Record

Natural selection and its evolutionary consequences provide a scientific explanation for the fossil record of ancient life-forms as well as for the molecular and structural similarities observed among the diverse species of living organisms. Found frequently within certain types of rocks are fossils, the preserved direct or indirect evidence of organisms that lived in the past. Fossils are most commonly discovered embedded in sedimentary rock, such as sandstone or limestone. However, the remains of organisms may also be found preserved in ice or permanently frozen soil or in naturally occurring tars or other chemical deposits. Knowing the age of the rock layers in which fossils are embedded enables scientists to determine with reasonable accuracy the age of those fossils. Fossils have been discovered that have been dated by scientific methods to be more than 3 billion years old.

In undisturbed layers (strata) of sedimentary rock, the lowest layers were laid down first, the middle layers next, and the topmost layers last. It follows logically, then, that fossils found embedded in the lower strata are older than those in the upper strata. In fact, deeper layers of such rock are known to contain fossils of older, simpler life-forms. Strata formed near the surface contain younger and generally more complex forms.



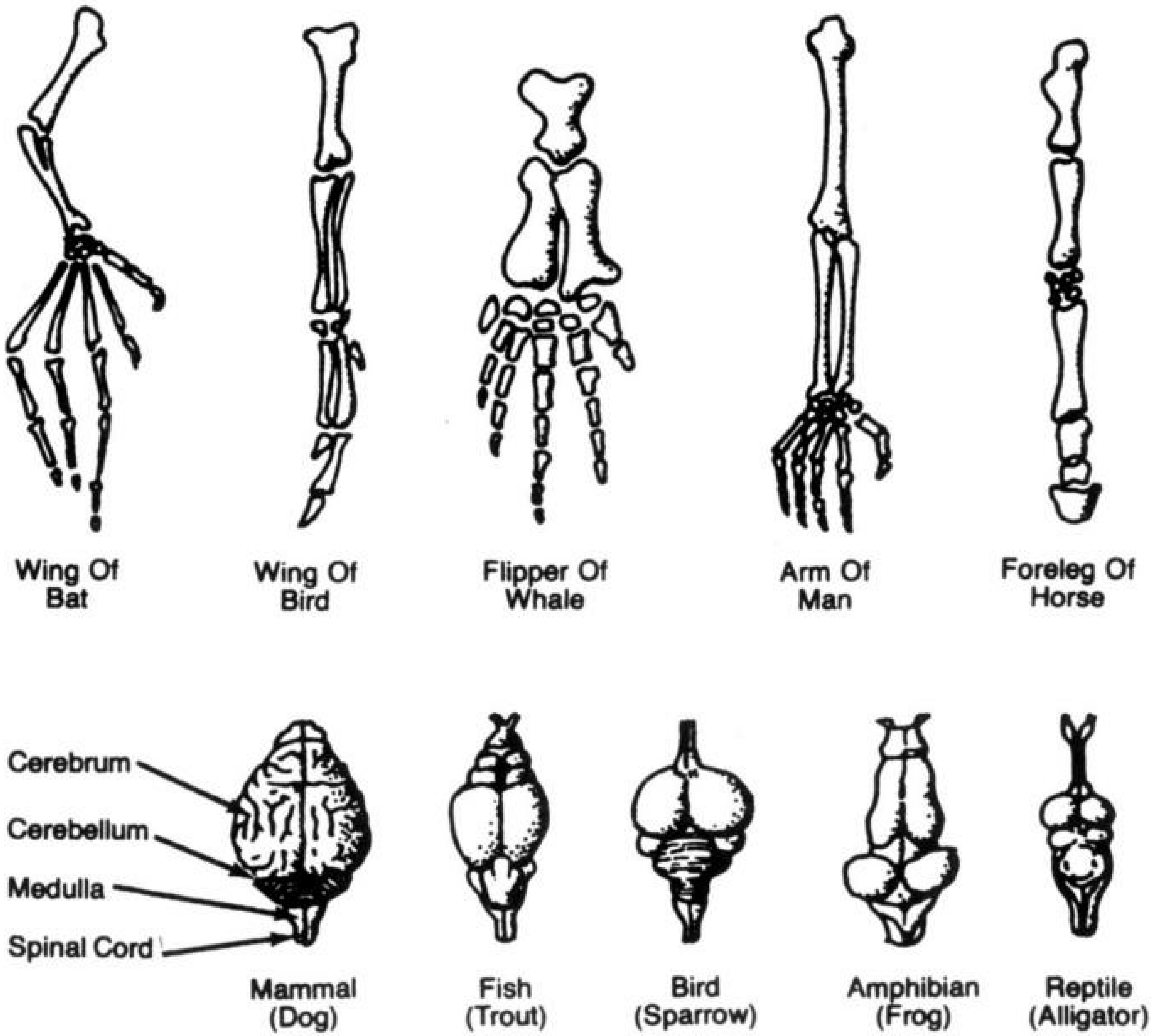
Geologic Record

Scientists have been able to identify a certain degree of continuity among the fossils in consecutive layers of fossil-bearing rock. It is possible to find fossils in upper strata that resemble those in lower strata, even though they are clearly different species. This fact lends support to the theory that genetic links exist between modem life-forms and ancient forms. It also suggests that genetic links exist among diverse modem life-forms by virtue of their common links to ancestral species. For example, all vertebrate species, from fish to mammals, share a common chordate ancestor that lived millions of years in the past. Modern species having similar structures share these ancestral forms in common. Even diverse species displaying few obvious similarities, such as earthworms and mollusks, are thought to share distant common ancestors. The concept of common ancestry, in which two divergent forms can trace their lineage to a single preexisting life form, is central to an understanding of the science of evolution.

Comparative Sciences

Added to evidence supplied through the fossil record is that stemming from the sciences of comparative cytology, anatomy, biochemistry, and genetics. The cell as a structural and functional unit is a feature that nearly all living things share in common. The organelles located within these cells function in much the same way in the cells of every organism. Despite the basic similarity of all cells, certain differences among cells of different species are known to exist. Organisms with a very similar cell structure are usually considered to be more closely related than organisms whose cells show many differences.

The determination of similarities in anatomic (structural) features is perhaps the most common method of demonstrating biological relationships among organisms. This method provides the basis for biological classification, in which an organism is placed into a kingdom, phylum, class, order, family, genus, and species, based on its degree of structural similarity with other members of those groups. Similar organisms have limbs, internal organs, or other structures that are constructed similarly. Such structures, known as homologous structures, are believed to have originated from common ancestral forms of the same structures.



Homologous Forelimbs and a Comparison of Vertebrate Brains

We learned that each polypeptide in the cell is coded by a unique strand of DNA. We also learned that the ability to produce such polypeptides may be passed from generation to generation through the processes of reproduction and genetic inheritance. Related organisms, therefore, having inherited their characteristics from common ancestors, may be expected to share many genes and their corresponding enzymes in common. Biochemical analysis of enzymes and other proteins shows that a great deal of similarity exists in the biochemical makeup of organisms known to be related genetically. For example, the complex protein hemoglobin is found in the blood of many vertebrate species, whereas it is less common among invertebrates. Generally, the more closely related two organisms are, the more similar is their biochemical makeup. Likewise, organisms that are not as closely related share fewer biochemical similarities.

Theories of Evolution

Species evolve over time. Evolution is the consequence of the interactions of (1) the potential for a species to increase its numbers, (2) the genetic variability of offspring due to mutation and recombination of genes, (3) a finite supply of the resources required for life, and (4) the ensuing selection by the environment of those offspring better able to survive and leave offspring. In the 19th century in England, a naturalist named Charles Darwin devised a theory of evolution based on variation and natural selection. This theory forms the basis of the modern theory of evolution. The theory of evolution by natural selection has been modified over the past 100 years to include the following points.

- Overproduction-Scientists observe that naturally occurring species have a tendency to produce far more offspring than can possibly survive to become reproducing adults. In fact, if all these offspring did survive, the Earth's habitats and available resources would be quickly used up.

- Competition-Despite the tendency to overproduce, the number of individuals in natural populations tends to remain relatively constant over many generations. This suggests that within each species, there is a struggle for survival that eliminates many individuals before they reach reproductive maturity. This struggle may be termed intraspecies (within a species) competition.

- Variation-For centuries, scientists have been aware of the extreme variability that exists between and within species. Scientists in the time of Darwin were unaware of the mechanisms that produced this variation. This knowledge would have to wait until scientists such as Mendel, DeVries, Morgan, and others had conducted their groundbreaking work in the science of genetics. We know now that this variability results from genetic and reproductive forces. As the chemical composition of DNA changes in the cell via mutation, the resulting new traits that develop enter the gene pool and are subjected to selection pressures that either increase or decrease the frequency of the variation in the species population.

Adaptive Advantage

Some characteristics give individuals an advantage over others in surviving and reproducing. The advantaged offspring, in turn, are more likely than others to survive and reproduce. The proportion of individuals that have advantageous characteristics will increase. Each individual in a species population is engaged in a struggle for existence in its own environment. The individuals that survive (are selected) are assumed to be those best adapted to survive under the particular set of environmental conditions in question. The individuals that perish are considered to be those less well adapted for survival. When the survivors later reproduce, they tend to pass on the genes associated with their adaptive advantages. In this way, nature provides selection pressures that limit or eliminate traits that do not promote individual survival. This is the primary role of natural selection in the process of evolution.

The frequencies of these favorable genes, then, increase in the gene pool relative to the frequencies of these genes controlling less favorable traits. This shift of gene frequencies in the gene pool of a species population is thought to constitute the mechanism of evolution.

The variation of organisms within a species increases the likelihood that at least some members of the species will survive under changed environmental conditions. It is important to recognize that the adaptations in a population that are favorable under one set of environmental conditions may prove to be highly unfavorable under a different set of environmental conditions. At the same time, traits present in the gene pool of a population that have low or neutral survival value may markedly increase in value if the environment changes or if the population moves to a new environment.

Some examples of this concept are as follows.

- In the past 100 years, the environments of many insect pests (for example, houseflies, mosquitoes, roaches, weevils) changed when new chemical pesticides such as DDT were introduced into their environments. Most of the insects that came into contact with the insecticide died since they were not genetically resistant to it. A small number of the organisms were genetically resistant to the chemicals, however, and survived to reproduce offspring that were also genetically resistant. Today, such resistant strains present a problem to chemists attempting to develop other new insecticides to deal with insect infestations. In this case, the insecticide has acted as an agent of natural selection. (Note that chemical pesticides are now considered to be an environmental threat to many species other than the target insect pests, including beneficial insects and humans.)

- A similar situation has occurred in the evolution of antibiotic-resistant strains of bacteria in some hospital environments. As in the example above, newly introduced antibiotics such as penicillin represented a change in the environment of disease-causing bacteria. Nonresistant bacteria died when they came into contact with the antibiotic, but a few resistant bacteria survived. The resistant bacteria gave rise to entire strains of the bacterial species that are resistant to the antibiotic. The selecting agent in this case is the antibiotic.

Behaviors have evolved through natural selection. The broad patterns of behavior exhibited by organisms are those that have resulted in greater reproductive success. Although structural and biochemical adaptations are those most frequently considered in discussions of genetically controlled characteristics in species, behavioral patterns are increasingly being recognized as having a genetic basis. Examples of genetically programmed behaviors include bird migration patterns, fish spawning behaviors, bird imprinting behaviors, and a host of others. The science of ethology studies the simple and complex behavior patterns of animals. Many of these behaviors promote reproductive success, whether to ensure that species members meet in favorable nesting environments or to ensure that only members of reproductively compatible species attempt mating.

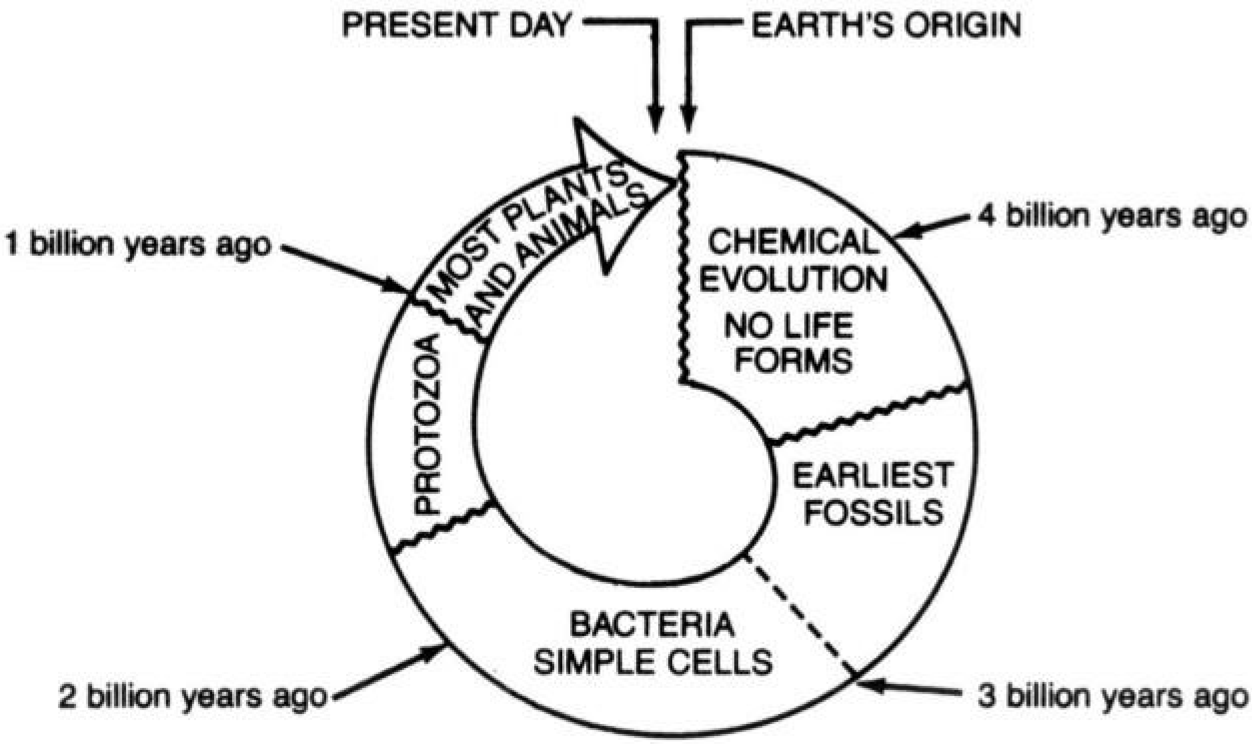
Origin of Life

Billions of years ago, life on Earth is thought to have begun as simple, single-celled organisms. About a billion years ago, increasingly complex multicellular organisms began to evolve. A question that has challenged scientists and nonscientists alike is the question of the origin of life. The cell theory assumes that all cells arise from previously existing cells. However, what gave rise to the first cell? Scientists have proposed the heterotroph hypothesis to help explain the origin of the first primitive life-forms on the ancient Earth. This scientific hypothesis assumes that the first primitive life-forms were not able to manufacture their own food (were heterotrophic). The heterotroph hypothesis is consistent with much of the currently accepted scientific theory on the origins of the universe and with current understandings of the sciences of biology and biochemistry. However, like many hypotheses developed to explain phenomena that cannot be directly observed and measured, the heterotroph hypothesis is based on extensions of basic assumptions about Earth's origins.

The first cell is theorized to have been an aggregate of simple organic molecules that were produced in the primitive oceans from the chance combinations of inorganic molecules under extremely energy-rich conditions. Experiments conducted in the laboratory by Stanley Miller, Sidney Fox, and other scientists have confirmed that this chance aggregation is possible, even in relatively short periods of time.

It is thought that the earliest living cells obtained their energy by means of a cellular process similar to fermentation, which has the natural by-product carbon dioxide. This carbon dioxide, it is believed, built up in concentration in the Earth's atmosphere as a result of widespread fermentative activity. Certain organisms, having spontaneously evolved the ability to use the newly introduced gaseous carbon dioxide to manufacture their own organic foods, became the Earth's first food producers. Extensive autotrophic nutritional activity, similar to photosynthesis, added free molecular oxygen to the Earth's atmosphere. This new environmental condition likely proved toxic to many of Earth's newly evolved species. A few species, having spontaneously evolved an ability to use this molecular oxygen in the respiratory process, became the Ear th's first aerobic organisms.

The first cell-like aggregations are assumed to have appeared about 3.5 billion years ago. Unicellular protists exist in the fossil record from about 1.8 billion years ago. The first simple multicelled organisms appear in the record approximately 1.0 billion years before the present.



The geologic clock shows all of earth's history from its formation 5 billion years ago to the present. Human beings appeared at "11:59," "1 minute" before the present!

Geologic Clock

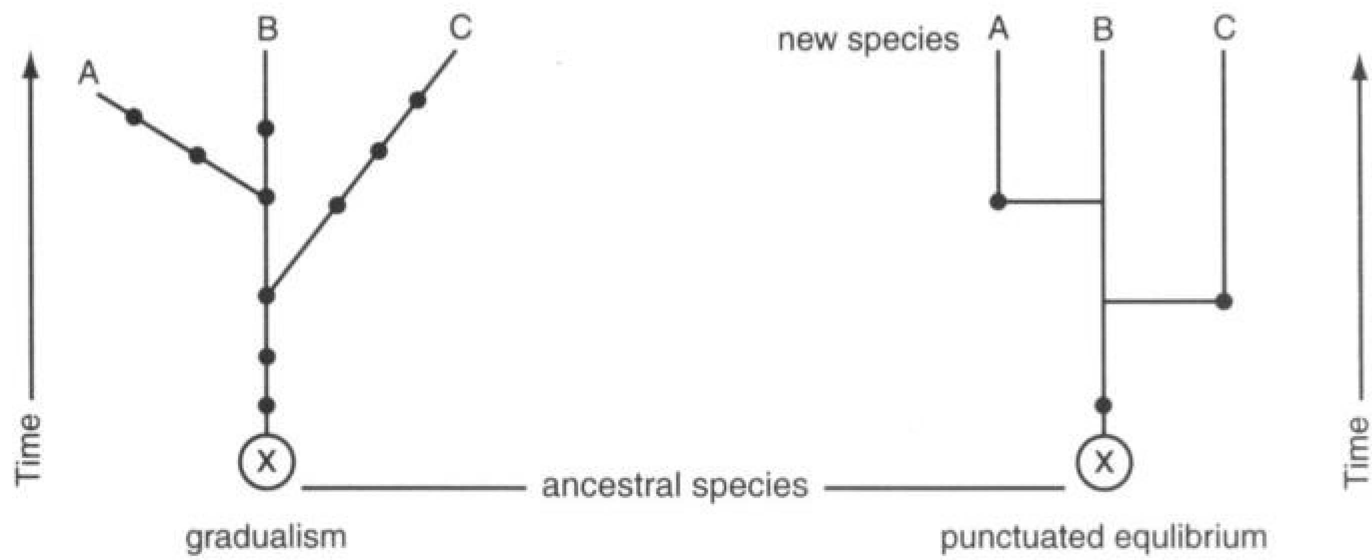
Patterns of Evolution

Evolution does not necessitate long-term progress in some set direction. Evolutionary changes appear to be like the growth of a bush. Some branches survive from the beginning with little or no change, many die out altogether, and others branch repeatedly, sometimes giving rise to more complex organisms. The processes of mutation, allelic recombination, and natural selection are constantly at work in the production and selection of new adaptations in all species. When enough unique adaptations have been accumulated in a species population so that it becomes distinct from other populations of the same species, it may be classified as a new variety of the species. Under the right set of selection pressures, a species variety may accumulate so many variations that it becomes reproductively isolated from other varieties of the species. At this point, it has become a distinct species. The process by which new species arise from parent species is known as speciation. Speciation may be accelerated by factors that isolate one variety from another. These include geographic isolation and reproductive isolation.

Most scientists generally agree that the mechanisms controlling the evolutionary process are similar to those outlined above. However, considerable debate still exists concerning the time frame in which this mechanism operates. Two theories about the time frame question have been put forth.

- Gradualism-This theory assumes that evolutionary change is slow, gradual, and continuous. A gradualistic view of evolution is supported by fossil records of a species that display slight changes in each sedimentary layer, leading to a significant divergence between specimens found in the bottom and top layers.

- Punctuated equilibrium-This theory assumes that species experience long geologic periods of stability (of a million years or more) in which little or no significant change takes place. This stability is punctuated by brief periods (of a few thousand years) in which dramatic changes occur within species. During these brief periods of change, many species are thought to evolve very quickly from parent species, while other species become extinct on a massive scale. Such a view of evolution is supported by fossil evidence in which little change is noted between most sedimentary layers but sudden bursts of change are evident in the fossils of a few sedimentary layers.



These earliest evolutionary events are at best incompletely understood. How they actually occurred and under what circumstances they took place can only be a matter of speculation supported by scientific evidence. What is known, however, is that modern species show a wide divergence (difference) in form and function. Modem species may be autotrophic or heterotrophic. They may be aerobic or anaerobic. They may reproduce sexually or asexu ally. They may differ from other species in countless ways. These varieties are thought to have come about via the evolutionary processes previously described, filling the Earth's available environments with countless species able to survive the various physical conditions they encountered.

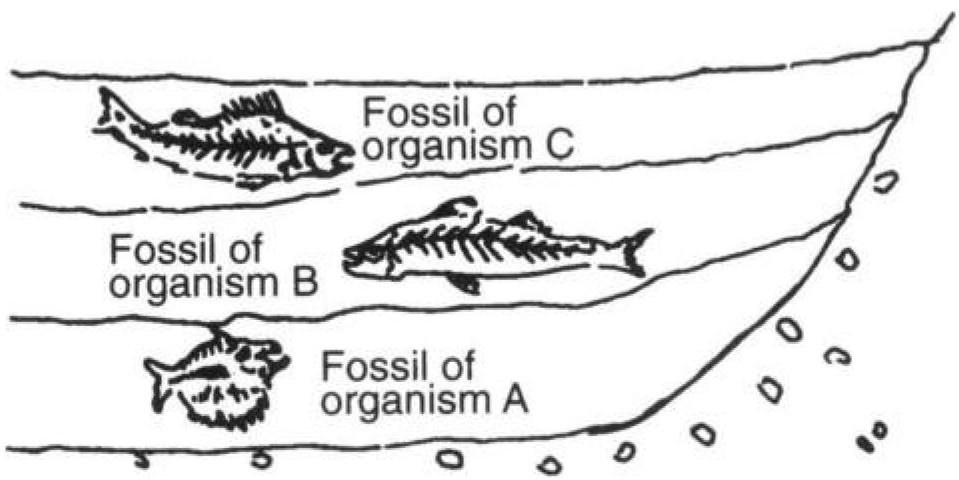
Extinction

Extinction of a species occurs when the environment changes and the adaptive characteristics of a species are insufficient to allow its survival. Fossils indicate that many organisms that lived long ago are extinct. Extinction of species is common; most of the species that have lived on Earth no longer exist. A natural component of evolution is the extinction of species whose adaptations no longer suit them to the environmental conditions that they encounter. The natural environment is always changing in subtle ways. As long as this change is slow and gradual, most species can adapt to it or migrate to nearby habitats in which the favored conditions can be reestablished. However, when environmental change is rapid or when species cannot escape gradual change by migrating to new environments, the extinction of nonadaptable species is inevitable. Much speculation has been made about the rapid extinction of most dinosaur species within a relatively short period of time. One theory holds that an asteroid strike of sufficient magnitude to be classified as an extinction level event may have created massive environmental changes that lead to the dinosaurs' extinction. Smaller, more adaptable species are thought to have evolved rapidly during this period, including the evolution of primitive bird species from ancestral dinosaur species.

In modem times, environmental changes introduced by human activities have greatly accelerated the rate of species' extinction. Although far from normal extinction, this situation should be regarded with concern that we are altering our environment so significantly that we are endangering our own survival as well as that of many other compatible and essential species.

QUESTION SET 2.6-ORGANIC EVOLUTION (ANSWERS EXPLAINED, P. 298)

1. The diagram below represents undisturbed rock strata in a given region. A representative fossil of an organism is illustrated in each layer.



Which statement best describes a relationship among these representative organisms?

(1) Organism A was probably more structurally advanced than organism B and organism C.

(2) Organism C probably gave rise to organism A and organism B.

(3) All of these organisms probably evolved at the same time.

(4) Organism A was probably more primitive than organism B and organism C.

2. In the early stages of development, the embryos of birds and reptiles resemble each other in many ways. This resemblance suggests that they

(1) belong to the same species

(2) are adapted for life in the same habitat

(3) share a common ancestry

(4) are both animal-like protists

3. In addition to the basic ideas of Darwin, the modern theory of evolution includes a concept that

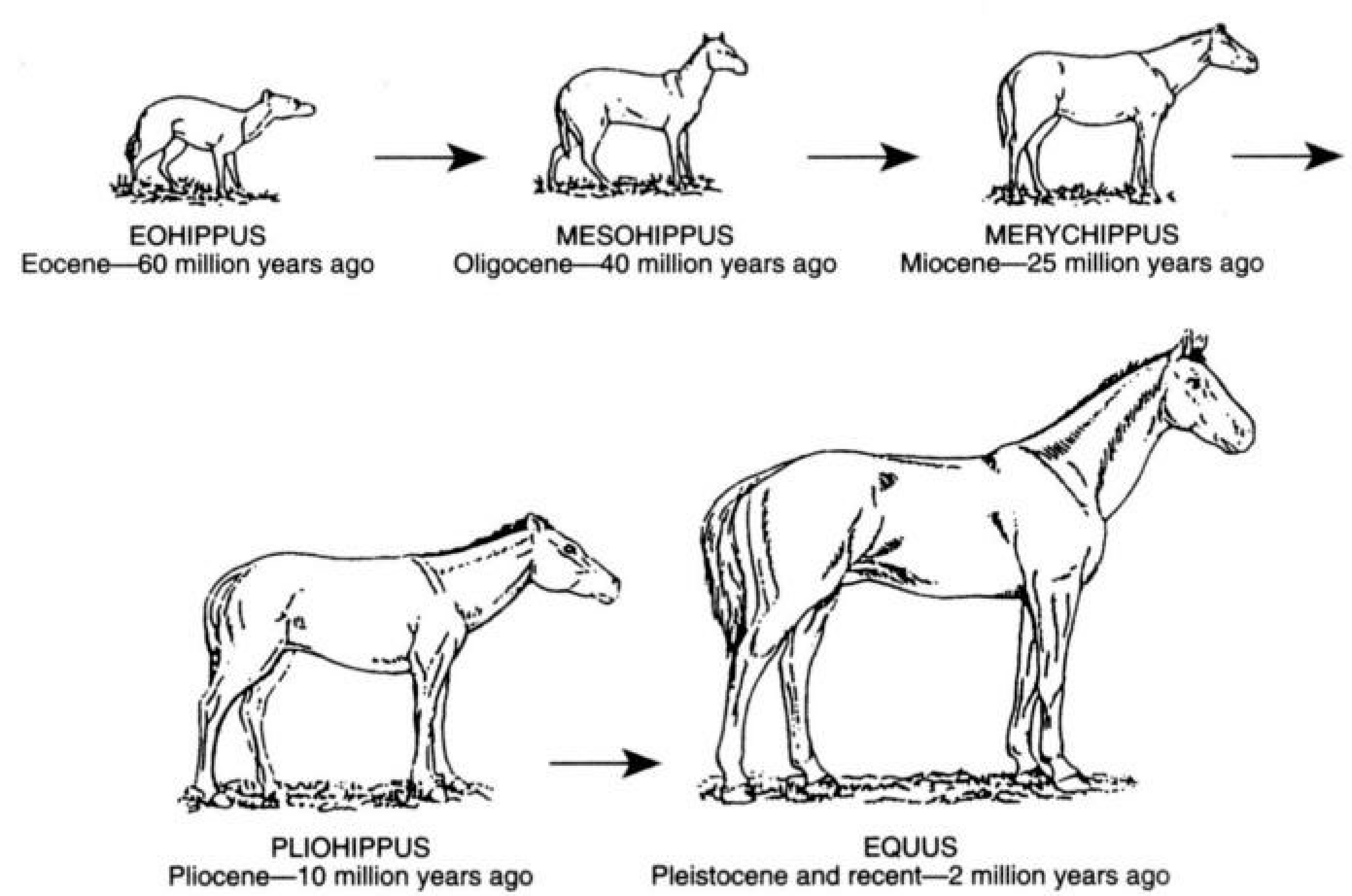
(1) variations result from mutations and gene recombination

(2) overproduction of organisms leads to extinction

(3) variations exist only in large populations

(4) competition occurs only between members of the same species

4. The diagrams below represent some structural changes that occurred over time, resulting in the development of the modem horse.



This sequence of structural changes best illustrates the concept of

(1) organic evolution

(2) ecological succession

(3) intermediate inheritance

(4) geographic isolation

5. Some species undergo long periods of stability interrupted by geologically brief periods of significant change. During these brief periods, new species may evolve. This pattern of evolution is part of the concept of

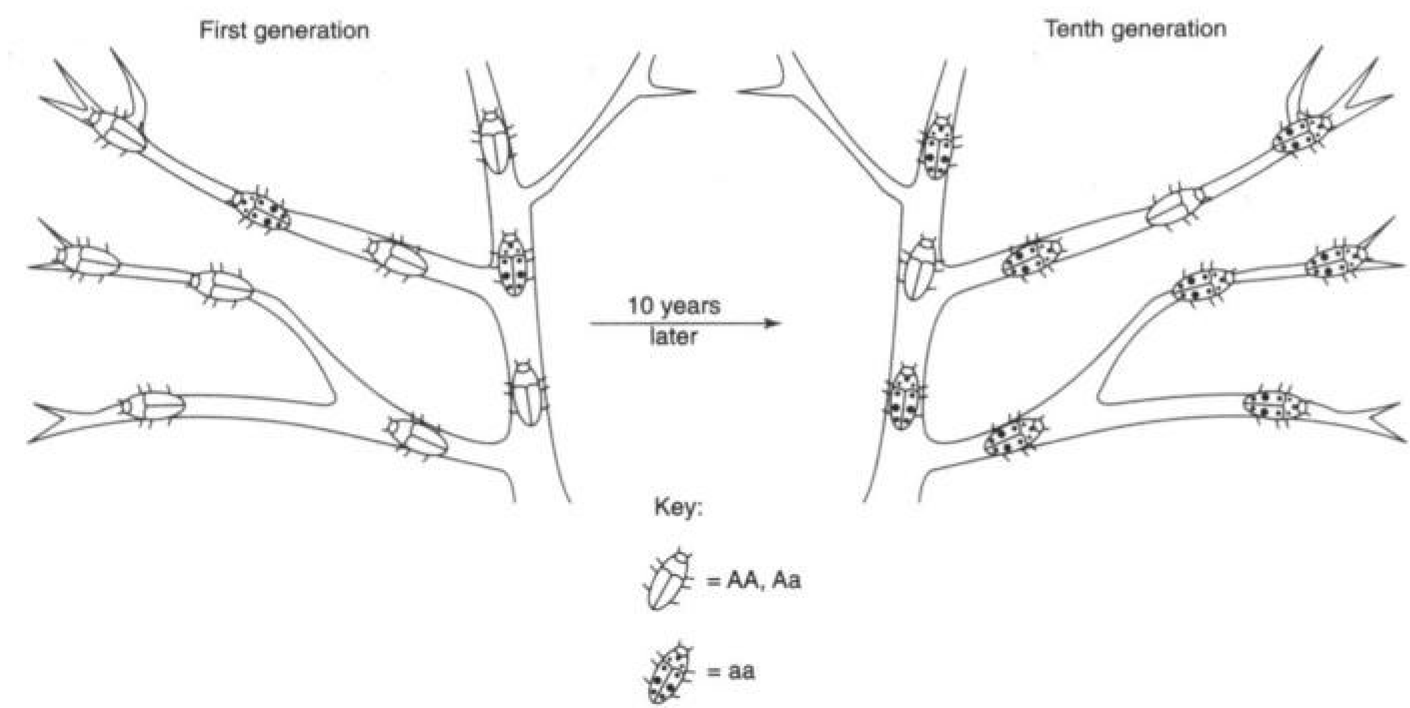
(1) use and disuse

(2) reproductive isolation

(3) homologous structures

(4) punctuated equilibrium

6. The diagram below illustrates the change that occurred in the frequency of phenotypes in an insect population over 10 generations.



A probable explanation for this change would be that over time there was

(1) a decrease in the adaptive value of gene a

(2) an increase in the adaptive value of gene a

(3) an increase in the population of this insect

(4) a decrease in the mutation rate of gene A

7. According to Darwin's theory of evolution, differences between species may result from

(1) the disuse of body structures

(2) the transmission of acquired characteristics

(3) natural selection

(4) mutagenic agents

8. The concept that new varieties of organisms are still evolving is best supported by the

(1) increasing need for new antibiotics

(2) increasing number of individuals in the human population

(3) decreasing number of new fossils discovered in undisturbed rock layers

(4) decreasing activity of photosynthetic organisms due to warming of the atmosphere

9. Two nucleotide sequences found in two different species are almost exactly the same. This suggests that these species

(1) are evolving into the same species

(2) contain identical DNA

(3) may have similar evolutionary histories

(4) have the same number of mutations

10. The theory that evolutionary change is slow and continuous is known as

(1) punctuated equilibrium

(2) geographic isolation

(3) speciation

(4) gradualism

11-12. Base your answers to questions 11 and 12 on the information below and on your knowledge of biology.

Before the Industrial Revolution, a light-colored variety of peppered moth was well camouflaged among light-colored lichens that grew on the bark of trees around London. A dark-colored variety of the peppered moth probably existed but was rarely observed because it was so easily seen by birds and eaten. When industry was introduced in London, soot killed the pollution-sensitive lichens, exposing dark tree bark. As a result, the dark-colored variety of the moth became the better camouflaged of the two moth varieties.

11. In this situation, what is the relationship between the birds and the moths?

(1) producer-consumer

(2) predator-prey

(3) parasite-host

(4) autotroph-heterotroph

12. Identify one way in which humans influenced the change in the populations of the peppered moth.

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13. When Charles Darwin was developing his theory of evolution, he considered variations in a population important. However, he could not explain how the variations occurred. Name two processes that can result in variation in a population. Explain how these processes actually cause variation. [2 points]

VII. CONTINUITY OF LIFE BY MEANS OF REPRODUCTION

KEY IDEA 4-REPRODUCTIVE CONTINUITY The continuity of life is sustained through reproduction and development.

Species produce more of their own kind through the process of reproduction. In a sense, species are able to transcend the life spans of individual members of the species by passing along the genetic information contained in their reproductive cells. In asexual reproduction, the parent organism passes an exact copy of its genetic makeup to the offspring. In sexual reproduction, the father and mother each contribute 50 percent of the genetic information needed to produce the new individual. For this reason, the offspring of sexual reproduction resemble, but are not exactly like, the parents. A zygote (fertilized egg) contains all the genetic information needed to produce a complete organism. Development of the embryo is a highly regulated process that involves mitosis and differentiation. It is sensitive to the environmental conditions in which it is occurring. Reproductive technologies such as cloning and genetic engineering have medical, agricultural, and ecological applications.

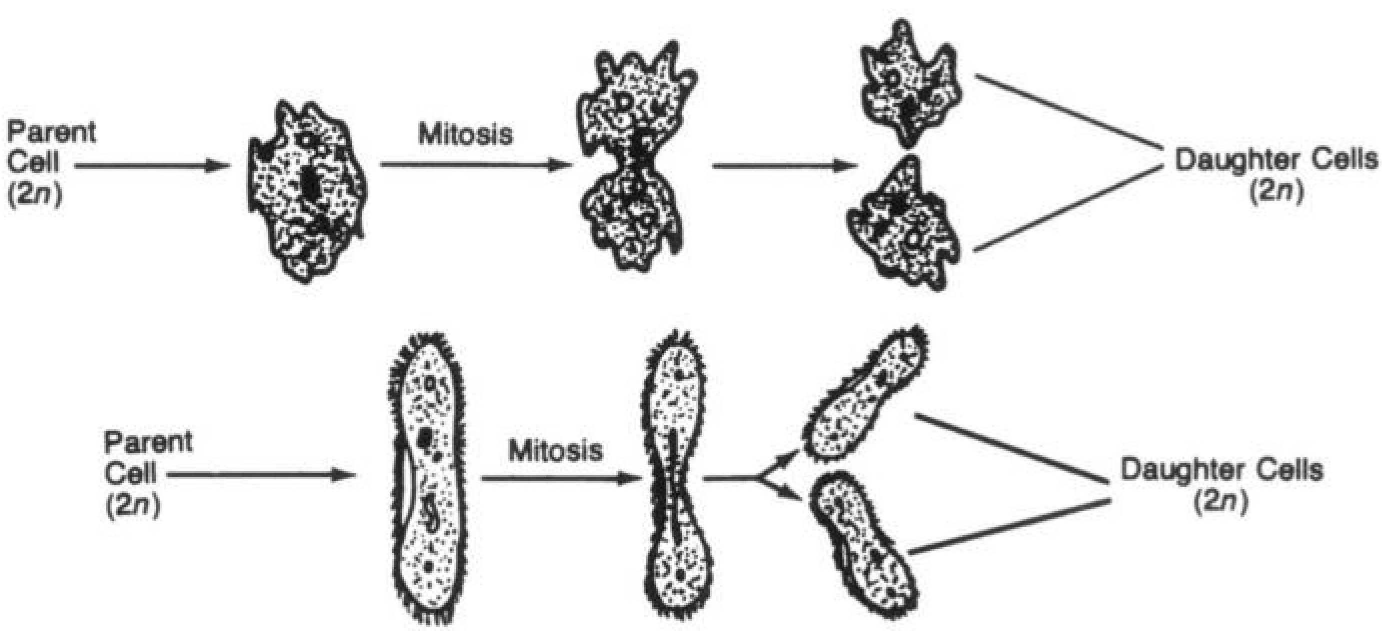
Mechanisms of Reproduction

Performance Indicator 4.1 The student should he able to explain how organisms, including humans, reproduce their own kind.

Reproduction and development are necessary for the continuation of any species. Cells have finite life expectancies. After formation by mitosis or fertilization, each new cell undergoes a period of growth followed by mitotic cell division. Growing evidence points to the fact that such cells have a limit to the number of times they can reproduce before they age and die. When cells specialize, their reproductive potential becomes significantly limited and aging becomes a more influential factor in their life expectancy. For all cells and all organisms, death is a certainty. Therefore, the only way that a species can be continued is through the reproductive process. The living material and genetic information passed from one generation to the next literally perpetuate the species.

Some organisms reproduce asexually with all the genetic information coming from one parent. Other organisms reproduce sexually with half the genetic information typically contributed by each parent. Cloning is the production of identical genetic copies. All types of asexual reproduction have in common the production of new organisms from a single parent organism. However, the process is carried on differently by different living things. Some types of asexual reproduction are as follows.

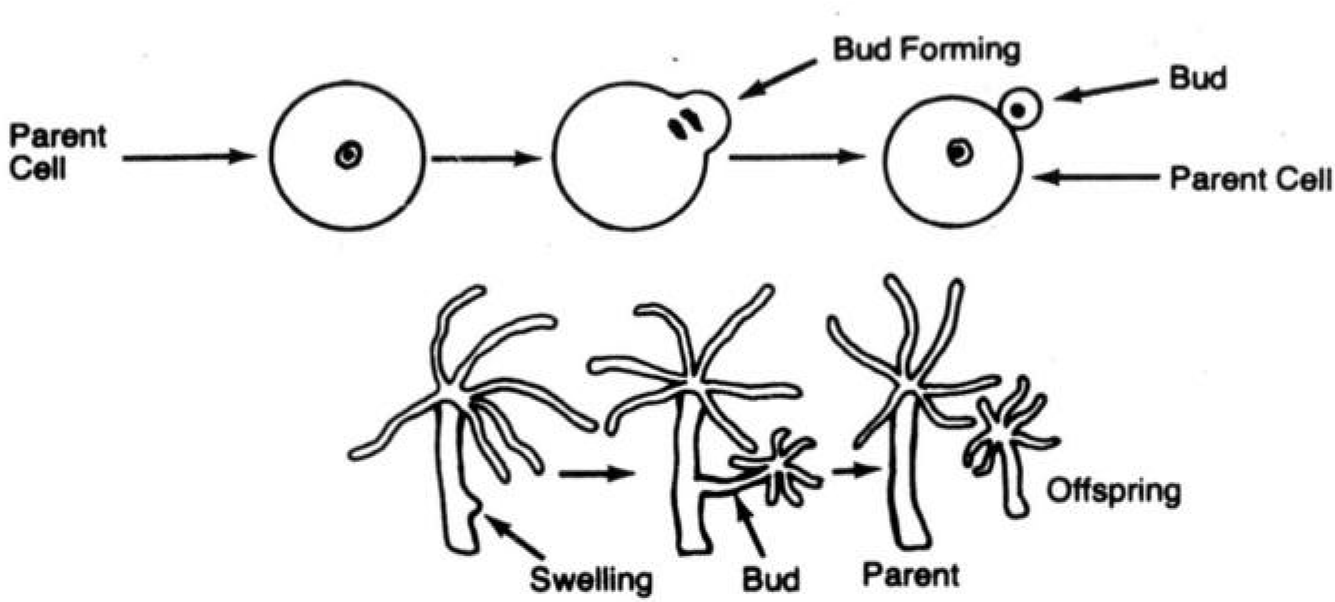
Binary fission is accomplished when a single cell undergoes mitosis followed by equal cytoplasmic division. This forms two daughter cells each having roughly the same size and shape and containing identical genetic information. Binary fission is carried on by many species of unicellular organisms, including the paramecium and the ameba. Bacteria are also known to reproduce in this manner.



Binary Fission in Ameba (above) and Paramecium (below)

Budding is accomplished when mitosis is followed by unequal cytoplasmic division. This results in daughter cells of unequal size that contain identical genetic information. The larger of the two cells may divide rapidly several more times, producing a chain or colony of daughter cells. Budding of this sort occurs commonly in yeast. A second form of budding occurs in certain simple multicelled animals, including the hydra. Undifferentiated cells begin to divide rapidly, forming a new, smaller organism from the tissues of the parent. This bud, genetically identical to the parent, then separates from the parent and begins to undergo rapid growth as an independent organism.

Sporullation is the formation of specialized reproductive cells, known as spores, within the parent organism. Each spore contains a nucleus surrounded by cytoplasm. When the spores are released from the parent plant and land in an environment containing conditions favorable to their growth, they begin to undergo mitotic division. The spores of most species require moisture and warmth to germinate. The mitotic divisions result in the formation of a new multicellular organism genetically identical to the original parent organism. This type of sporulation is carried on by fungi, mosses, and ferns.



Budding in Yeast (above) and Hydra (below)

Regeneration involves the production of one or more new organisms from the severed parts of a single parent organism. The pieces of cut-up planaria worm may frequently grow back lost tissues to produce as many as four or five new, identical planaria worms. Starfish cut into pieces that contain part of the central disk area may undergo regeneration that produces several new, genetically identical starfish. The term "regeneration" may also be used to refer to the production of new tissues to replace those lost or damaged by accident or disease. In both cases, invertebrate animals, with less highly differentiated tissues than those of vertebrates, are known to display a higher degree of regenerative ability than vertebrate animals.

Vegetative propagation is a general term referring to any of several forms of asexual reproduction carried on by multicellular plants. An aspect common to all types of vegetative propagation is the production of new plant organisms from the leaves, stems, or roots (vegetative parts) of the parent plant rather than from the flower (reproductive part). As in other forms of asexual reproduction, the new organisms produced by vegetative propagation are genetically identical to the parent. Examples of vegetative propagation include cuttings, bulbs, tubers, runners, and grafting.

Cloning is a term that refers to the production of a group of genetically identical offspring from the cells of a single parent organism that would normally reproduce by sexual means. Cloning has been attempted with varying success with a number of different organisms, both plant and animal. Although the process remains experimental in animals, it has proven to be quite successful in plants. It is used extensively in the production of certain commercial crops. Its main advantage is that organisms with desirable combinations of traits, which would otherwise be changed in sexual reproduction, can be reproduced rapidly, with no alteration of their phenotypic combinations. Each of the genetically identical offspring is known as a clone.

The processes of meiosis and fertilization are key to sexual reproduction in a wide variety of organisms. The process of meiosis results in the production of eggs and sperm that each contain half of the genetic information. During fertilization, gametes unite to form a zygote, which contains the complete genetic information for the offspring. Sexual reproduction involves the production and fusion of sex cells (gametes) of two parent organisms. This process ensures variations in a species. Key to this process is the production of monoploid (n) gametes from the diploid (2n) cells of the parent, using the process of meiotic cell division. Meiotic cell division, also known as meiosis, occurs in distinct stages.

- Replication of the cell's single-stranded chromosomes, forming doublestranded chromosomes, is the first event in the process of meiosis. The chromatids resulting from this replication are chemical and genetic duplicates of the original chromosome strands.

- Synapsis, the second phase of meiosis, is characterized by the close pairing of homologous chromosomes, forming groupings of four chromatids. Such groupings are known as tetrads.

- Disjunction is the separation of homologous pairs into two groups as the cell enters the actual division phase. The result of disjunction is the formation of two sets of double-stranded chromosomes. These migrate along a spindle apparatus to opposite poles of the cell.

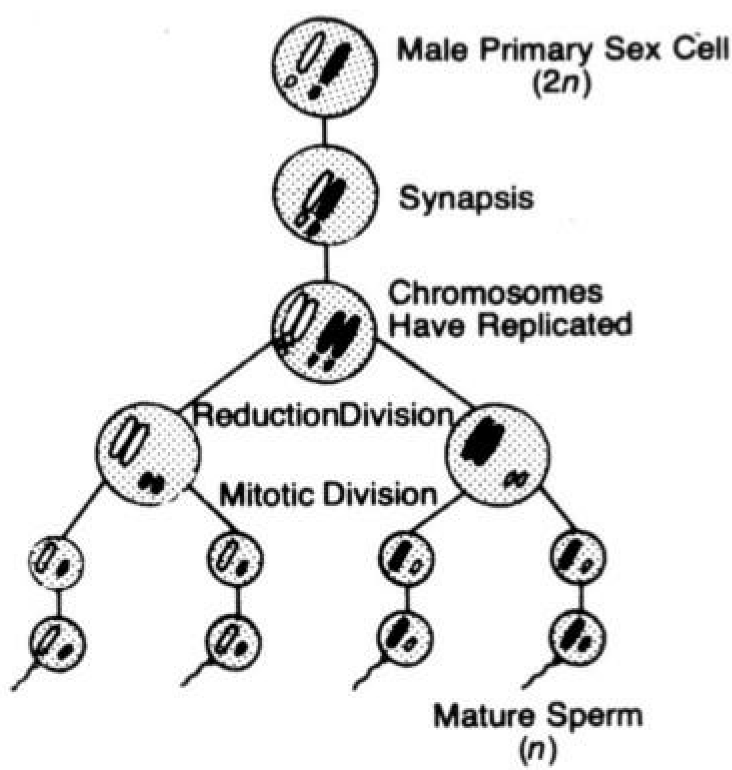
- First meiotic division (reduction division) follows disjunction and results in the formation of two separate cells, each of which contains the monoploid set of double-stranded chromosomes. The term "reduction division" refers to the fact that a diploid cell has been divided into two monoploid cells.

- Soon after the first meiotic division, the double-stranded chromosomes line up in the center of the two new cells. The centromeres joining the chromatids replicate. The resulting single-stranded chromosomes migrate along a spindle apparatus to opposite poles of the cell.

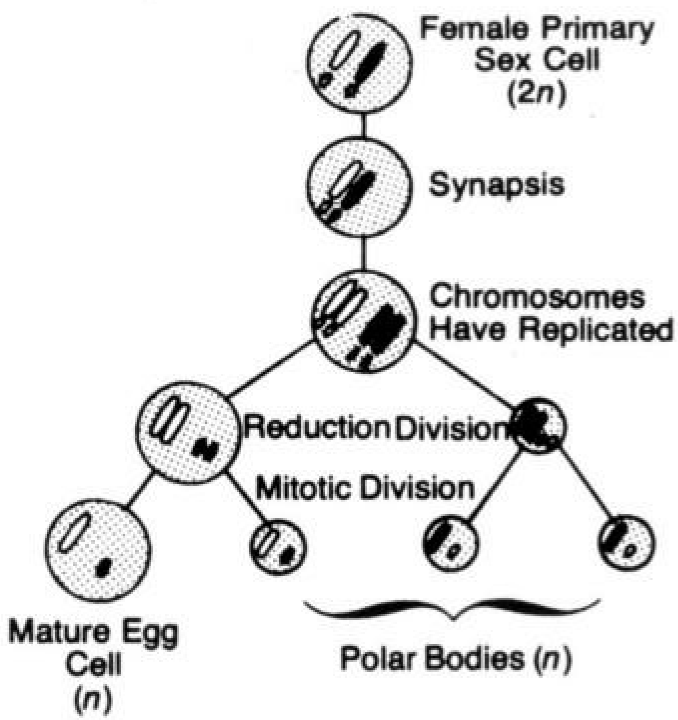
- Second meiotic division involves a second cytoplasmic division and the formation of four daughter nuclei, each of which contains a monoploid set of single-stranded chromosomes. The cells that result from this process will mature into specialized reproductive cells known as gametes.

Spermatogenesis is a specific type of gametogenesis carried on in the male gonad, or testis. The kind of gamete produced by the testis is the sperm cell. In spermatogenesis, the meiotic process normally results in the production of four monoploid nuclei housed within individual cells. Each of these cells has the potential to mature into a functional, motile sperm cell containing its own monoploid nucleus.

Oogenesis is a specific type of gametogenesis carried on in the female gonad, or ovary. The kind of gamete produced by the ovary is the egg cell. In oogenesis, the meiotic process normally results in the production of four monoploid nuclei housed within individual cells. Only one of these cells has the potential to mature into a functional egg cell containing a monoploid nucleus. The other three cells, known as polar bodies, degenerate and are eventually reabsorbed by the body.



Spermatogenesis



Oogenesis

During fertilization, fusion of a monoploid sperm cell and a monoploid egg cell results in the formation of a diploid zygote, or fertilized egg. The restoration of the diploid condition allows the zygote to undergo mitotic divisions that eventually lead to the production of a new organism. Because the genes of the father and mother are combined in the offspring, the offspring resembles both parents but is not identical to either.

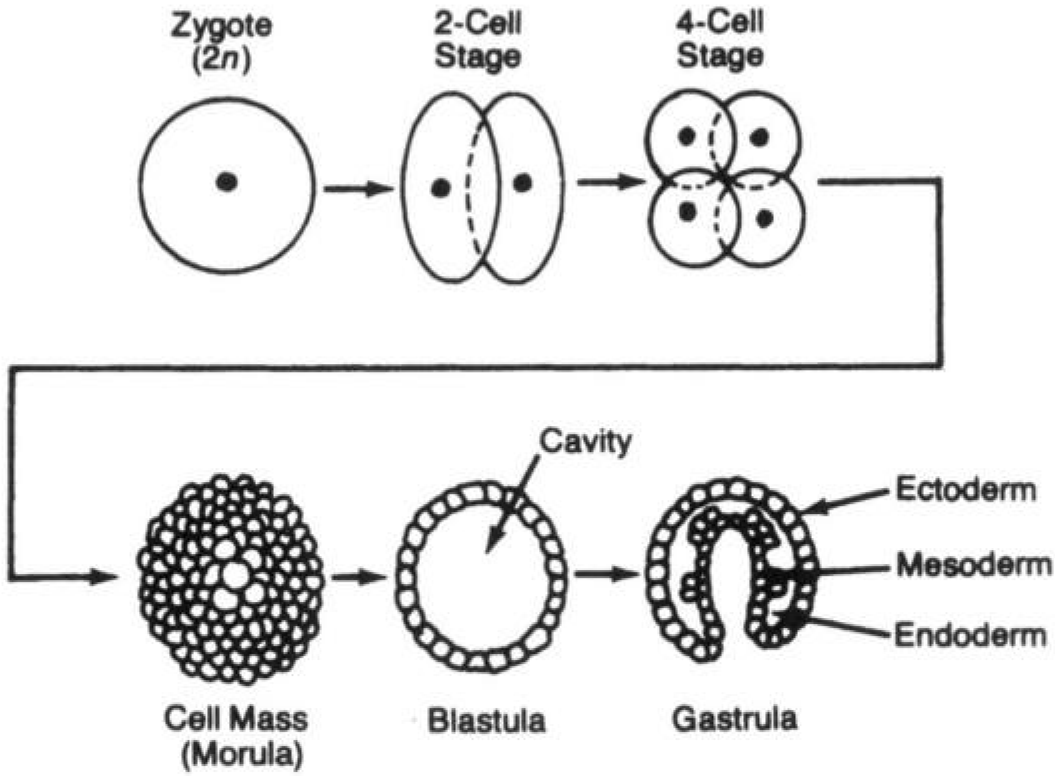
Early Development

The zygote may divide by mitosis and differentiate to form the specialized cells, tissues, and organs of multicellular organisms. After fertilization, the zygote begins to undergo a series of rapid mitotic divisions. This process, known as cleavage, increases the number of cells in the growing cell mass. Little cell growth accompanies cleavage, resulting in a reduction of cell size with each division. A zygote undergoing cleavage is an embryo. As cleavage continues, distinct stages of development may be noted that differ with different species:

- Blastula-a hollow ball of cells during which the basic body plan becomes established.
- Gastrula-an indented blastula in which cells begin to move into the positions they will have in the adult offspring. Basic cell differentiation is thought to occur as this phase is reached.
- Embryo-a stage of development in which the new living organism takes on the final shape and differentiation it will have when it hatches or is born, depending on the species involved.

Differentiation is how embryonic cells become specialized into tissues that perform the various tasks throughout the body. As shown on the following chart, these tissues arise from three embryonic cell layers:

- Ectoderm-outer epidermis, nervous system
- Endoderm-digestive tract lining, respiratory tract lining, portions of the liver and pancreas
- Mesoderm-muscles, circulatory system, skeleton, excretory system, gonads



Cleavage and Differentiation

Human Reproduction

Human reproduction and development are influenced by factors such as gene expression, hormones, and the environment. The reproductive cycle in both males and females is regulated by hormones such as testosterone, estrogen, and progesterone. Development of a human embryo is governed by many factors. Principal among these factors is the precise genetic information provided to the embryo by the parents. The physical and functional traits inherited by the embryo will comprise a combination of the traits of the father and the mother. Evidence supports the probability that basic behavioral traits are inherited in a similar fashion. Hormones produced by the embryo as it develops, as well as those of the mother, will also help to shape the embryo. The environment of the embryo is also of extreme importance in determining the characteristics of the child. Growing evidence suggests that the health, diet, and use of drugs, tobacco, and alcohol by the mother during pregnancy can have a powerful effect on the developing embryo and subsequently on the child after birth.

The reproductive process in adult humans, like most physiological activities, is governed by hormones. Testosterone in males is important in the production of male secondary sex characteristics, including the production of healthy sperm cells. In females, the hormones estrogen and progesterone, among others, are essential in the production of female secondary sex characteristics, including the production and maturation of healthy egg cells.

The menstrual cycle, which begins at puberty, is a hormone-controlled process in the human female that is responsible for the monthly release of mature eggs. The average duration of the menstrual cycle is 28 days. The four stages of the menstrual cycle are as follows.

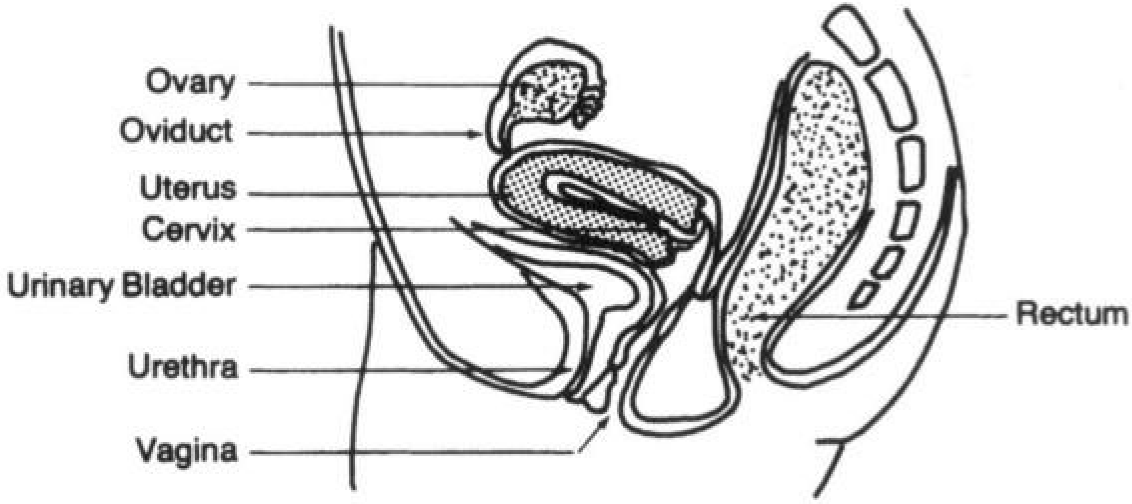
- Follicle stage-As the cycle begins, a single egg matures within the ovarian follicle under the influence of follicle stimulating hormone (FSH) produced by the pituitary gland. The ovary begins to produce estrogen, which stimulates the lining of the uterus to thicken and vascularize. This portion of the cycle takes approximately 14 days to complete.

- Ovulation stage-This portion of the cycle involves the release of the mature egg from the follicle into the oviduct. On average, this event occurs about day 14 of the cycle.

- Corpus luteum stage-After ovulation, the cells that made up the ovarian follicle begin to change under the influence of lutenizing hormone (LH), which is produced by the pituitary gland. The resulting structure, known as the corpus luteum, secretes the hormone progesterone, which helps to ready the uterine lining for the possible implantation of a fertilized egg. This portion of the cycle continues for about 8 to 10 days.

- Menstruation stage-If no fertilized egg is received in the uterus within a few days after ovulation, the uterine lining begins to break down. The disintegrated tissue and blood are expelled from the body via the vaginal canal during menstruation. This aspect of the cycle normally occurs over a few days.

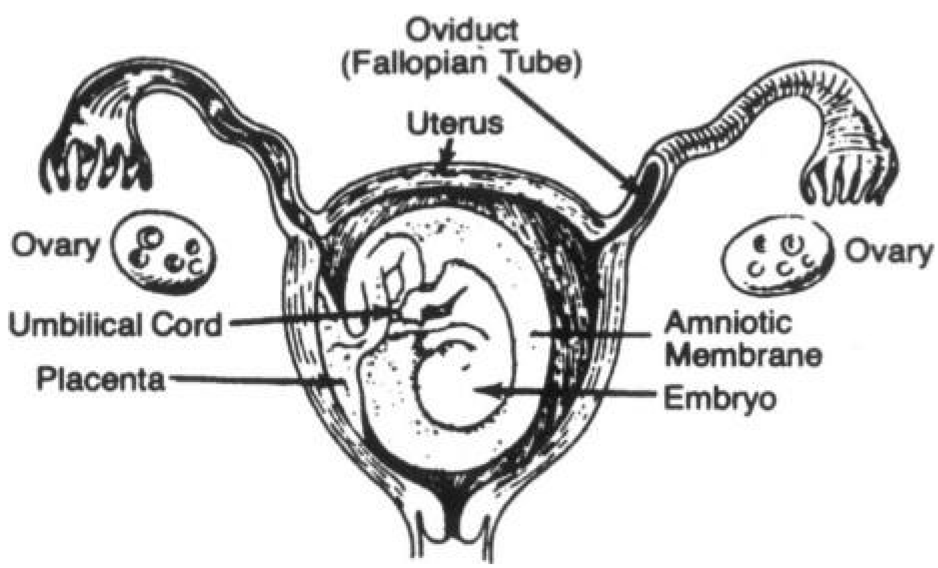
Human Female The structures and functions of the human female reproductive system, as in almost all other mammals, are designed to produce gametes in ovaries, allow for internal fertilization, support the internal development of the embryo and fetus in the uterus, provide essential materials through the placenta, and provide nutrition through milk for the newborn. In human females, ova (egg cells), the female gametes, are produced by meiosis in the ovary. Two ovaries are located in the lower abdomen. After it has been formed, the egg cell is stored in the follicle of the ovary until it matures and is released. Once released, the egg cell travels along a short tube, the oviduct (fallopian tube), to the uterus. The lower end of the female reproductive tract consists of the vagina, which functions to receive sperm cells during intercourse and later as the birth canal. Internal fertilization normally occurs in the oviduct, where sperm cells and the egg cell meet. The uterus acts as the internal development chamber after implantation of a fertilized egg in its lining. The lower end of the uterus is bounded by the muscular cervix.



Human Reproductive System: Female

Prenatal development includes all the processes of embryonic development that occur before birth. Prenatal development begins as soon as the egg is fertilized. The resulting zygote begins to undergo cleavage. Within 10 days after fertilization, the ball of cells resulting from cleavage, now known as an embryo, implants itself in the lining of the uterus. Once embedded in the uterine lining, the embryo undergoes the process of gastrulation. At the same time, the cells of the embryo begin to differentiate into the specialized tissues-and organs of the adult organism.

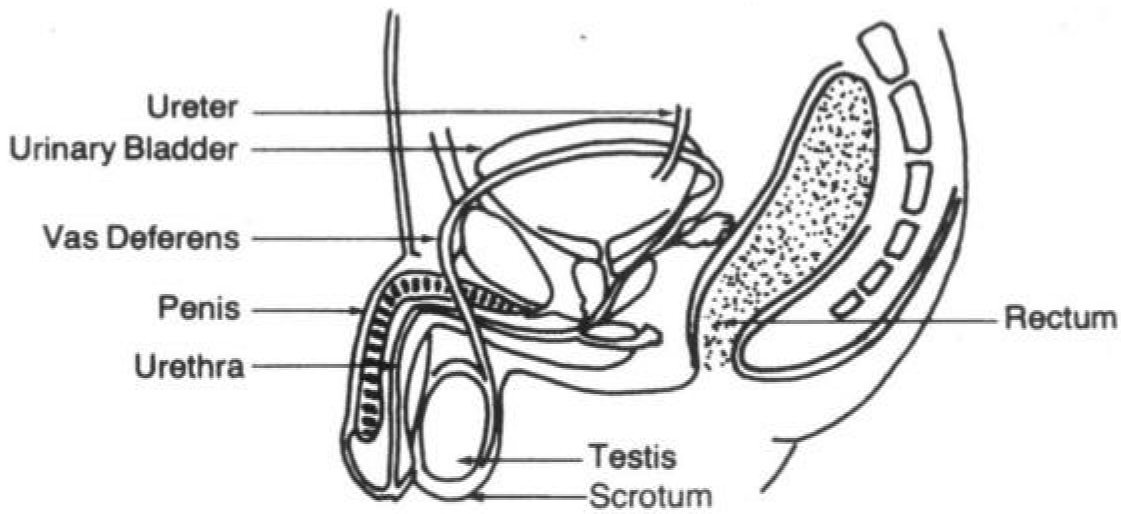
The tissues of the embryo and the mother grow together to form the placenta, the connection that allows nutrients and oxygen to pass from mother to embryo during the 9-month gestation period. Wastes such as carbon dioxide and urea pass by diffusion from the embryo's blood to that of the mother for excretion through the mother's excretory processes. The fetus (embryo) is connected to the placenta by the umbilical cord. The fetus is enclosed in an amnion sac filled with amniotic fluid.



Placental Development

Birth occurs after a period of development, known as the gestation period, of approximately 9 months. Strong contractions of the muscular uterus force the baby headfirst through the cervix and vagina to the outside of the body, where the baby begins to breathe, eat, and excrete wastes on his/her own. Milk produced by the mammary glands provides food specialized for newborns.

Human Male The structures and functions of the human male reproductive system, as in other mammals, are designed to produce gametes in testes and make possible the delivery of these gametes for fertilization. In human males, sperm cells, the male gametes, are produced by meiosis in the testis. Two testes are located in an internal pouch, the scrotum, which extends from the wall of the lower abdomen. Temperatures in the scrotum are generally 1°C to 2°C cooler than normal body temperature. This reduced temperature is optimum for sperm production. When first formed, the sperm are inactive and are stored in the testis until activated and released. Once released, the sperm travel along a series of tubes, the vas deferens, to the exterior of the body. Along this route, a number of glands add various fluids to the sperm cells to activate them and increase their volume. This mixture of sperm cells and fluid is known as semen.



Human Reproductive System: Male

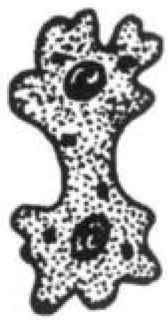
The urethra is a tube that carries the activated sperm along the last portion of its journey in the body. The urethra extends from the urinary bladder, at its connection with the vas deferens, to the exterior of the body through the penis. In human beings, the penis is the structure that permits internal fertilization through direct implantation of sperm into the female reproductive tract.

Embryonic Development

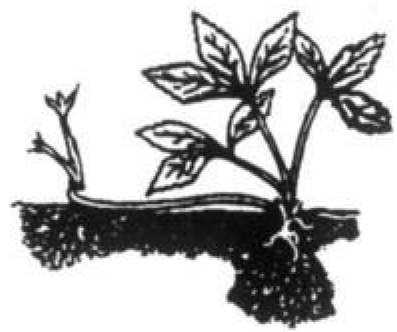
In humans, the embryonic development of essential organs occurs in early stages of pregnancy. The embryo may encounter risks from faults in its genes and from its mother's exposure to environmental factors such as inadequate diet, use of alcohol/drugs/tobacco, other toxins, or infections throughout her pregnancy. The human embryo begins to develop its organs and organ systems very early in the gestation period. During this development period, the tissues of the embryo/fetus are extremely susceptible to the effects of outside influences. These influences can include the general health of the mother, the diet maintained by the mother, or use of alcohol, drugs, or tobacco products by the mother. Because the maternal and fetal blood supplies exchange soluble materials through the tissues of the placenta, any substances that enter the mother's blood can easily diffuse across the placental membranes to affect the fetal tissues. Substances easily tolerated by adult tissues can cause severe damage to the developing fetal tissues. A direct connection has been drawn between these environmental influences and learning disabilities, attention deficits, health problems, and physical deformities experienced by infants and young children.

QUESTION SET 2.7-CONTINUITY OF LIFE BY MEANS OF REPRODUCTION (ANSWERS EXPLAINED, P. 303)

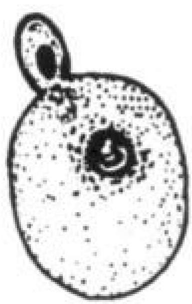
1. Which diagram represents binary fission?



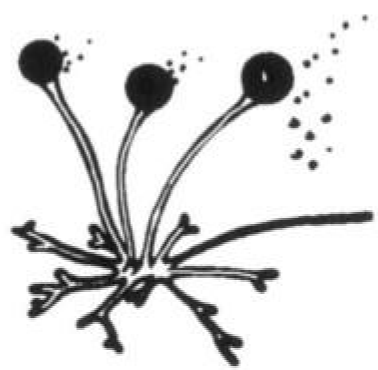
(1)



(3)



(2)



(4)

2. The process of meiotic cell division in a human male usually forms, from each primary sex cell,

(1) one diploid cell, only

(2) four diploid cells

(3) one monoploid cell, only

(4) four monoploid cells

3. Which sequence represents the correct order of events in the development of sexually reproducing animals?

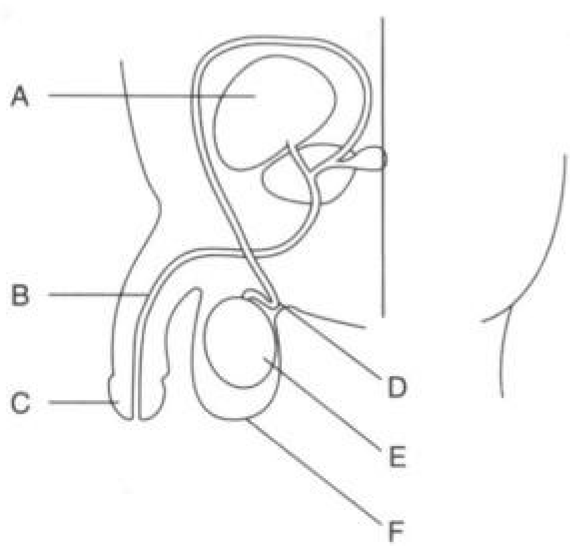
(1) fertilization → cleavage → differentiation → growth

(2) cleavage → fertilization → growth → differentiation

(3) growth → cleavage → fertilization → differentiation

(4) fertilization → differentiation → cleavage → growth

4-7. Base your answers to questions 4.though 7 on the diagrams below and on your knowledge of biology.



4. Which structures secrete hormones that regulate the development of secondary sex characteristics?

(1) A and J

(2) D and H

(3) F and I

(4) E and G

5. After sperm cells are deposited inside the female, the pathway they follow to reach the egg is from

(1) Hto Ito K

(2) J to K to H

(3) Kto Ito H

(4) G to H to I

6. Gametogenesis occurs within structures

(1) A and J

(2) E and G

(3) B and I

(4) D and H

7. Which structures are directly affected by hormones involved in the menstrual cycle?

(1) C and E

(2) A and D

(3) G and I

(4) 1 and J

8-10. Base your answers to questions 8 .through 10 on the information in the chart below and on your knowledge of biology.

STAGES OF THE MENSTRUAL CYCLE

Stage	Event
A	Periodic shedding of the thickened uterine lining
B	Release of the egg
C	Production of progesterone by tissue in a follicle
D	Maturation of the egg and secretion of estrogen

8. Which structure does the egg released in stage B normally enter first?

(1) cervix

(2) vagina

(3) uterus

(4) oviduct

9. Which stage is represented by letter A?

(1) ovulation

(2) menstruation

(3) follicle

(4) corpus luteum

10. Which sequence best represents the order of stages in the menstrual cycle?

(1) $D \rightarrow B \rightarrow C \rightarrow A$

(2) $A \rightarrow B \rightarrow D \rightarrow C$

(3) $C \rightarrow A \rightarrow B \rightarrow D$

(4) $A \rightarrow B \rightarrow C \rightarrow D$

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11. In human males, sperm cells are suspended in a fluid medium. The main advantage gained from this adaptation is that the fluid

(1) removes polar bodies from the surface of the sperm

(2) activates the egg nucleus so that it begins to divide

(3) acts as a transport medium for sperm

(4) provides currents that propel the egg down the oviduct

12. Substances can diffuse from the mother's blood into the fetal blood through the structure known as the

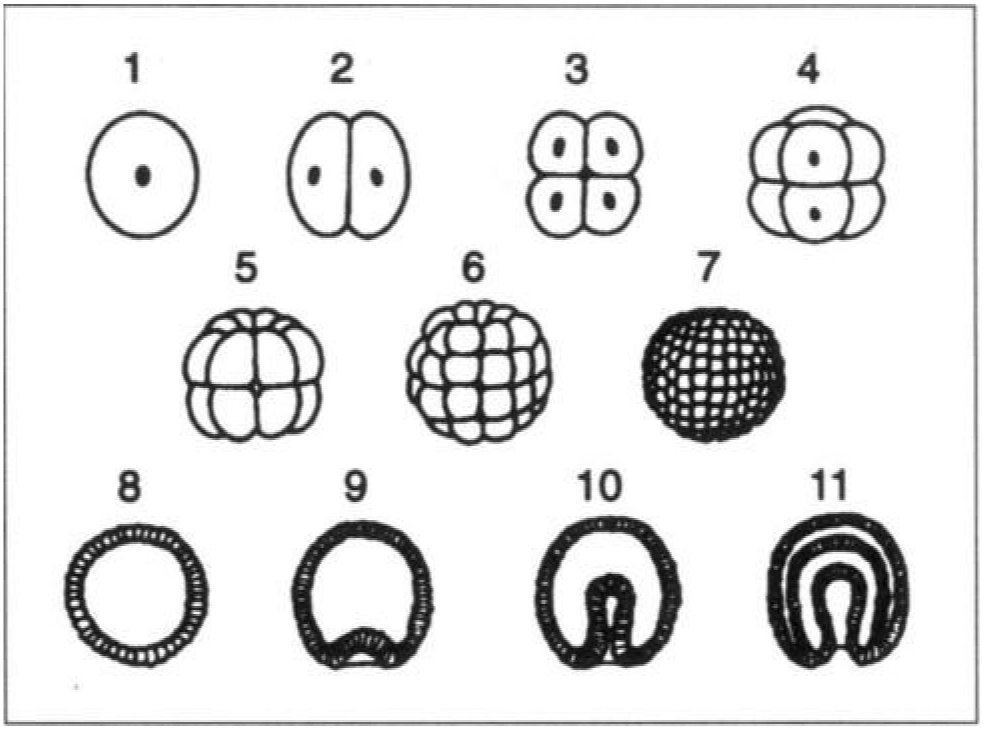
(1) amnion

(2) fallopian tube

(3) yolk sac

(4) placenta

13-15. Base your answers to questions 13 through 15 on the diagram below and on your knowledge of biology.



13. Which diagram shows the first appearance of the distinct layer of cells that will form the muscular, skeletal, and circulatory systems?

(1) 11

(2) 8

(3) 6

(4) 4

14. If stages 1 through 4 represent developmental stages of a human, where in the human female would these stages normally occur?

(1) ovary

(2) vagina

(3) oviduct

(4) uterus

15. Which events must occur immediately before the sequence represented in the diagrams can take place?

(1) gametogenesis and fertilization

(2) menstruation and menopause

(3) prenatal development and gestation

(4) placental formation and metamorphosis

16-18. Base your answers to questions 16 through 18 on the information and data tables below and on your knowledge of biology. Use one or more complete sentences to answer each question.

Drinking alcohol during pregnancy can cause the class of birth defects known as fetal alcohol syndrome (FAS). Scientists do not yet understand the process by which alcohol damages the fetus. Evidence, however, shows that the more a pregnant woman drinks, the greater the chances that the child will be affected and the birth defects will be serious. Some evidence indicates that even low levels of alcohol consumption can cause intellectual and behavioral problems.

INFANT CHARACTERISTICS

Characteristics (Average)	**Alcohol Use During Pregnancy**	
	Drinker	**Nondrinker**
Weeks of development before birth	36.9	38.7
Birth weight (g)	2,555	3,094
Birth length (cm)	46.8	50.1
Head circumference (cm)	32.1	34.5

PHYSICAL ABNORMALITIES DETECTED IN INFANTS AT BIRTH

Physical Abnormalities	**Alcohol Use During Pregnancy**	
	Drinker (Percentage of 40 Infants)	**Nondrinker** (Percentage of 80 Infants)
Low birth weight	73	12
Small brain	33	0
Flattened nasal bridge	8	0
Abnormal facial features	15	0
Spinal defects	8	0
Heart defects	8	0

16. Do the data in the tables justify scientists' conclusions that alcohol causes physical abnormalities at birth by interfering with the normal development of the fetus? Defend your position with supporting data.

17. What additional data would be needed to better support the scientists' conclusions?

18. Explain why alcohol consumption by the mother is especially harmful during the early stages of pregnancy.

19. Write one or more paragraphs that compare the two methods of reproduction, asexual and sexual. Your'answers must include at least:

- one similarity between the two methods
- one difference between the two methods
- one example of an organism that reproduces by asexual reproduction
- one example of an organism that reproduces by sexual reproduction

VIII. DYNAMIC EQUILIBRIUM IN LIVING THINGS

KEY IDEA 5-DYNAMIC EQUILIBRIUM AND HOMEOSTASIS Organisms maintain a dynamic equilibrium that sustains life.

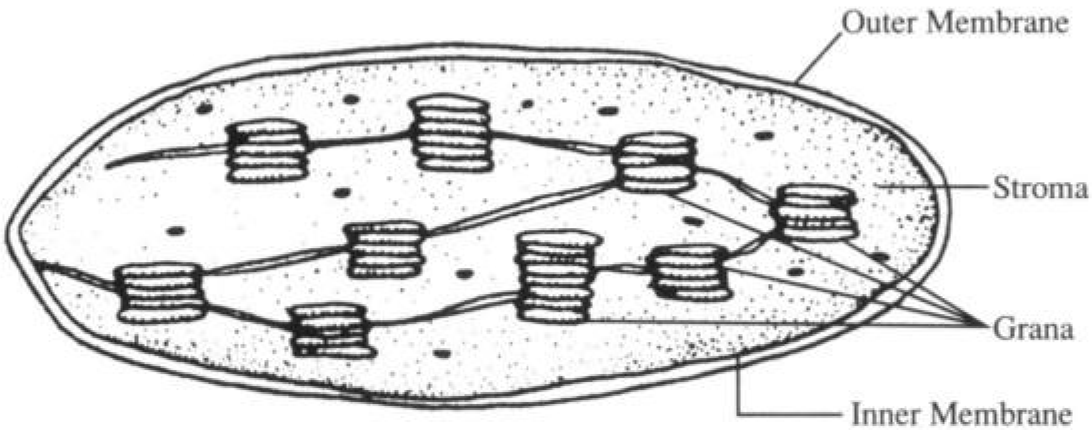
Energy and materials must be constantly provided to living systems to keep them operating. Within the cell, biochemical processes occur within a very narrow range of conditions. These conditions are maintained by the very biochemical processes that require their stability. This maintenance is accomplished by the responsiveness of living systems to the environmental changes that occur around the cell. These responses can range from simple biochemical reactions to complex behaviors and result in a dynamic equilibrium called homeostasis. When the feedback mechanisms that create and maintain homeostasis fail, the living condition is threatened, and disease or death can result.

Biochemical Processes and Homeostasis

Performance Indicator 5.1 The student should be able to explain the basic biochemical processes in living organisms and their importance in maintaining dynamic equilibrium.

Photosynthesis The energy for life comes primarily from the Sun. Photosynthesis provides a vital connection between the Sun and the energy needs of living systems. The Sun, actually a medium-sized star, is the ultimate source of all energy on Earth. It produces radiant energy in many forms, some of which is detectable by humans as light. Visible sunlight appears white but actually contains the wavelengths needed to produce all colors. In photosynthesis, the energy of sunlight is trapped and converted into the chemical bond energy of organic compounds such as sugar. Once trapped in the chemical bonds of these compounds, the energy of sunlight is made available to all living things in a more stable form. Green plants provide a vital link between the Sun's energy and the life processes of all living things.

Plant cells and some one-celled organisms contain chloroplasts, the site of photosynthesis. The process of photosynthesis uses solar energy to combine the inorganic molecules carbon dioxide and water into energy-rich organic compounds (for example, glucose) and release oxygen to the environment. Cells contain functional components, known as organelles, that perform a variety of different functions. An organelle found in the cells of green plants and algae is the chloroplast. It absorbs sunlight and converts the energy to chemical bond energy. Chlorophyll, a green pigment found in the chloroplast, absorbs light energy. In the presence of the proper enzymes, the atoms of carbon dioxide (CO,) and water (H20) are rearranged to form the more complex organic molecule glucose (C6H1206). A by-product of this process is molecular oxygen (02).



Chloroplast

A more detailed study of the photosynthetic process reveals that it actually consists of two separate processes. Each is characterized by its own set of chemical reactions.

Photochemical (light) reactions Stacked layers of chlorophyll-containing membranes within the chloroplast, known as grana, contain the enzymes that catalyze this process. The light energy absorbed by the chlorophyll and other pigments on these grana is used to split water molecules into their component elements, hydrogen and oxygen. This process is known as photolysis (splitting with light) and involves the production of an energy-carrying molecule known as adenosine triphosphate (ATP). Atoms of oxygen recombine to form molecular (atmospheric) oxygen, which is released as a gas. The hydrogen released is transferred to the next phase of the process by a hydrogen carrier compound.

Carbon-fixation (dark) reactions A second set of photosynthetic reactions combines the released hydrogen atoms with the atoms making up carbon dioxide. An intermediate product of this reaction is a carbohydrate-like, three-carbon compound known as phosphoglyceraldehyde (PGAL). This compound may be used by the cell to synthesize several other compounds such as glucose. The name carbon-fixation reactions is derived from the fact that carbon atoms are fixed in place in a stable form as a result of this process. This set of reactions occurs in the stroma of the chloroplast. The stroma lies between the grana.

In all organisms, organic compounds can be used to assemble other molecules such as proteins, DNA, starch, and fats. The chemical energy stored in bonds can be used as a source of energy for life processes. The compound glucose, which results from photosynthesis, may be used in many ways by the cell. Some of these include the following.

- Direct use as a source of energy in cellular respiration, which is carried on by all living things, plants as well as animals.

- Conversion, for purposes of storage, into more complex forms of carbohydrates, such as starch, by the process of dehydration synthesis. Such storage carbohydrates must be reconverted to simpler molecules by intracellular digestion before they can be used in metabolic processes or transported to other sites in the organism.

- Conversion into other types of metabolic compounds, such as proteins, lipids, and nucleic acids.

Photosynthesis is perhaps the single most significant biochemical process carried on by living things. Significant results of the photosynthetic reactions include the following.

- Carbohydrates manufactured as a result of photosynthesis are used by virtually all living things as a source of cellular energy. This energy is released in a controlled fashion in the process of cellular respiration.

- Oxygen gas released as a by-product of the photosynthetic reactions is the principal source of atmospheric oxygen required by most living things for cellular respiration. Reductions in photosynthetic rate can have disastrous effects on such life-forms by reducing the concentration of oxygen in the air or water environment.

Respiration In all organisms, the energy stored in organic molecules may be released during cellular respiration. This energy is temporarily stored in ATP molecules. In many organisms, the process of cellular respiration is concluded in mitochondria. ATP is produced more efficiently, oxygen is used, and carbon dioxide and water are released as wastes. One of the fundamental differences between living and nonliving matter is living matter's continual need for energy. The chemical bonds between atoms of food molecules provide the energy used by all living organisms to sustain life. Respiration is how this energy is released for use in the cell. Once released, it becomes available to the cell for use in all other life functions. Respiration takes place in cell organelles known as the mitochondria.

Cellular respiration is a biochemical process that includes the reactions used by cells to release energy from organic molecules such as glucose. The energy released as a result of these reactions is temporarily stored in the bonds of molecules of adenosine triphosphate (ATP). This energy may be released for use in cell processes when ATP is converted to adenosine diphosphate (ADP) and phosphate (P). Like other reactions that occur in the cell, the reactions of respiration are controlled by enzymes. The following equation illustrates the reactions involving the formation of ATP:

$$H_2O + ATP \xrightarrow{\text{ATPase}} ADP + P + \text{energy}$$

The two forms of cellular respiration carried on by living things are known as aerobic (with oxygen) and anaerobic (without oxygen).

1. Anaerobic respiration is a form of cellular respiration carried on by cells in the absence of molecular oxygen. This process operates by means of chemical reactions catalyzed by enzymes located in the cytoplasm of the cell. Organisms typically employing this form of cellular respiration as their primary mode of energy production include certain bacteria and fungi (yeasts). Human beings have learned to take advantage of this process by using these organisms in the manufacture of foods such as cheese, buttermilk, and yogurt. These organisms also play an important role in the baking, wine-making, and brewing industries. Two principal types of anaerobic respiration occur.

   - Alcoholic fermentation is so called because one of the major byproducts produced in this process is ethyl alcohol:

$$\text{glucose} \xrightarrow{\text{enzymes}} \text{2 ethyl alcohol} + 2\ CO_2 + \text{2 ATP}$$

   - Lactic acid fermentation-which produces lactic acid as one of its by-products:

$$\text{glucose} \xrightarrow{\text{enzymes}} \text{2 lactic acid} + \text{2 ATP}$$

   Both types of anaerobic respiration are considered inefficient. The end products of both contain considerable amounts of energy that are not effectively released for use by the cell.

2. Aerobic respiration is a form of cellular respiration carried on by certain cells in the presence of molecular oxygen. This process operates by means of chemical reactions catalyzed by enzymes located primarily in the mitochondria of the cell. As in anaerobic respiration, the principal product of aerobic respiration is the energy released from organic molecules for use by the cell in other processes. Unlike anaerobic respiration, however, aerobic respiration uses molecular oxygen to release substantially more energy per glucose molecule metabolized. For this reason, aerobic respiration is a more efficient form of respiration than anaerobic respiration. In general, aerobic respiration may be illustrated as follows.

$$\text{glucose} + \text{6 oxygen} \xrightarrow{\text{enzymes}} \text{6 water} + \text{6 carbon dioxide} + \text{36 ATP}$$

   Like anaerobic respiration, aerobic respiration is characterized by a series of enzyme-catalyzed reactions that progressively convert glucose to end products and energy. These reactions are conceptually divided into two phases, known as the anaerobic phase and the aerobic phase.

- Anaerobic phase-Glucose molecules are converted to two molecules of pyruvic acid. The process is initiated through release of the energy stored in two molecules of ATP. Four molecules of ATP are formed in this conversion, resulting in a net gain of two molecules of ATP. A summary equation of this phase is as follows:

$$\text{glucose} + 2\ \text{ATP} \xrightarrow{\text{enzymes}} 2\ \text{pyruvic acid} + 4\ \text{ATP}$$

- Aerobic phase-The cell uses molecular oxygen to break down pyruvic acid further to form energy and the waste end products water and carbon dioxide. In this part of the process, an additional 34 molecules of ATP are formed. A summary equation of this phase is as follows:

$$2\ \text{pyruvic acid} + 6\ \text{oxygen} \xrightarrow{\text{enzymes}} 6\ \text{water} + 6\ \text{carbon dioxide} + 34\ \text{ATP}$$

The net gain of ATP molecules in aerobic respiration is 36, making it 18 times more efficient than anaerobic respiration. The significance of aerobic respiration is that usable energy is stored in the chemical bonds of the ATP molecules.

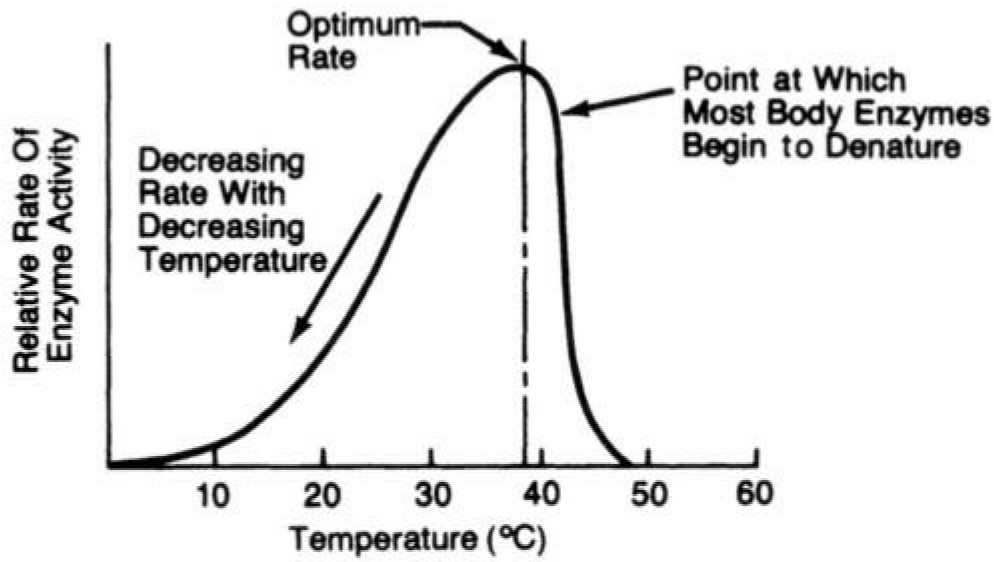
The energy from ATP is used by the organism to obtain, transform, and transport materials and to eliminate wastes. Cellular operations, primarily biochemical reactions, are energy-consuming activities. The energy in ATP is released to initiate these reactions if they are exothermic (energyreleasing) or to provide sustained energy if they are endothermic (energyconsuming). Active transport, in which materials are moved into or out of the cell against the concentration gradient, is a good example of an energyconsuming process. By using this process, the cell can obtain and concentrate needed materials, move them around the cell interior, and expel potentially toxic wastes to the exterior environment.

Enzymes

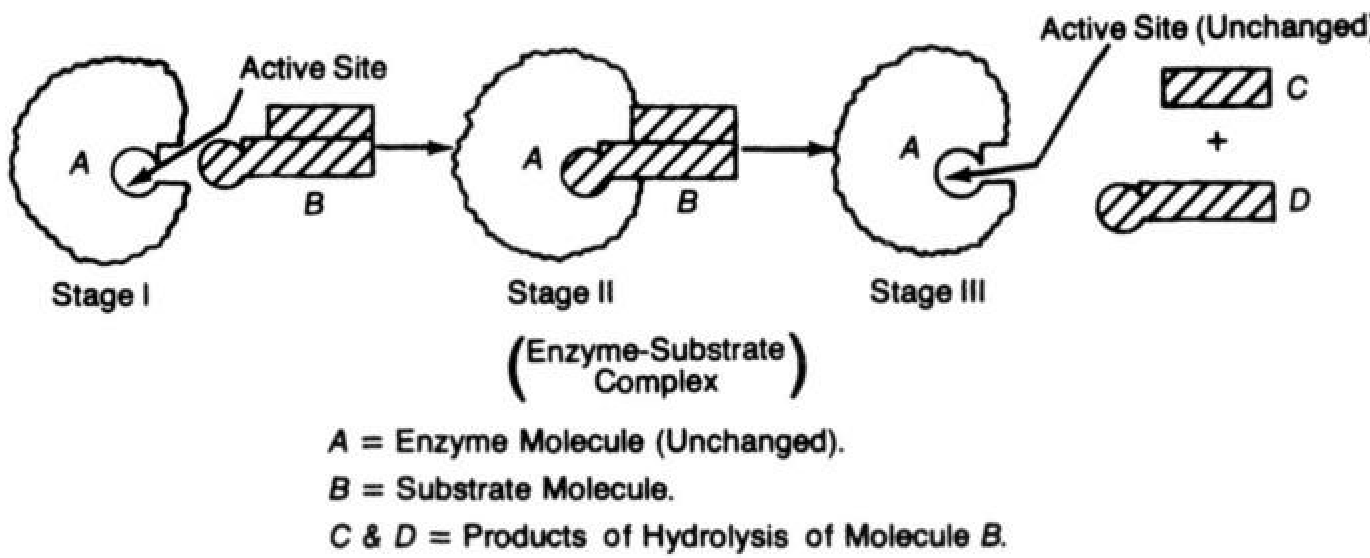
Biochemical processes, both breakdown and synthesis, are made possible by a large set of biological catalysts called enzymes. Enzymes can affect the rates of chemical change. The rate at which enzymes work can be influenced by internal environmental factors such as pH and temperature. The controlled nature of cellular chemical reactions is made possible through the actions of cellular enzymes. Enzymes regulate the rate at which the cell's chemical reactions occur. In this role, enzymes function as organic catalysts. Each chemical reaction in the cell requires its own, specific type of enzyme in order to operate.

The rate at which enzymes catalyze their reactions changes as conditions inside the cell change. Such conditions as the temperature of the cell, the relative concentrations of enzyme and substrate within the cell, and the pH of the cell can alter the rapidity with which enzymes work.

Temperature The cell and its enzymes are very sensitive to temperature conditions. Extreme cold can slow enzyme action nearly to a halt. As the temperature of the cell rises, its enzymes begin to operate more and more rapidly. An optimum (best or most efficient) temperature allows the most rapid reaction rate. Extreme heat can halt enzyme action by deforming the molecular shape of the enzyme. This distortion is known as denaturation and is a permanent condition that makes the enzyme incapable of further catalytic action. The effect of temperature on a typical enzyme is shown below.



Enzyme Activity Versus Temperature

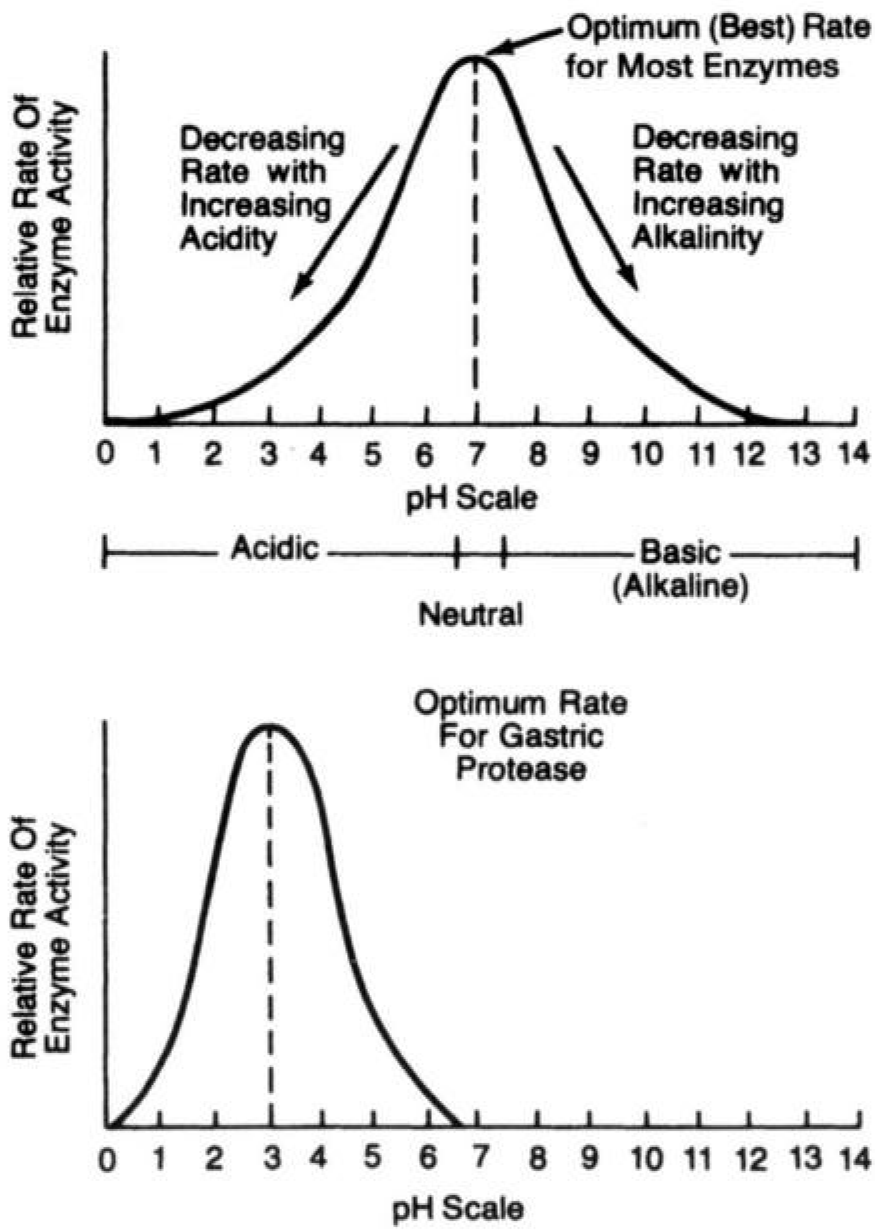


Catalytic Action of an Enzyme

Concentration of enzyme and substrate In order to operate, enzyme molecules require the presence of substrate. In a system in which the concentration of enzyme is constant, increasing the substrate concentration from zero will result in a steady rise in reaction rate. This rise continues until the concentration roughly equals that of the enzyme. At this point, the rate of increase slows and levels off. Increases in substrate concentration beyond this equilibrium point have little or no effect on the rate of enzyme action.

Cell acidity (pH) The cell environment may be characterized by its level of acidity or alkalinity. To measure this characteristic accurately, scientists have devised methods of measuring the relative concentration of hydrogen ion (H+), which is given off by acids in solution with water. The pH scale has been devised to indicate the relative hydrogen-ion concentration. This scale runs from 0 to 14, 0 being extremely acidic and 14 being extremely alkaline. A pH of 7 indicates a neutral condition (neither acidic nor alkaline). A pH less than 7 indicates an acidic condition; a pH greater than 7, an alkaline condition.

Most enzymes seem to work best at or near a pH of 7 (neutral). Despite this fact, there are many enzymes for which the optimum pH is extremely acidic (stomach enzymes) or extremely alkaline (intestinal enzymes). In general, however, as the cell's acidity increases above 7 or decreases below 7, most enzymes show a decrease in activity.



Enzyme Rate Versus pH

Enzyme Structure Enzymes and other molecules, such as hormones, receptor molecules, and antibodies, have specific shapes that influence both .how they function and how they interact with other molecules. Enzymes are protein molecules. They are both extremely complex and extremely variable. Certain enzymes are also known to contain nonprotein components known as coenzymes; vitamins frequently function as coenzymes. Enzymes are usually named for the particular chemical (substrate) whose reactions they catalyze; enzyme names end in the suffix -ase.

Enzyme molecules are thought to contain specific areas responsible for linking to the substrate molecules. These reacting areas are known as active sites. They can be thought of as pockets or slots on the enzyme molecule into which the substrate molecules fit during the reaction catalyzed by the enzyme.

You can picture the catalytic action of enzymes in many ways. However, the following model, known as the lock-and-key model, is widely accepted as being a reasonable summary of this action.

- To begin the process, the enzyme molecule must link with the substrate in a temporary, close physical association known as the enzyme-substrate complex.
- This association is thought to occur at the enzyme's active site. The chemical fit between this active site and the substrate must be exact in order for the desired reaction to occur, in much the same way that a key must fit a lock in order for the lock to be opened (hence the name "lockand-key" model).
- During the existence of the enzyme-substrate complex, the reaction involving the substrate takes place. The substrate is chemically altered in this reaction, and products are formed. The enzyme molecule, however, remains unchanged by the reaction.
- When the reaction is completed, the enzyme and product(s) separate. The enzyme molecule, being unchanged, is free to form additional complexes and to catalyze additional reactions of this substrate.
- A single enzyme molecule may catalyze millions of reactions in this manner during its lifetime. Eventually, however, the structure of the enzyme molecule begins to deteriorate. The molecule must then be replaced. Amino acids are joined to synthesize the specific enzyme molecules.

Disease as a Failure of Homeostasis

Performance Indicator 5.2 The student should be able to explain disease as a failure of homeostasis. Homeostasis in an organism is constantly threatened. Failure to respond effectively can result in disease or death.

Homeostasis refers to the normal condition of balance (or equilibrium, steady state, stability) that exists within cells and organisms. This equilibrium depends on the coordination of thousands of chemical reactions occurring at the same time within the cells and that may be easily upset by any change of the cell's physical or chemical environment. Examples of homeo stasis include the maintenance of body temperature and blood sugar levels in human beings.

This balance of life is fragile at best. Living things are constantly subjected to changes in their environments that threaten to interfere with homeostatic balance. Living systems have been developed that provide feedback mechanisms to help the regulatory system monitor the interior and exterior environment and send commands to the body to adjust to changes it detects. If these feedback mechanisms fail to provide the appropriate responses, then cell functions could become less efficient than normal, which in turn could lead to illness or death.

Organisms That Interfere with Cell Activity

Viruses, bacteria, fungi, and other parasites may infect plants and animals and interfere with normal life functions. In addition to internal disruptions in the cell that can trigger an imbalance, other organisms and materials can also disrupt the cell's operation. Many human diseases are caused by viruses, bacteria, fungi, and parasites of various types. These organisms interfere with cell activity in a number of ways.

Viruses enter the body by inhalation of airborne viruses, consumption of contaminated water or foods, or through direct contact with infected tissues. They act by commandeering the cell's protein synthesis mechanism, redirecting it to produce many copies of the virus that go on to infect other cells. The host cells are destroyed in the process, impacting the operation of the affected tissues and organs. Examples of viral diseases in humans include the common cold, measles, hepatitis, polio, smallpox, rabies, viral pneumonia, yellow fever, herpes, and AIDS.

Bacteria invade healthy tissues through breaks in the skin, through consumption of contaminated food or water, or by inhalation of airborne bacteria. They begin to reproduce rapidly within the host. Bacterial infections are dangerous because they produce toxins that can kill healthy host tissues. Some bacteria actually enter host cells and consume them from within. Examples of bacterial diseases in humans include Lyme disease, giardiasis, whooping cough, tetanus, typhoid fever, diphtheria, bacterial pneumonia, bubonic plague, tuberculosis, gonorrhea, chlamydia, and syphilis.

Fungi feed on healthy tissues of the body by sending rootlike tendrils into the tissues and digesting the tissues extracellularly. Common examples of fungal infections in humans include athlete's foot and ringworm.

Parasites of various kinds can invade the body through the skin via insect bites or through consumption of contaminated water or foods. Some parasites bore directly through the exposed skin to reach internal tissues. Examples of parasitic diseases in humans include hookworm, tapeworm, trichinosis, malaria, typhus, and African sleeping sickness.

Plants and other animals can be similarly infected by disease-causing agents that are specific to the tissues of those host organisms. Scientists are constantly at work developing new treatments for the diseases caused by these agents, both to protect human health and to safeguard the health of agricultural products such as grains and livestock.

The Immune System

The immune system protects against antigens associated with pathogenic organisms or foreign substances and against some cancer cells. A special function of the blood is to defend the body against disease, to provide immunity. In addition to the other functions associated with the transport system, the blood provides the immune response to help it react to foreign invaders. Such invaders may include the viruses, bacteria, fungi, and parasites discussed above. They may also include the chemical antigens and toxins produced by those organisms. Special cells in the body can also be important in defending the body against its own cells, when those cells become abnormal through cancer.

Some white blood cells engulf invaders. Others produce antibodies that attack the invaders or mark them for killing. Some specialized white blood cells will remain, able to fight off subsequent invaders of the same kind. White blood cells exist in several different forms with several different functions. Two such types are described here, both important in the control of disease in humans.

- Phagocytes engulf and destroy bacteria that enter the bloodstream through breaks in the skin surface. These phagocytic white blood cells gather in large numbers at sites of bacterial infection in the body.

- Lymphocytes produce antibodies specifically designed to fight off particular types of foreign proteins, known as antigens, that enter the bloodstream by various routes.

Once these cells react to a foreign invader, the immune system develops a chemical memory of the invader's proteins (antigens). When this happens, an active immunity develops, which is a long-lasting immunity created when the body recovers from an infectious disease. The lymphocytes carry their chemical memory of that antigen and churn out specific antibodies at the first sign of its return to the bloodstream.

Vaccinations use weakened microbes (or parts of them) to stimulate the immune system to react. This reaction prepares the body to fight subsequent invasions by the same microbes. Many years ago, it was discovered that inoculating people with solutions containing dead or weakened disease microbes would impart the same level of immunity to the inoculated person as does recovery from the disease but without many of the risks associated with contracting the full-blown disease. This inoculation of dead or weakened microbes is known as vaccination. Active immunity acquired through vaccination usually results in the same long-lasting immunity as does the body's own immune reaction.

Some viral diseases, such as AIDS, damage the immune system, leaving the body unable to deal with multiple infectious agents and cancerous cells. AIDS is an acronym for acquired immune deficiency syndrome and is caused by the HIV virus. As its name implies, AIDS leads to a reduced efficiency of the immune system, leaving its victims unable to ward off diseasecausing agents that enter the body. Certain types of cancer can also gain a foothold under these conditions. As the body's ability to fight off infectious diseases diminishes, an AIDS victim can contract multiple diseases, leaving him/her in a progressively weakened condition. If untreated, this situation can gradually lead to death. There is currently no cure for AIDS.

Some allergic reactions are caused by the body's immune responses to usually harmless environmental substances. Sometimes the immune system may attack some of the body's own cells or transplanted organs. Allergies are the result of the body's reaction to the chemical composition of such materials as pollen, dust, animal dander, insect saliva, foods, drugs, molds, and many other substances. Many of these materials are harmless allergens. Sensitive people produce antibodies or antitoxins to these allergens as though they were the antigens of disease-causing organisms. An additional response to the antigens is the production of histamines, which may cause irritation and swelling of the mucous membranes, a symptom typical of allergic reactions.

Organ and tissue transplants, including blood transfusions, can be safely accomplished only if the antigen types of the donor and recipient are the same or very similar. If a close match does not exist between the recipient's and the donor's antigens, the recipient's body will react to the transplanted tissues as though they were foreign, disease-causing organisms and produce antibodies. The result of such a reaction is the rejection of the transplanted tissue or organ.

Other Disorders

Disease may also be caused by inheritance, toxic substances, poor nutrition, organ malfunction, and some personal behaviors. Some effects show up right away; others may not show up for many years. There are other causes of diseases and disorders. Some examples are as follows.

- Inheritance:

  > sickle cell anemia-abnormal red blood cells are crescent-shaped and hemoglobin is defective

  > Tay-Sachs disease-fatty deposits build up around nerves, leading to mental retardation

  > hemophilia-blood does not clot due to its inability to produce clotting factors

  > arthritis-cartilage breaks down and skeletal joints deteriorate and/or fuse together

  > phenylketonuria (PKU)-mental retardation caused by inability to metabolize phenylalanine

- Toxic substances:

  > ulcers-erosion of the stomach/intestine from irritation by alcohol or other substances

  > asthma-narrowing of the bronchial tubes due to swelling caused by allergic reaction

  > emphysema-a general deterioration of the lung structure that results from exposure to air pollutants or tobacco

- Poor nutrition:

  > goiter-enlargement of the thyroid caused when that gland fails to produce sufficient quantities of thyroxin due to a lack of iodine in the diet

> gallstones-deposits of hardened cholesterol that lodge in the gallbladder and cause pain

> anemia-a reduced ability of the blood to carry oxygen that results from an iron-deficient diet

- Organ malfunction:

> constipation-the large intestine absorbs too much water from feces, leading to difficult elimination

> diarrhea-large intestine fails to absorb sufficient water from feces, leading to watery elimination

> coronary thrombosis-blockage of the coronary artery, which feeds the heart muscle

> angina-chest pain caused by gradual deterioration of coronary circulation

> gout-painful inflammation of the skeletal joints caused by the buildup of uri c acid

> stroke-condition caused when a portion of the brain fails due to inadequate or blocked blood supply

diabetes-inability to maintain proper sugar balance in the blood due to failure of the pancreas to produce sufficient quantities of insulin

- Personal behavior:

> high blood pressure-caused by fatty buildup in arteries, is aggravated by stress, smoking, and diet, among other activities

> tendinitis-inflammation of the tendon-bone junction caused by repeated physical stress on the affected part

Gene mutations in a cell can result in uncontrolled cell division, called cancer. Exposure of cells to certain chemicals and radiation increases mutations and thus increases the chance of cancer. Normal mitotic cell division results in the production of new cells for growth and for the repair of damaged or worn out body tissues. It is controlled within the cell itself and occurs countless times in every living cell without flaw. However, in some cells at some times, the mitotic process-appears to break down and begins to occur so rapidly that insufficient time is available for normal replication and chromosome separation. This rapid, abnormal cell division is known as cancer. In a very short time, cancer may produce a very large number of such abnormal cells, which begin to crowd out the normal tissues. This results in damage to these tissues and often in the death of the host organism.

Biological research generates knowledge used to design ways of diagnosing, preventing, treating, controlling, or curing diseases of plants and animals. A large and increasingly important branch of biology deals with the study and control of disease in humans and other organisms. Some scientists study the bacteria and viruses that cause disease in an attempt to determine how these organisms work within the body to disrupt systems. Other scientists are hard at work decoding the genomes of these organisms to learn how their genetic makeup affects other living things. The human genome is also being mapped and decoded, enabling scientists to trace the root causes of genetically based diseases and to design gene therapy techniques to treat them. Branches of science deal with finding effective treatments for disease in the form of drugs and antibiotics. These and other research activities are providing medical and agricultural science with a sophisticated and effective arsenal to help us to combat diseases in living things.

Body Systems and Homeostasis

Performance Indicator 5.3 The student should be able to relate processes at the system level to the cellular level in order to explain dynamic equilibrium in multicelled organisms.

Dynamic equilibrium results from detection of and response to stimuli. Organisms detect and respond to change in a variety of ways both at the cellular level and at the organismal level. A stimulus is any change that occurs in the environment of an organism that elicits a response in that organism. Such stimuli may be external or internal to the body of the organism. Examples of stimuli include light, sound, and chemical stimuli. A response is a reaction that an organism makes to a specific stimulus. Responses may include physical movements or glandular secretions. By reacting to its environment, an organism is able to adjust to changing conditions with the result that its systems remain in a dynamic equilibrium (energy-charged and adapting steady state). This equilibrium is an important prerequisite to homeostasis.

A unique feature of living matter is its sensitivity to its environment and its ability to adjust to changes both inside and outside of itself. As is the case with all life functions, this sensitivity has its basis at the cellular level. Independent one-celled organisms display sensitivity appropriate to their lifestyle and environment. This phenomenon is known as cytoplasmic sensitivity. It allows the cell to receive environmental stimuli and perform simple actions, such as avoidance behaviors, in response to them. Some one-celled organisms have specialized sensory areas that can detect environmental stimuli, such as light or vibration. Unicellular organisms use simple structures such as cilia or flagella to effect their responses to these stimuli.

In multicelled organisms, a variety of specialized adaptations assist the organism to detect stimuli and to effect responses to those stimuli. In simple organisms such as the hydra, these adaptations are limited to specialized cells that sense stimuli and communicate to other cells (nerve net) and other cells that produce crude movement (contractile fibers) or release stinging barbs (nematocysts). In more complex organisms such as the human, specialized sensing organs take in a wide range of environmental stimuli and send complex information, via nerves, to the central-processing centers of the brain and spinal cord. After analysis, this information provides the basis for complex responses including movements and secretions. The effectors of these responses (muscles and glands) receive their commands from the brain. Constant feedback allows the system to adjust its reactions based on the effects of the initial response.

In addition to sophisticated nervous responses, the bodies of complex multicelled organisms use a system of endocrine glands to control the metabolic activities of specific tissues, organs, and systems. By controlling the body's metabolism, the balance needed to sustain life is maintained.

Feedback mechanisms have evolved that maintain homeostasis. Examples include the changes in heart rate or respiratory rate in response to increased activity in muscle cells, the maintenance of blood sugar levels by insulin from the pancreas, and the changes in openings in the leaves of plants by guard cells to regulate water loss and gas exchange.

The term feedback mechanism refers to any process in which the body is able to adjust its actions in response to internal stimuli. The examples given represent just a few ways that the body monitors its own internal environment and adjusts to the changes it detects.

As the body becomes physically active, the muscle cells carry on respiration at an elevated rate. This produces additional energy but also elevated levels of carbon dioxide. As this carbon dioxide enters the bloodstream, its concentration increases and blood chemistry changes as a result. This change in the body's internal environment is detected by nerve centers in the brain and spinal cord. These nerve centers initiate commands to the breathing apparatus and heart that cause these organs to increase their rates of activity. The body's elevated heart rate causes the blood to circulate more rapidly around the body, enabling it to carry more oxygen to the muscle cells and carry away more carbon dioxide from these tissues. Breathing rate increases to accelerate the rate of gas exchange in the lungs. This response reduces carbon dioxide levels and increases oxygen levels in the blood. When carbon dioxide levels drop to a sufficiently low level, this change is also detected by the nerve centers. They then issue commands to the breathing apparatus and heart muscle to slow their rates of activity, returning the body to its resting levels. This is a clear example of a feedback loop.

In a like manner, the body monitors the concentration of sugar (glucose) in the blood. When blood sugar levels become elevated, as they would after a person consumes and digests a meal containing carbohydrates, the pancreas is stimulated to release the hormone insulin. Insulin causes the liver to increase the rate at which blood sugar is converted to glycogen (animal starch). A second hormone, glucagon, is released from the pancreas when blood sugar concentrations drop too low, as they would long after a meal has been consumed. Glucagon stimulates the conversion of glycogen to glucose, which then enters the bloodstream to increase the blood sugar concentration. This is a clear example of a feedback loop.

Stomates are tiny openings on the leaves of green plants that allow gas exchange between the environment and the photosynthetic cells of the leaf interior. These openings are regulated by pairs of guard cells that flank each stomate. Guard cells contain chloroplasts. When photosynthetic activity is high, the concentration of sugar builds up in the guard cells. This change causes the guard cells to absorb additional water in an effort to maintain a constant sugar concentration in the cytoplasm. The absorption of this water causes the guard cells to become turgid, opening the stomate and promoting rapid gas exchange. When photosynthetic activity is low, the guard cells lose sugar and water, causing them to become limp. In this condition, the guard cells are no longer able to keep the stomates open, so gas exchange is minimized.

QUESTION SET 2.8-DYNAMIC EQUILIBRIUM IN LIVING THINGS (ANSWERS EXPLAINED, P. 309)

1. What is a major distinction between living and nonliving matter?

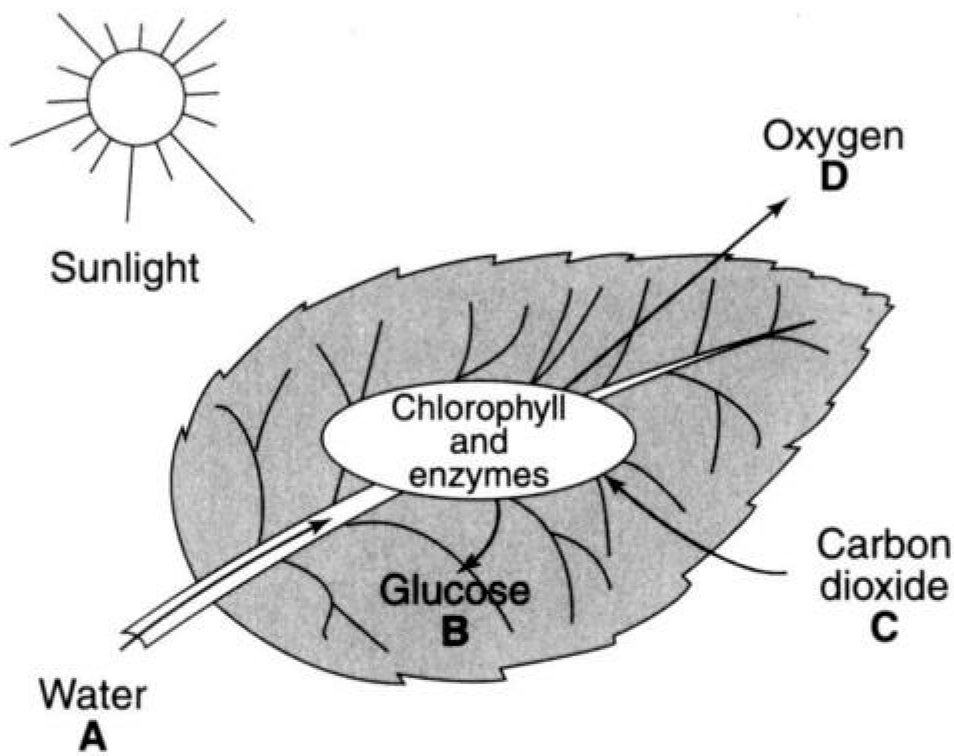
   (1) Living matter is unable to diffuse materials.

   (2) Living matter is able to control chemical activities with organic catalysts.

   (3) Living matter is able to create energy.

   (4) Living matter is unable to use energy for metabolic activities.

2-3. Base your answers to questions 2 and 3 on the diagram below and on your knowledge of biology. The diagram represents some processes occurring in the leaf of a plant.



2. Which equation illustrates a process of nutrition carried out within the leaf?

(1) $B + D \rightarrow A + C$

(2) $A + C \rightarrow A + B + D$

(3) $B + C \rightarrow A + D$

(4) $A + B + D \rightarrow B + C$

3. Which letters indicate substances needed by the leaf to carry out the process of aerobic cellular respiration?

(1) A and C

(2) C and D

(4) B and D

(3) B and C

---

4. All producers and consumers use the chemical process of respiration to synthesize

(1) C 6 H 1206

(2) ATP

(3) alcohol

(4) oxygen

5. Brine shrimp live in shallow coastal waters or near the surface of the ocean where light penetrates. Under laboratory conditions, brine shrimp are attracted to areas with the greatest light intensity and avoid areas of low light intensity. The movement of the brine shrimp to bright light is an example of

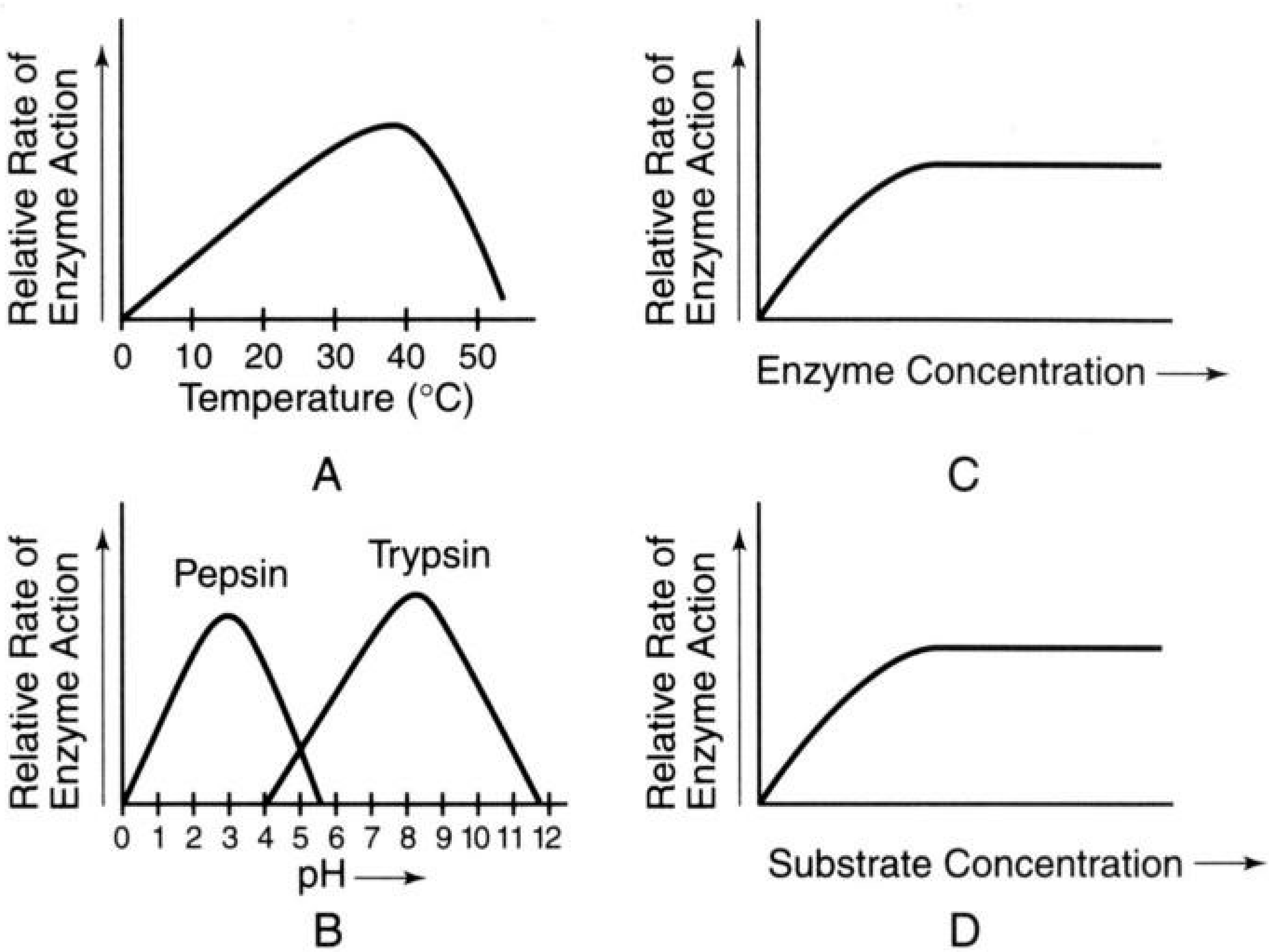
(1) negative feedback

(2) a response

(3) a stimulus

(4) active transport

6-7. Base your answers to questions 6 and 7 on the graphs below and on your knowledge of biology. The graphs represent human enzyme activity.



6. Human enzymes would most likely begin to denature at a

(1) temperature of 40°C

(2) temperature of 23°C

(3) pH of 3

(4) pH of 2

7. Certain enzymes work best within an acidic or a basic environment. This concept is illustrated in graph

(1) A

(2) B

(3) C

(4) D

8. The equation below summarizes some of the reactions involved in a specific biochemical process.

hydrogen + carbon dioxide → carbohydrate + water

The source of the hydrogen in the equation is most likely

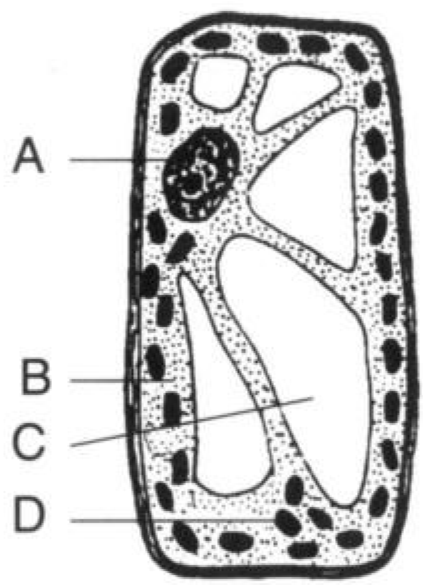
`1) C6H1206

(2) H;O'

(3) PGAL

(4) ATP

9. In which structure of the cell shown below do photolysis and carbonfixation reactions occur?



(1) A

(2) B

(3) C

(4) D

10-11. For each statement in questions 10 and 11, select the immune response, chosen from the list below, that is most closely associated with that statement. Then record the name of the immune response in the space provided.

Immune Response

Active immunity
Passive immunity
Allergies
Tissue rejection

10. A vaccine containing a weakened disease-causing organism is injected into the body.

____

11. Chemicals known as histamines are released as a result of antibody production.

____

12. An insufficient amount of hemoglobin is most closely associated with the disorder known as

(1) angina

(2) anemia

(3) coronary thrombosis

(4) high blood pressure

13. In a certain community, a number of humans have an abnormally enlarged structure under the skin of the lower front side of their necks. The cause of this condition is most likely

(1) an excess of calcium in the diet, which has caused a muscle deformity

(2) deposits of fat under the skin caused by a vegetable diet

(3) inherited neck deformities caused by elevated environmental temperatures

(4) a lack of iodine in the diet, which has caused the development of a goiter

14. What does photosynthesis produce?

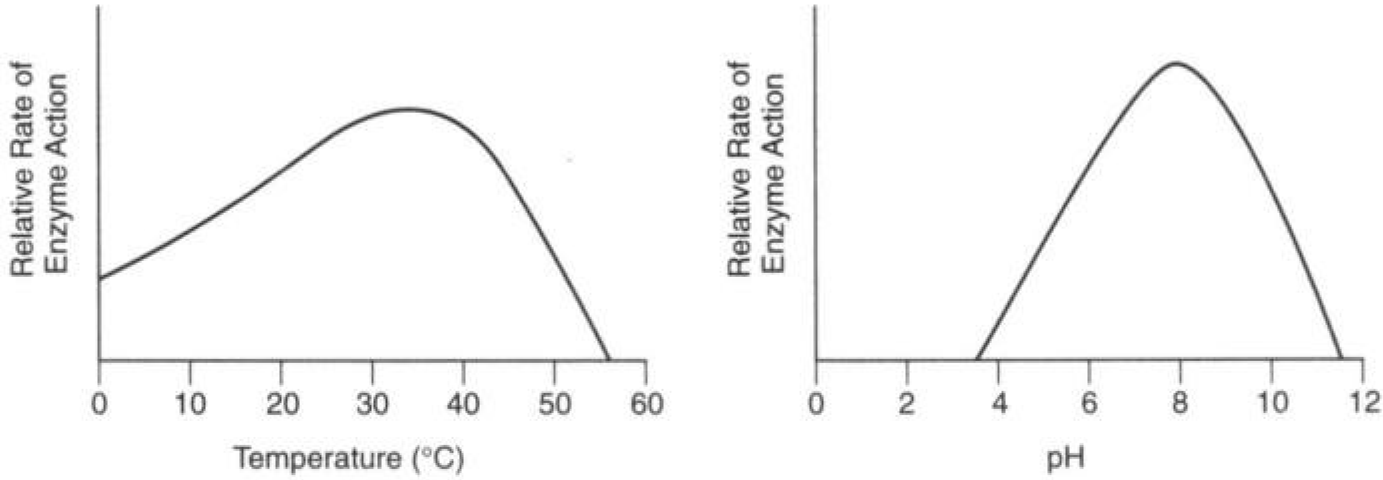
(1) starch, which is metabolized into less complex molecules by dehydration synthesis

(2) protein, which is metabolized into less complex molecules by dehydration synthesis

(3) glycerol, which is metabolized into more complex molecules by dehydration synthesis

(4) glucose, which is metabolized into more complex molecules by dehydration synthesis

15. Which statement best describes the enzymes represented in the graphs below?



(1) This enzyme works best at a temperature of 35°C and a pH of 8.

(2) This enzyme works best at a temperature of 50°C and a pH of 12.

(3) Temperature and pH have no effect on the action of this enzyme.

(4) This enzyme works best at a temperature above 50°C and a pH above 12.

16-19. Base your answers to questions 16 through 19 on the reading passage below and on your knowledge of biology.

Take Two and Call Me in the Morning

Hippocrates observed that pain could be relieved by chewing the bark of a willow tree. We now know that this bark contains salicylic acid, which is similar to acetylsalicylic acid, the active ingredient in aspirin. Over 2,300 years after this observation by Hippocrates, scientists have learned how aspirin works.

When people get the flu or strain their backs, the body responds by making prostaglandins (PG), a group of hormonelike substances. The presence of certain prostaglandins may result in fever, headaches, and inflammation. Scientists have determined that aspirin interferes with prostaglandin H2 synthase (PGHS-2), an enzyme that the body uses to make pain-causing prostaglandins. In 1994, the structure of this enzyme was found to be a crystal with a tube running up the middle of it. Raw materials move through this tunnel to reach the core of the enzyme, where they are transformed into prostaglandin molecules. Research has shown that aspirin blocks this tunnel. Part of the aspirin molecule attaches to a particular place inside the tunnel, preventing the raw materials from passing through the tunnel. This blockage interferes with the production of prostaglandins, thus helping to prevent or reduce fever, headaches, and inflammation.

The body makes two forms of the enzyme. PGHS-1 is found throughout the body and has a variety of uses, including protecting the stomach. PGHS-2 usually comes into play when tissue is damaged or when infections occur. Its action results in pain and fever. Aspirin plugs up the tunnel of PGHS-1 completely and often causes stomach irritation in some people. Aspirin plugs up the tunnel partially in PGHS-2, thus helping to relieve pain and fever.

Perhaps further research could result in a drug targeting PGHS-2 but not PGHS1, relieving the aches, pains, and fever but not irritating the stomach as aspirin does now.

16. How does aspirin relieve the symptoms of the flu?

(1) It forms a barrier around the outer surface of PGHS-2 molecules, separating them from the prostaglandins.

(2) It dissolves the crystal of the enzyme, preventing it from producing prostaglandins.

(3) It is an acid that dissolves the prostaglandins that cause the symptoms.

(4) It reduces the amount of raw material reaching the active site of the enzyme that produces prostaglandins.

17. Why does aspirin irritate the stomach of some people who take it?

(1) It interferes with the activity of an enzyme that helps to protect the stomach.

(2) It is the only acid in the stomach and eats away at the stomach lining.

(3) It stimulates prostaglandin production in the stomach.

(4) It is obtained from willow bark, which cannot be digested in the stomach.

18. By using one or more complete sentences, describe the molecular structure of prostaglandin H2 synthase.

19. By using one or more complete sentences, explain why chewing the bark of a willow tree could help relieve the symptoms of headache and fever.

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20. Which human disorder is characterized by a group of abnormal body cells that suddenly begin to undergo cell division at a very rapid rate?

(1) albinism

(2) cancer

(3) hemophilia

(4) color blindness

21. An allergic reaction characterized by the constriction of the bronchial tubes is known as

(1) coronary thrombosis

(2) arthritis

(3) asthma

(4) emphysema

22. In some regions of the world, children suffer from a protein deficiency known as kwashiorkor. This deficiency occurs when a child's diet is changed from high-protein breast milk to watery cereal. Even though the child is receiving calories, the child becomes sick and less active, and growth ceases. These symptoms are probably due to

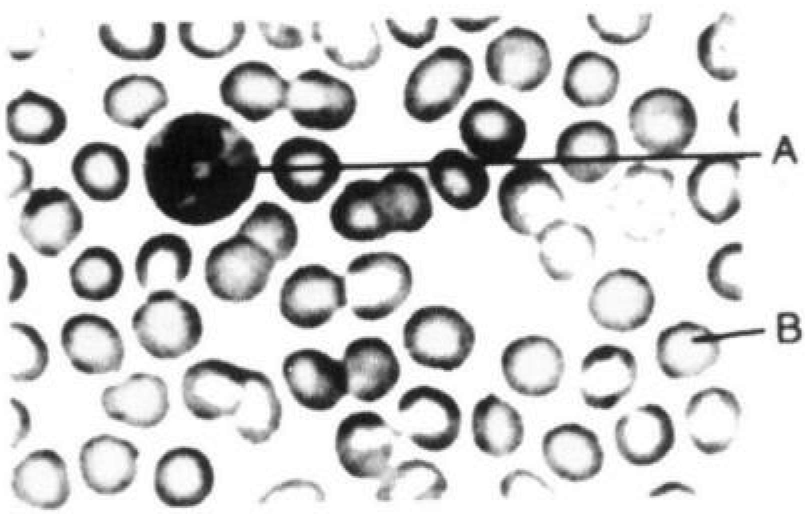
(1) too many nucleic acids in the diet

(2) an overconsumption of complete protein foods

(3) not enough carbohydrates in the diet

(4) a lack of essential amino acids in the diet

23. A photograph of a slide of human blood taken from a healthy individual is shown below.



Which statement best describes the change that would be observed if the slide contained blood from an individual with anemia?

(1) Cell type A would be fewer in number and larger in size.

(2) Cell type B would be fewer in number and lighter in appearance.

(3) Cell type B would be larger in size and greater in number.

(4) Cell type A would be larger in size and darker in appearance.

24-26. Base your answers to questions 24 through 26 on the information below and on your knowledge of biology. Use one or more complete sentences to answer each question.

When a drug manufacturer develops a new drug to treat some form of disease, the drug should be tested to ensure that it does what it is supposed to do. Usually, the drug is tested on animals. If these tests are successful, it is then tested on humans.

A drug called Lowervil was developed by a drug company to lower blood pressure. Lowervil has been tested successfully on animals, and the drug company is now ready to test it on humans. The drug company claims that one dose of Lowervil per day will decrease blood pressure in individuals experiencing high blood pressure.

A researcher has been hired to determine whether or not Lowervil lowers blood pressure. Answer the following questions related to the experimental testing of the new drug Lowervil.

24. How should the experimental group and control group be treated differently?

25. Why would using a large number of people be important in this experiment?

26. How could the researcher determine if the drug is effective in reducing blood pressure?

27-30. Base your answers to questions 27 though 30 on the information below and on your knowledge of biology.

Organ Transplants of the Future

While most people take good health for granted, thousands of others desperately need to replace a failing organ with one that is healthy. Most healthy organs come from people who agreed to donate them upon their death, although it is possible to remove some tissue and organs (such as kidneys and bone marrow) from living donors. Unfortunately, organs for transplant are in short supply. As of 1992, over 22,000 Americans were waiting for a transplant.

Although increasingly common, transplants are risky procedures. During the operation, veins and arteries must be blocked to prevent blood loss. This deprives parts of the body of oxygen and nutrients and may result in permanent damage. In addition, the body may recognize the transplanted organ as foreign and mount an immune response in which specialized white blood cells (T cells) attack the transplanted organ.

Drugs called immunosuppressants are given to transplant patients to prevent their immune system from rejecting the transplanted organ. However, these drugs weaken the ability of the body to fight disease and leave the patient less able to fight infection.

Scientists are exploring new technology for producing transplanted tissues and organs. Unspecialized cells called stem cells are removed from the patient and then grown in a laboratory. Treating stem cells with the appropriate chemicals causes them to differentiate into various specialized tissues. In the future, scientists hope to develop chemical treatments that will cause stem cells to grow into complete organs needed for transplants. Transplants produced by this process would not be foreign material and, therefore, would not be rejected by the immune system of the patient.

27. Explain why a transplant might be dangerous to the health of a patient.

28. State one reason that transplant patients might take an immunosuppressant drug.

29. State one specific disadvantage of taking an immunosuppressant drug.

30. Explain why doctors would consider using tissues or organs grown from stem cells.

IX. INTERDEPENDENCE OF LIVING THINGS

KEY IDEA 6-INTERDEPENDENCE OF LIFE Plants and animals depend on each other and their physical environment.

Living things in the environment interact with each other, developing an interdependence crucial to the survival of these populations and to the overall health of the environment. The energy and materials needed to drive this living system derive from the nonliving, abiotic factors present in the environment. Living systems serve to cycle materials and provide a mechanism to absorb and transfer energy among organisms.

Populations of organisms interact with each other in many ways in the natural environment, including competition, symbiosis, and nutritional relationships. Each species population in a natural community has a role to play in the environment, further enhancing the interdependence of species.

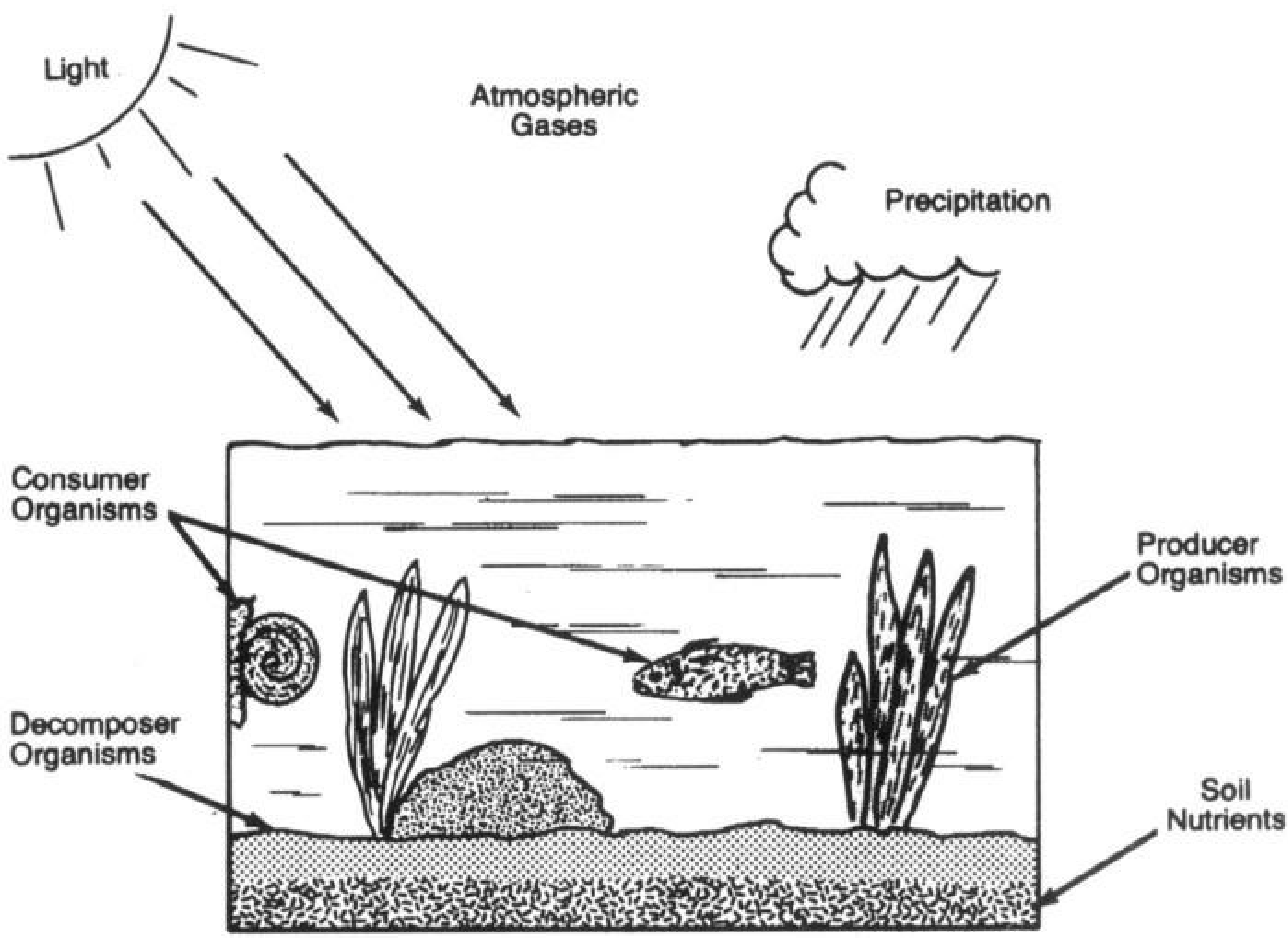
The Ecosystem

Diversity and Ecosystem Stability

Performance Indicator 1.1 The student should be able to explain how diversity of populations within ecosystems relates to the stability of ecosystems. When studying ecological interactions, the basic unit of study is the ecosystem. The ecosystem is the lowest level of ecological organization in which all environmental factors, both living and nonliving, are represented and interact freely. The Earth contains many different ecosystems that provide habitats for millions of different species of plants, animals, and simpler life-forms. The diversity of life directly results from the vast variety of different ecosystems that exist on Earth.

Food Webs

Populations can be categorized by the function they serve. Food webs identify the relationships among producers, consumers, and decomposers carrying out either autotrophic or heterotrophic nutrition. Organisms can be categorized by the functions they serve in an ecosystem. Each species in an ecosystem has a role for which it is best suited. The environmental role of an organism is known as its niche. In general, no two species inhabit the same niche in an ecosystem. This fact allows different species to coexist successfully and helps maintain the stability of the ecosystem. Producers, consumers, and decomposers exist within food webs in these ecosystems, carrying out either autotrophic nutrition or heterotrophic nutrition. A food web is a diagram that illustrates the nutritional relationships among species in a given ecosystem. Each species population in the food web has a different role to play in the transfer of energy and the cycling of elements in the environment.



Balanced Ecosystem

Producers are the green plants and algae (the autotrophs) in the community responsible for trapping the Sun's radiant energy and using it to manufacture organic compounds that are used for their own consumption, as well as that of animals. Consumers include herbivores, carnivores, omnivores, and decomposers (the heterotrophs). Herbivores are primary consumers because they are the first consumers to tap the energy trapped by the producers. Carnivores are secondary consumers because they do not tap plant energy directly but obtain it through their consumption of primaryconsumer organisms. Omnivores may be either primary consumers or secondary consumers, depending on whether they consume plant matter or animal matter, respectively. Decomposers include saprophytic fungi and bacteria responsible for breaking down the complex structure of the bodies of living things into simpler forms that can be used by other living things. In a sense, decomposers are responsible for operating a recycling system that reuses the chemical substances of life over and over. This action is essential to the continued functioning of the ecosystem.

Organisms capable of producing their own food are known as autotrophs (self-feeders). Green plants and algae, the principal autotrophic organisms, manufacture organic molecules that serve as food for all the other organisms in the environment. This food is the main source of energy and structural components for all living things. Heterotrophic organisms, particularly animals, protozoa, bacteria, and fungi, are incapable of producing their own food. As such, heterotrophs (other feeders) depend on other organisms for the food they consume.

Ecosystem Structure and Function

An ecosystem is shaped by the nonliving environment as well as its interacting species. The world contains a high diversity of physical conditions, which creates a variety of environments. The Earth is made up of many diverse, interactive ecosystems. The conditions of each ecosystem vary in the particular set of nonliving, or abiotic, factors found there. The abiotic factors are subject to the physical laws of nature, varying as these laws dictate. For example, sunlight is filtered by the atmosphere to remove many of the most harmful forms of solar radiation. Water expands and becomes less dense as it freezes, ensuring that ice forms at the tops, rather than the bottoms, of lakes. The living species that are successful in any given ecosystem are those best adapted to survive in that set of environmental conditions. The living, or biotic, factors abide by natural biological laws that govern all lifeforms. For example, all known life-forms are composed of cells that serve as the organisms' functional unit. All living things depend on their ability to carry out basic life functions. Living things depend on the presence and activities of other living things to provide them with nutrients and other essential components.

Biomes

The Earth's natural environments are organized into broad climatic zones known as biomes. Each biome is categorized by a particular range of abiotic conditions, such as temperature, rainfall, solar radiation, and altitude. Each biome is also known by the type of dominant, or climax, vegetation that establishes itself in the region as well as by the typical, or index, animal species it supports. The biome that makes up the majority of New York State is the temperate deciduous forest biome. It has moderate temperature and rainfall, abundant solar radiation, climax vegetation made up of a mixture of broadleaf hardwood trees such as oaks, maples, and beeches, and index animals such as the deer, squirrel, and hawk. Other terrestrial biomes found on the Earth include the tundra, taiga, grassland, desert, and tropical rain forest biomes. The chart below summarizes the characteristics of these terrestrial biomes.

CHARACTERISTICS OF TERRESTRIAL BIOMES

Biome	Abiotic Features	Climax Vegetation	Index Animals
Tundra	Permanently frozen subsoil	Mosses, lichens	Caribou, owl
Taiga	Long, severe winters, thawing subsoil	Pine, spruce, cedar	Moose, bear, eagle
Temperate deciduous forest	Moderate precipitation, cold winters, warm summers	Oak, hickory, maple, beech trees	Squirrel, fox, deer, hawk
Grassland	Considerable variation in rainfall and temperature, strong prevailing winds	Grasses, tumbleweed	Prairie dog, antelope, bison
Desert	Sparse rainfall, extreme variation in temperature	Cactus, mesquite	Roadrunner, snake, lizard
Tropical rain forest	Abundant rainfall, constant warmth	Broad-leaved plants, palm trees	Monkey, parrot, jaguar

Interaction of Populations and the Environment

In all environments, organisms compete for vital resources. The linked and changing interactions of populations and the environment compose the total ecosystem. A vital characteristic of all natural ecosystems is the interaction of species populations found within them. A population is defined as all the members of a species inhabiting a particular place at a particular time. In an ecosystem, some species take on the role of producers, others the role of consumers. Among the consumers, some species are predators, others prey. Still others may be scavengers or decomposers that break down complex organic matter into simpler components usable by other living things. Some species produce oxygen, while others consume it. The wastes left by one type of living thing may be vitally important to the life functions of another. The complexity of these interactions is extreme and the dynamic balance to which they contribute is delicate. Specific types of interactions based on nutritional relationships are material cycles, food chains, and food webs.

Competition

When different species living in the same environment (habitat) use the same limited resources, competition occurs. These resources may include requirements such as food, space, light, water, oxygen, and minerals. The more similar the requirements of the competing species, the more intense the competition is likely to be. Of course, when such resources are abundant, different species may share them without creating significant competition. Only when the resources become scarce does the competition become intense. Such competition might be termed interspecies competition (competition between species) since it involves members of different species. This type of competition should not be confused with the concept of intraspecies competition (competition within a species).

As an example, consider the variable growth patterns of goldenrod plants growing in different but neighboring environments. Goldenrod is a species of wildflower that commonly inhabits sunny fields. It is a hardy plant that competes well against other field plants, often growing to heights of five or six feet and crowding out other light-loving species. Goldenrod seeds carried into a nearby forest may germinate and produce young plants, but these plants grow to be only a few inches tall. Their stems are thin and weak, their leaves are small and sparse, and their flowers, if they form at all, are underdeveloped. How can one species of plant, inhabiting the same general area, have such different growth patterns? The key is in the different amounts of light available in the forest and the field. As long as light is abundant, as it is in the field, the goldenrod is a good competitor. When light becomes scarce, as it is in the forest, goldenrod does not compete well, and will eventually be eliminated from that environment altogether.

The interdependence of organisms in an established environment often results in approximate stability over hundreds and thousands of years. For example, as one population increases, it is held in check by one or more environmental factors or another species. Over a period of many years, a steady cycle of interspecies competition will result in a relatively stable environment in which populations coexist under sets of environmental conditions that will support their long-term survival. In this sense, a successful plant species is one whose adults can grow and thrive and whose seeds can germinate and survive to adulthood. A plant species that dominates as an adult population in an environment, but whose seedlings cannot grow to adulthood in that environment, will not continue to be a dominant species in the area for more than a few generations.

Abiotic Factors

It is important to recognize that abiotic conditions are established as a function of the nonliving components present in the environment. These conditions include the range of temperature, the abundance of moisture, the combination of soil minerals, and the intensity of light. These conditions are modified by the living species that inhabit such an area. For example, the intensity of light falling onto the ground in a forest can be greatly reduced by a thick leaf canopy. A thick carpet of leaves and rotting wood can soak up and retain rainwater and reduce runoff. The conditions created by high tree density in a forest may depress air temperatures by several degrees compared with surrounding field environments. A dominant community of plant species may establish conditions that favor that community's long-term survival to the exclusion of other communities.

Cyclic Change

Ecosystems, like many other complex systems, tend to show cyclic changes around a state of approximate equilibrium. Ecosystems are dynamic and complex. The many biotic and abiotic factors that characterize a given environment interact in complex ways that create a relatively stable system. This stable state is said to be at equilibrium. These factors balance each other. When one factor changes, all the remaining factors are affected. Periodic changes in these factors can set off repeating cycles of change that become part of the dynamic state of the environment. Such periodic changes can include food availability, seasonal temperature change, cyclic rainfall patterns, and population reductions caused by disease, among many others.

Perhaps the easiest cyclic change to understand is that caused by seasonal change. As spring arrives in most of New York State, natural ecosystems emerge from a dormant state to an actively growing one. Seeds lying in the moist earth germinate, producing new annual and perennial plants. The buds of mature trees and shrubs swell with new growth and open to produce new leaves and flowers. Ice and snow melt, and ground frost gives way to warming temperatures. The abundance of liquid water, warm temperatures, and new plant food provide an inviting environment that supports herbivores. The presence of herbivores attracts populations of carnivores. The environment continues to warm and stabilize throughout the summer months, bringing still more change. As these periodic fluctuations occur, they affect the ability of other species populations in the area to thrive or survive. Swings in population numbers represent another aspect of the changes in the environment. Such changes do not always promote the survival of individuals; death is a normal part of the cycle of change.

Another example of cyclic change is the predator-prey relationship. Each environment has a carrying capacity for its animal populations. The carrying capacity of herbivores, such as rabbits, is the abundance and type of plant matter (such as clover) available in the environment. If left unchecked, the rabbit population would increase as a function of the amount of such food until all clover plants were consumed. Obviously, the destruction of the food supply would cause the destruction of the rabbit population as well. In a balanced environment, predators such as foxes exist that feed on the populations of herbivores, reducing their number. This promotes the growth of clover a s the numbers of rabbits decrease. As more rabbits are consumed, the well-fed fox population increases. As the rabbit population declines due to hunting by the foxes, the fox population soon also declines. As the fox population declines, hunting pressure on the rabbits is diminished, so there is a resurgence in the rabbit population. This cycle repeats itself as the populations of clover, rabbits, and foxes respond to increases or decreases in the other populations. Such cyclic and interrelated changes ultimately lead to relatively stable populations of all three species over time.

Ironically, the result of these small periodic changes is normally the perpetuation of a relative stability in the environment. Each of the small changes contributes to a dynamic tension to which other environmental factors respond. The cumulative result of all these changes is ecosystem stability.

Direct and Indirect Interactions

Every population is linked, directly or indirectly, with many others in an ecosystem. Disruptions in the numbers and types of species and environmental changes can upset ecosystem stability. The presence or absence of other species populations in an environment can affect the stability of an individual species. Species populations interact in many ways, sometimes directly and sometimes indirectly. Since most organisms depend on other organisms for food, the absence of a species that is used as a food source by other species will affect the ability of those other species to survive. For example, the Kamer Blue butterfly, a species unique to New York pine barrens, depends on the growth of a plant, known as lupine, for food and breeding. Lupine, in turn, can tolerate only a narrow range of soil conditions. If these conditions change, the population of lupine may be adversely affected. If the availability of lupine decreases, the survival of the Kamer Blue is also impacted adversely.

Some direct relationships are nutritional. A nutritional relationship is where one organism uses the bodies of other organisms for food. In nature, all organisms fit into food chains that involve patterns of consumption. For example, grass is a common plant that is used by many herbivorous species for food. An example of a grass-eating herbivore is a grasshopper. Grasshoppers may serve as a food source for a carnivore, such as a bird. The bird, in turn, may become a food source for a bobcat. This food chain may be illustrated by means of the diagram below, where arrows illustrate the direction of material and energy flow in the ecosystem:

$$\text{grass} \longrightarrow \text{grasshopper} \longrightarrow \text{bird} \longrightarrow \text{bobcat}$$

An outside force that affects any of the populations in this food chain will affect all other populations in the food chain. A blight that kills the grass will cause the grasshoppers to die of starvation. The lack of grasshoppers will drive birds to new environments to find food. Without the birds, the bobcats will have to seek out alternative food sources, a step that puts them into direct competition with other top predators for limited food resources. Food chains that intersect are known as food webs.

Other direct relationships are symbiotic. Symbiosis refers to interacting species populations where some aspect of their lives is shared. Common symbiotic relationships include parasitism, mutualism, and commensalism. These interrelationships are covered in detail later.

The linkage between the Karner Blue butterfly and the lupine plant is direct. However, many interrelationships in an ecosystem are indirect. Some times, many steps intervene in the connection between two organisms, but a connection nearly always exists. When no direct link is obvious, it is easy to dismiss such interactions as being of little consequence to human survival. However, the potential impact of species destruction on human survival should not be discounted. There is every reason to assume that when the environment becomes inhospitable to one species, it becomes inhospitable to all similarly situated species, including humans.

Limiting Factors

Performance Indicator 6.1 The student should be able to explain factors that limit the growth of individuals and populations.

Energy flows through ecosystems in one direction, typically from the Sun, through photosynthetic organisms including green plants and algae, to herbivores to carnivores and decomposers. Energy is a necessary part of the life of each living thing. Each of the cell's life functions requires energy to operate. The ultimate source of energy used by living things is the energy of sunlight. Energy is transferred through the ecosystem by means of food chains and food webs involving nutritional relationships, among many things.

The Sun's energy is absorbed by specialized organisms that convert it to a more stable form-food. Organisms capable of producing their own food are known as autotrophs. Green plants and algae, the principal autotrophic organisms, manufacture organic molecules that serve as food for all the other organisms in the environment. This food is the main source of energy and structural components for all living things. Green plants that manufacture food by photosynthesis are known as producers.

Herbivores are animals that use only plant matter for food. This group contains many species of wild grazing animals as well as many domesticated species. Examples of herbivores include deer and rabbits. Because herbivores are the first animals to receive the energy captured by green plants, they are also known as primary consumers.

Carnivores are animals that consume the bodies of other animals for food. Some carnivores, known as predators, kill other animals (prey) for food. Others, known as scavengers, consume the dead bodies of animals killed by predators or by other natural causes. Examples of carnivores include wolves and mountain lions. Because carnivores are the second animals to receive the energy captured by green plants, they are also known as secondary consumers.

Omnivores are animals that eat both plant and animal matter as regular parts of their diet. Human beings are classified as omnivores.

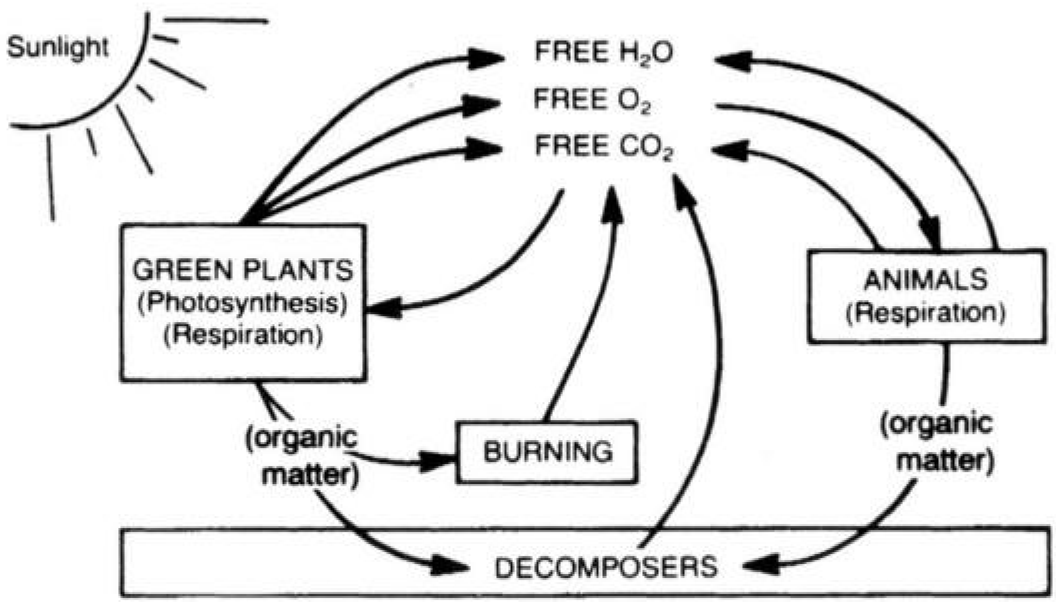
Decomposers include saprophytic fungi and bacteria responsible for breaking down the complex structure of the bodies of living things into simpler forms that can be used by other living things. At the same time, decomposers release and use energy stored in those organic molecules. In a sense, decom posers are responsible for operating a recycling system that reuses the chemical substances of life over and over. This action is essential to the continued functioning of the ecosystem.

Material Cycles

The atoms and molecules on the Earth cycle among the living and nonliving components of the biosphere. For example, carbon dioxide and water molecules used in photosynthesis to form energy-rich organic compounds are returned to the environment when the energy in these compounds is eventually released by cells. Continual input of energy from sunlight keeps the process going.

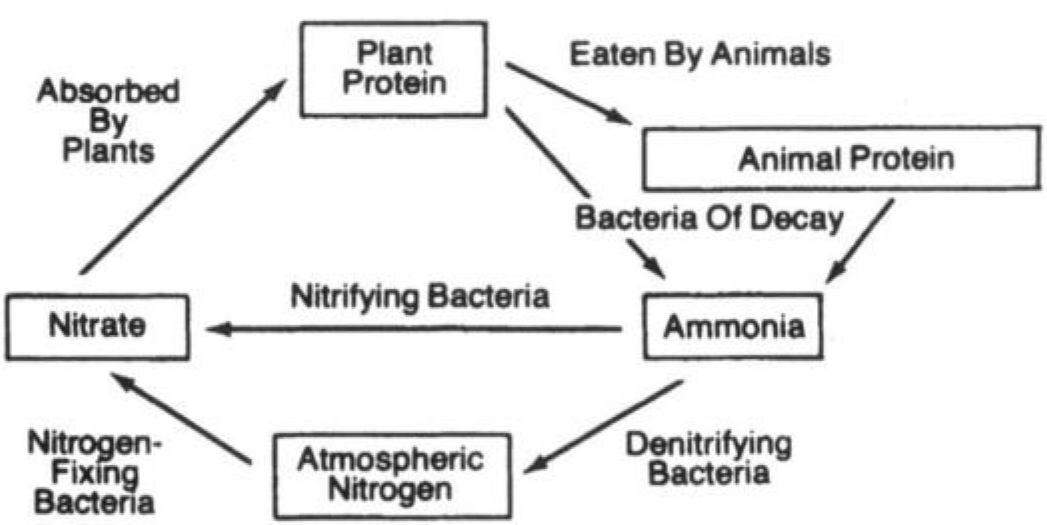
Material cycles function in nature to make chemical substances available to living things for their continued growth and reproduction. Material cycles consist of sequential chemical reactions that allow for such periodic recycling. Some examples of material cycles are as follows.

Carbon-hydrogen-oxygen cycle-In previous sections, we studied the processes of respiration and photosynthesis and discovered that they are quite similar in terms of the chemical substances involved. In photosynthesis, carbon dioxide and water combine with the aid of solar energy, producing glucose and oxygen gas. In respiration, glucose and oxygen combine to produce carbon dioxide and water, releasing cellular energy. One process produces waste products that serve as raw materials for the other. In this way, environments that contain balanced communities of plants and animals should be self-sustaining in terms of the supply of the elements carbon, hydrogen and oxygen.



Carbon-Hydrogen-Oxygen Cycle

Nitrogen cycle-Nitrogen is an elemental component of the class of compounds known as proteins. The nitrogen cycle makes nitrogen available to organisms for use in protein synthesis. As in the carbon cycle, living organisms are an important part of the nitrogen cycle. Decomposers and other soil bacteria are essential in converting nitrogenous wastes of animals and plants into a form of nitrogen usable by plants as fertilizer. Animals of various types round out the nitrogen cycle as consumer organisms in the food web.



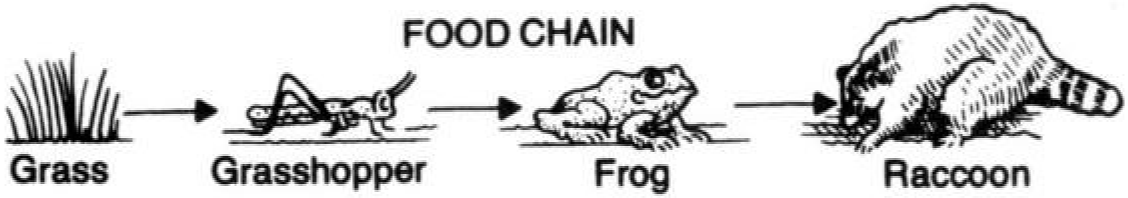
Nitrogen Cycle

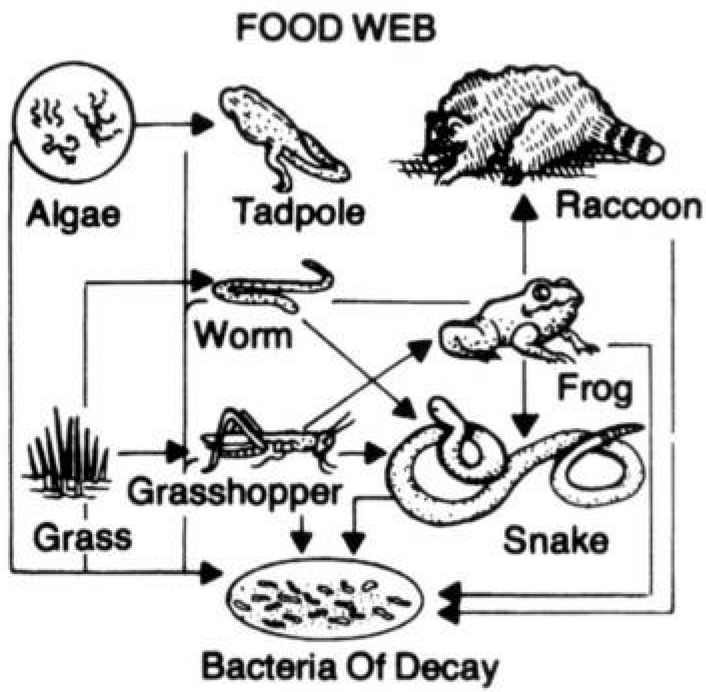
Energy Flow Relationships

The chemical elements, such as carbon, hydrogen, nitrogen, and oxygen, that make up the molecules of living things pass through food webs and are combined and recombined in different ways. At each link in a food web, some energy is stored in newly made structures. However, much is dissipated into the environment as heat. This concept may be illustrated with an energy pyramid.

Food Chains Food chains begin when green plants absorb sunlight and convert it into chemical bond energy in photosynthesis. The carbohydrates produced as a result of this activity forge the first, essential link in the food chain. A herbivore that consumes the plant represents the next link in the food chain by incorporating the stored energy of the plant into its own tissues. The next link in the food chain is a carnivore that consumes the body of the herbivore, thereby taking in the energy-containing molecules and releasing their energy for its own uses. Several more carnivorous animals may be involved as successive links in the food chain as animals consume other animals and in turn are consumed. The final link in any food chain is a saprophytic organism or bacteria of decay.

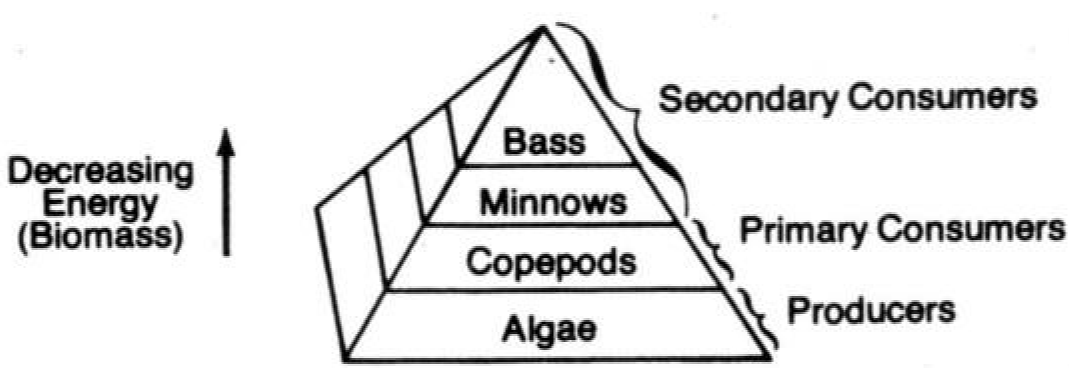
Food Webs To illustrate more realistically the complex nature of nutritional relationships in a natural community, the food web is used. The food web concept recognizes that many plant species are present in any ecological community, all producing energy-rich organic compounds for consumption by many different species of herbivore. At the same time, multiple combinations of carnivorous and omnivorous species interact to consume the herbiv orous species. Saprophytes of many different varieties are responsible for consuming the decaying bodies of plants and animals alike. In fact, different species may compete strongly for the same type of food available in the ecosystem. When the names of all the species present in a community are written onto a sheet of paper and lines are drawn between the species for which a nutritional relationship exists, a pattern resembling a web emerges.





Food Chain and Food Web

The solar energy available to the producer organisms in a food chain is considerable. At each step of the food chain, however, some of this energy is lost. Some is used in the life processes, some is radiated as heat, some is lost in excretory waste. In any food chain, the producer level contains the greatest amount of energy. Primary consumers contain only about 10 percent of the energy found in the producers. In turn, secondary consumers contain only about 10 percent of the energy housed in the bodies of the primary consumers and only about 1 percent of the energy in the producers. Since each feeding level contains less energy than the level below it, this phenomenon can be illustrated as a pyramid, known as the pyramid of energy. Eventually, all energy received by the ecosystem will be lost and will radiate as heat into the atmosphere. A constant resupply of energy from the Sun is necessary to sustain the ecosystem.



Energy (Biomass) Pyramid

Carrying Capacity,

The number of organisms any habitat can support (carrying capacity) is limited by the available energy, water, oxygen, and minerals and by the ability of ecosystem to recycle the residue of dead organisms through the activities of bacteria and fungi. The carrying capacity of an environment is the number of organisms of different species that can be supported by that environment. Various factors, including available sunlight, moisture, minerals, oxygen, organic food, and other abiotic factors, are instrumental in determining the number of each species that can be supported by that environment. For example, in a grassland environment, the number of buffalo that can be supported is determined by the available food, water, and other components required by the buffalo. If these requirements are limited by natural disaster or human intervention, then the number of buffalo that can be supported may be severely limited.

Also critical to the carrying capacity of the environment is the rate of turnover of the material components of the ecosystem. This turnover is accomplished by organisms of decay-fungi and bacteria. These organisms use their specific characteristics to convert the complex polymers characteristic of most plant and animal life to simpler components that can be absorbed by plants and other organisms capable of synthesizing organic molecules. These activities are directly related to the material cycles discussed previously.

Abiotic Factors

In any particular environment, the growth and survival of organisms depend on the physical conditions including light intensity, temperature range, mineral availability, soil/rock type, and relative acidity (pH). Abiotic factors are the physical and chemical factors in the environment upon which life depends, but which themselves are nonliving. These factors often determine what type of plant and animal community can become established and thrive in a particular area. Examples of abiotic factors include:

- light intensity available for photosynthesis
- temperature range
- amount of available moisture
- type of rock substratum under the soil
- availability of minerals
- availability of atmospheric gases
- relative acidity (pH) of the system

The abiotic conditions determine to a large extent what plant species can exist in a particular environment. In turn, the animal populations that exist in an environment are determined largely by the plant community. For example, a dry, sunlit field with a clay-loam soil in a temperate zone might support a wide diversity of wildflower species, such as goldenrod, aster, and wild daisy, that would thrive under these conditions. On the other hand, species such as mosses and ferns would have a difficult time existing in such an environment because of the need of these species for moist, shady conditions such as those found in a forest environment.

Living organisms have the capacity to produce populations of unlimited size, but environments and resources are finite. This has profound effects on the interactions among organisms. Each environment is characterized by variations in the amount of abiotic factors making one environment different from another environment. Because each species of living thing depends on a different mix of abiotic factors, the available amount of any factor can limit the types of species that can inhabit a particular environment. Factors that so limit the makeup of an ecological community are known as limiting factors. Some examples of the way limiting factors operate include the following.

- The herb species inhabiting a forest differ markedly from those inhabiting an adjacent field because of the difference in light intensity in the two areas.
- Low temperature conditions common to extreme northern latitudes prevent certain plant and animal species from living there while favoring the survival of others.
- Certain fish species require an abundance of dissolved oxygen in their water environment. If oxygen concentrations drop, members of the species will die from suffocation.
- Freshwater and saltwater environments play host to completely different species of fish, shellfish, and other aquatic species because of the difference in salinity between these two environments.

Biotic Factors

Relationships between organisms may be negative, neutral, or positive. Some organisms may interact with one another in several ways. They may be in a producer/consumer, predator/prey, or parasite/host relationship; or one organism may cause disease in, scavenge, or decompose another. Biotic factors include all the living components of the environment that affect the ecological community, either directly or indirectly, and help to limit the species that inhabit an area. Examples of biotic factors include:

- the population levels of an individual species
- the particular set of food requirements ofa species
- the interactions that a species has with other species
- the wastes produced by the members of a species

Nutritional relationships between species involve the transfer of nutrient materials between one organism and another within the environment. Organisms may be classified as follows in terms of the type of nutritional relationships they have with other organisms.

- Autotrophs are organisms capable of manufacturing their own food. We have learned that these organisms, mainly green plants, have a unique role in the environment by forming the basis of the food chain.

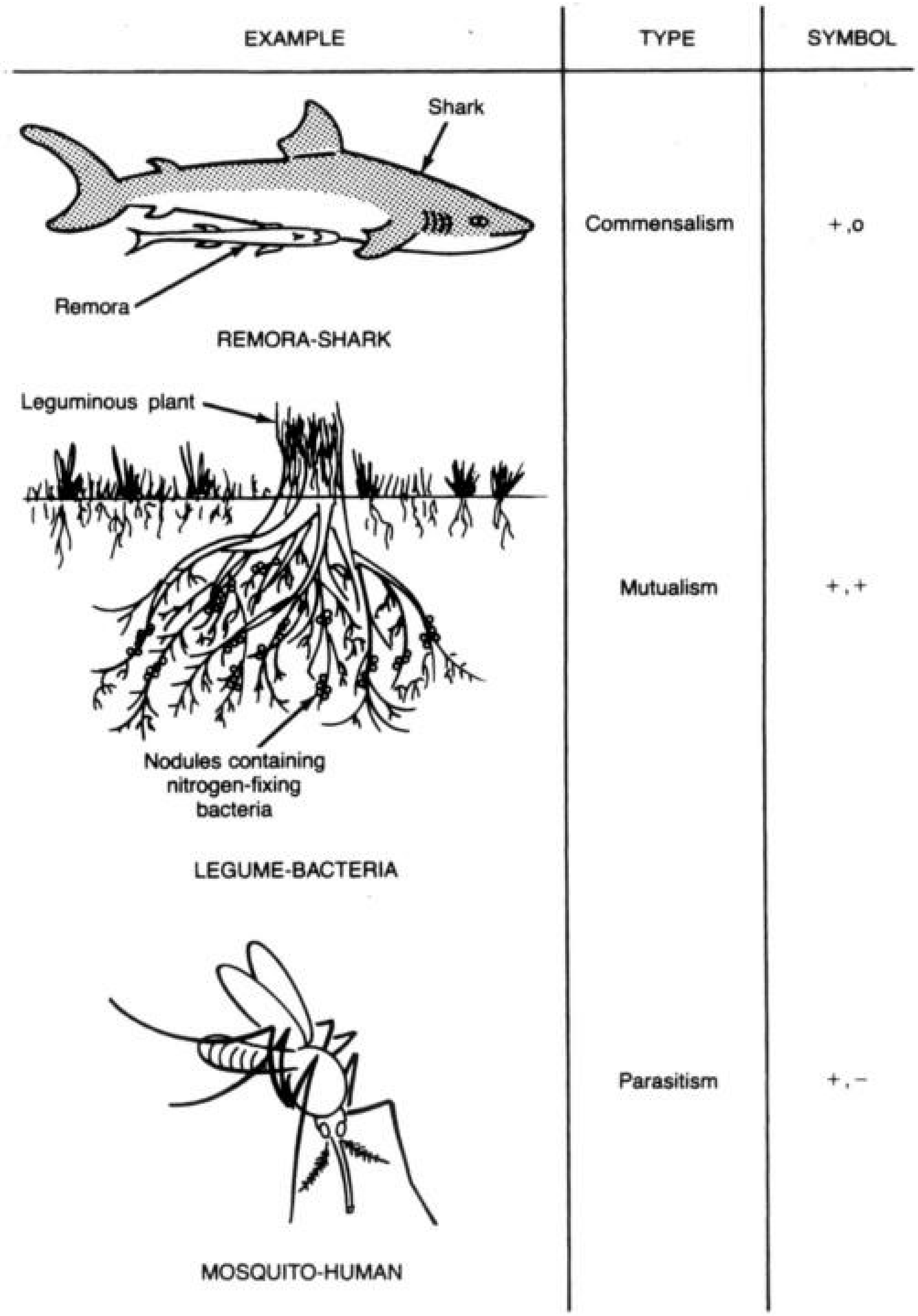
- Heterotrophs depend on other organisms for food. These organisms, represented by many types of animals, fungi, protists, and other species, consume other organisms as a source of energy and materials.

Symbiotic relationships between species involve the ways that different types of organisms can live together in close physical association. Symbiosis is the term used to describe such relationships. Types of symbiosis include the following.

- Parasitism is a form of symbiosis in which one organism (the parasite) in the relationship benefits, while the other (the host) is harmed. The symbolic representation of parasitism is +, - indicating the positive and negative impacts on the organisms in this relationship. Examples of parasitism include (1) athlete's foot fungus on human beings, in which the fungus derives nutrients from the human's skin and the human is harmed when the skin is opened to infection; (2) tapeworm infestation in a rabbit, in which the tapeworm gets nutrition from the digested food in the rabbit's intestine and the rabbit is deprived of much of the food it eats and digests; and (3) heartworm in dogs, in which the worm parasite infects the heart muscle of the dog and eventually kills the animal.

- Commensalism is a form of symbiosis in which one organism is benefited while a commensal partner is neither harmed nor helped. A symbolic representation of this relationship is +, 0. This indicates the positive effect (+) coupled with the neutral effect (0) at work in this type of symbiosis. Examples of commensalism include (1) the barnaclewhale relationship, in which the barnacle attaches itself to the whale and benefits from worldwide transport in food-rich waters while the whale remains unharmed; (2) the orchid-tree relationship, in which the orchid benefits from a stable growing environment on the tree while the tree is unharmed; and (3) the remora-shark relationship, in which the remora attaches itself to the shark and benefits from food particles not eaten by the shark while the shark is unaffected.

- Mutualism is a form of symbiosis in which both organisms in the relationship benefit. The symbolic representation of this type of symbiosis is +, + indicating the mutually positive result of the association. Examples of mutualism include (1) the relationship between nitrogen-fixing bacteria and the roots of leguminous plants on which they live; the bacteria benefit by having a stable environment to reproduce, and the legume benefits from the nitrates manufactured by the bacteria; (2) the protozoa-termite relationship; the protozoa benefit from the nutrientrich environment of the termite's intestine and the termite benefits from the wood-digesting action of the protozoa; and (3) the relationship that exists between an alga and a fungus in a lichen; the fungus provides a moist surface for the algae, and the algae in turn provide manufactured food to the fungus.



Symbiotic Relationships

Diversity of Species and Habitat

Preservation of Species Diversity and Habitat

Performance Indicator 6.2 The student should be able to explain the importance of preserving diversity of species and habitats.

As a result of evolutionary processes, there is a diversity of organisms and roles in ecosystems. This diversity of species increases the chance that at least some will survive in the face of large environmental changes. Biodiversity increases the stability of the ecosystem. Evolutionary processes are constantly at work in nature. These forces create new varieties, test them against environmental pressures, select those best adapted for survival, and ensure their perpetuation in the species gene pool. This process ensures that many varieties of each species will be present in the ecosystem at any given time, increasing the likelihood that at least some members of each species will survive in the event of a drastic change in the environment.

While the exact cause of the dinosaur extinction 65 million years ago is still unclear, scientists are discovering more and more evidence that points to mass extinction due to a drastic environmental change of some sort. Whether triggered by an asteroid strike, a volcanic eruption, or some other extinction-level event, the change likely took place too quickly to allow those species to adapt to it. The fossil record shows that during a comparatively brief period of time, hundreds of thousands, perhaps millions, of species of plants and animals were eliminated by this change. The relatively small number of species that survived this event were the ancestors of species that still survive on Earth today. A popular theory holds that members of one of the only dinosaur species to have survived this mass extinction were the ancestors of modem birds. These ancestral animals were able to survive and eventually thrive in the changed environment, producing generations of offspring that filled the newly available habitats and environmental niches. The vast variety of bird species that inhabit the Earth is a testament to the forces of evolution producing new, ever more adaptable, species. It is also an insurance policy safeguarding the dinosaur-bird hereditary line against any future extinction-level event.

Environmental Niche

Each species of organism has a role to play in the environment. This role is the organism's niche in the environment. Although the niches of some organisms may, on the surface, seem insignificant to human survival, scientists have come to understand that all populations in a natural community depend on all other populations to provide a balanced set of conditions conducive to the survival of all members of the community. Removal of any one species degrades the quality of the ecosystem because its elimination removes the role that species plays and makes it that much more difficult for the environment to recover from drastic change. The elimination of any species reduces biodiversity and makes survival of other species in that environment problematic.

An example of this is the elimination of predators from the Kaibab Plateau of Arizona in the early part of the 20th century. For hundreds if not thousands of years, the community of plants and animals on the plateau remained in balance. Each species filled its appropriate niche and interacted as predator, prey, producer, or decomposer. Misguided conservation policies introduced in the early 1900s placed a bounty on mountain lions and other natural predators of the Kaibab deer. As hunters reduced the numbers of predatory species on the plateau, the deer population, with fewer natural enemies, exploded. The thousands of additional deer that resulted quickly outstripped the food supply of this fragile environment. As edible plants were consumed and root systems destroyed by the foraging deer, the deer population starved to death in great numbers.

Putting Ecological Principles to Work

Scientists have learned much from this and similar incidents about the interactions among diverse species in the ecosystem and the effects of removing species from a balanced system. Today's system of identifying and protecting endangered species is a manifestation of our growing understanding of the vital roles that all species, from snails to whales, play in our global environment. We are beginning to understand that an environment hostile to any natural species is potentially hostile to our own species, as well.

Biodiversity also ensures the availability of a rich variety of genetic material that may lead to future agricultural or medical discoveries with significant value to humankind. As diversity is lost, potential sources of these materials may be lost with it. Medical science is developing techniques to analyze and exploit the genetic makeup of animals and plants to treat diseases in humans and other species. An essential aspect of this research is the discovery of new species. Each new discovery is studied in order to determine whether it might contain genetic information leading to the production of antibiotics and other medicinal biochemicals. These newly discovered species can then be cultured in the laboratory in order to maximize the production of the desired chemical. The specific genes responsible for the manufacture of these biochemicals may also be isolated and spliced into the genome of common bacteria in order to reduce the time and expense of this production.

Natural areas with an abundance of unknown species must be preserved in order to allow scientists to discover new organisms and study their characteristics. One of the most diverse terrestrial environments on Earth is the Brazilian rain forest of South America. Thousands of unknown species exist in this area. Environmental damage caused by unchecked agricultural and urban development in this area is threatening the habitat of many such species. Extinctions of species with the potential to aid medical science likely occur every day.

Ecosystem Formation

Ecosystem Change

Performance Indicator 6.3 The student should be able to explain how the living and nonliving environments change over time and respond to disturbances.

The interrelationships and interdependencies of organisms affect the development of stable ecosystems. Many interrelationships exist among species in any natural environment. Some of these relationships are nutritional or symbiotic in nature, while others are less direct. The particular mix of species populations in an ecosystem helps to establish a set of environmental conditions favorable to the perpetuation of that community. Each different ecosystem eventually reaches a state of dynamic equilibrium in which abiotic and biotic factors interact to maintain a stable, balanced system. Such systems can last for thousands of years as long as no outside force acts upon it to upset the balance. When such forces, including human activities, intervene, the balance of nature can be thrown off. In most such cases, the ecosystem adjusts to the change until a new balance is established. If the change is drastic, many species may be eliminated from the area and the environment may take centuries to establish a new balance.

Ecological Succession

By ecological succession, all ecosystems progress through a sequence of changes during which one ecological community modifies the environment, making it more suitable for another community. These long-term gradual changes result in the community reaching a point of stability that can last for hundreds or thousands of years.

Ecosystems are not unchanging. They tend to undergo dynamic change with time as biotic and abiotic environmental factors alter. This dynamic change results in the establishment of an equilibrium state whose characteristics are determined by the particular set of conditions and limitations that affect the living community. The term ecological succession refers to a process in which an established ecological community is gradually replaced by another. It, in turn, is replaced by other communities until a stable, selfperpetuating community is formed.

The beginning stages of an ecological succession frequently occur in barren, almost lifeless environments that may have been swept clean by glaciation, erosion, fire, volcanic eruption, or some other destructive event. The first living things to invade such an area and establish themselves in it are known as pioneer organisms. A typical pioneer organism populating bare rock is lichen, a fungus-alga symbiotic association that can tolerate this harsh, dry, soilless environment. A pioneer organism such as lichen, although small, can significantly alter the environment it has invaded. The lichen produces a mild acid that acts on the rock surface and erodes it into grains of sand. At the same time, the material comprising the lichen adds organic matter to the sand grains, producing a crude form of soil. This soil gradually fills the rock crevices, providing favorable areas for seed germination and thereby paving the way for later stages of ecological succession, including mosses and grasses.

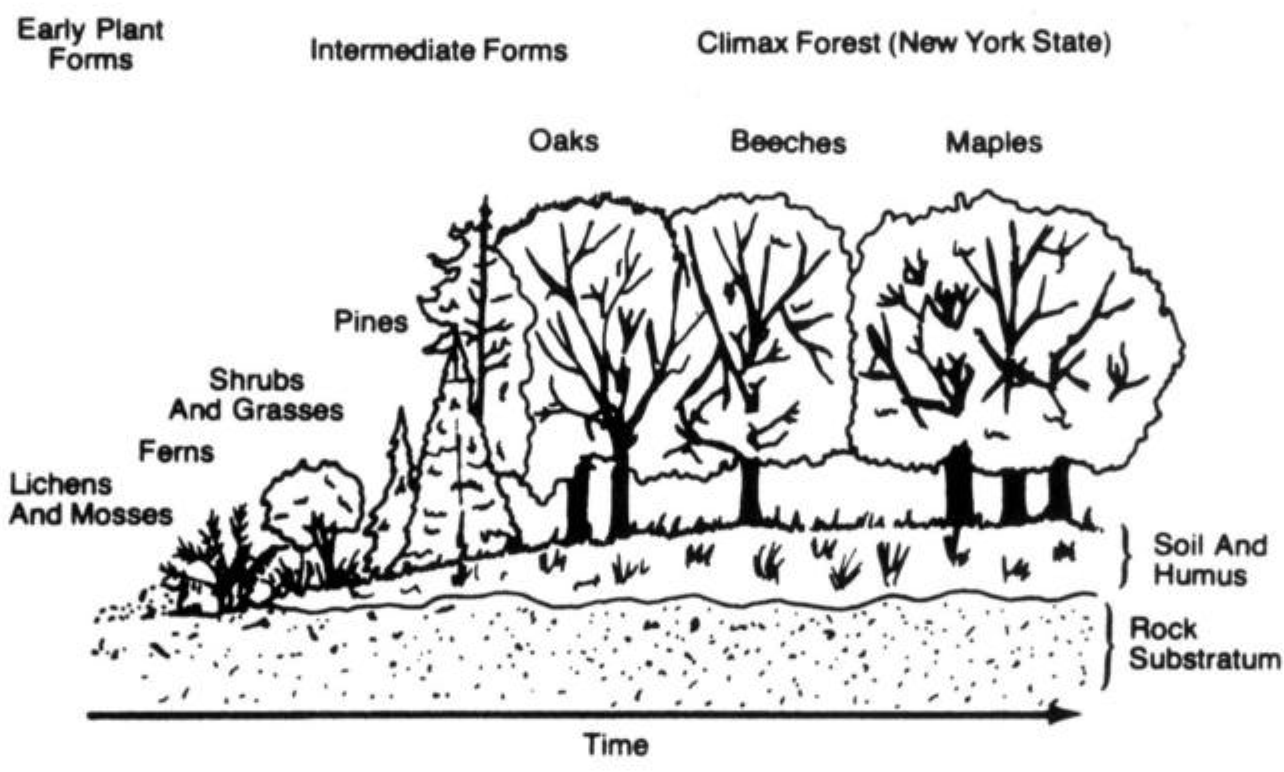
The germinating spores of mosses and seeds of grasses and other herbs give rise to the second succession stage. As this stage dominates over several generations, its members contribute organic matter to the soil. The root system protects the thin soil layer from erosion. Weathering and root pressure continue to fragment the rock substratum, adding still more substance to the thickening soil layer. Eventually, the soil layer is able to support the growth of shrubs and other woody plant species. When soil depth and quality are sufficient, varieties of trees and the animal species associated with them begin to invade and then dominate the area.

In this way, each successive community of plants and animals modifies the environment to make it less favorable for its own offspring but more favorable for the establishment of the next succession stage. In such a pattern, plant species tend to dominate since they provide the basis of the food chain for the area. The animal species that can live in the area are normally those that depend on the plant community. A succession stage is normally named for the dominant plant types in the environment since these species exert the most influence on the environmental conditions of the area. Eventually in each succession, a community becomes established that is self-perpetuating and relatively stable. Such a community is known as a climax community. A climax community remains the dominant community for an indefinite period, maintaining a relatively stable set of environmental conditions for both plant and animal species.

Ecosystem Stability

An individual species' reproductive rate may be limited by the microclimate created by the dominant community. It may also be limited by the microclimate created by such factors as moisture, temperature, light, latitude, and altitude. For example, the seedlings of hardwood trees such as oak and hickory grow well in environments characterized by low altitudes, sandy soils, and high light intensities. As these species mature, they create a microenvironment that is so deeply shaded that their own seedlings can no longer thrive. Instead, the seedlings of beech and maple, which tolerate low-light conditions, can successfully grow until they replace the populations of oak and hickory that once dominated. However, these same beech and maple seedlings do not compete well at higher altitudes and can easily be crowded out by tree species, such as spruce and hemlock, that are more tolerant of the conditions found at high altitudes. At very high altitudes, tree species in general do not thrive and are replaced by alpine wildflowers and other extreme altitude plant populations.

A stable ecosystem can be altered, either rapidly or slowly, through the activities of organisms (including humans) or through climatic changes or natural disasters. The altered ecosystem can usually recover through gradual changes back to a point of long-term stability. A climax community will nor mally remain intact as long as conditions in the environment do not change appreciably. If, however, the environment changes drastically because of some catastrophic event, then the climax community may die out or be swept away, making way for a new succession of communities. If the alteration is temporary, the same climax community may result. If the change is permanent, then a new group of climax organisms may be favored.



Forest Succession

Examples of this phenomenon can be readily observed in nature in a variety of settings. Keen observation and careful identification and inventorying of plant species in an area will provide evidence that succession is an ongoing biological activity in many ecosystems of the world. A few examples include the following.

- An abandoned farm field undergoes rapid succession, first playing host to wild grasses and wildflowers, then to invading shrubs and light-loving tree species such as aspen and white pine. After a relatively short period, the former field resembles a dense, young forest and the seedlings of climax stage trees are sprouting and competing with the early tree species. Often, such a succession pattern requires only a few decades to revert to the low-elevation oak-hickory climax forest characteristic of much of New York State.

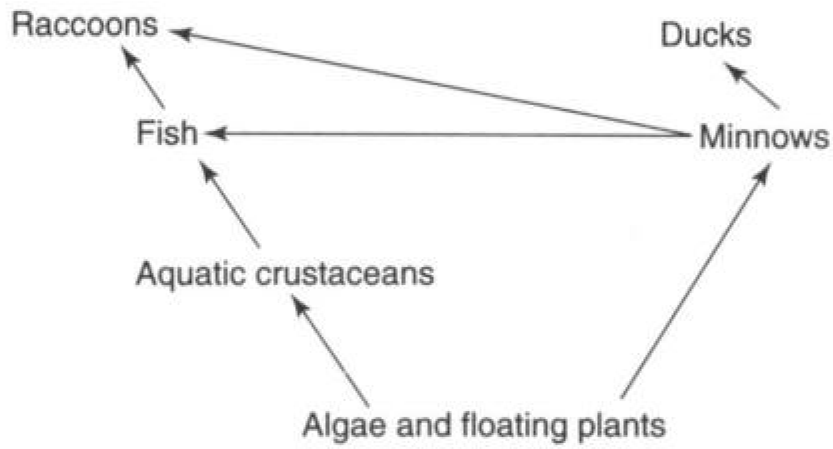
- A burned mountain forest tract quickly sprouts new pitch pine and other fire-resistant species. The seed cones of pitch pine are specially adapted to protect the seeds of this species during a fire but to release them rapidly after the ground has cooled. The new pine seedlings act to stabilize the soil, reducing erosion. Seed of other tree species, such as birch and aspen, from nearby unburned forest are transported to the bum area and quickly germinate to help stabilize the soil still further. Eventually, the seeds of slow-growing hemlock, beech, and maple trees take root and reestablish this high-elevation climax community typical of the Catskill and Adirondack Mountains of New York State.

- A stream valley flooded by a landslide that dams the stream quickly takes on the characteristics of a shallow lake. Over a period of many years, sedimentation and decay gradually fill the lake until marsh plants such as cattail and sphagnum moss gain a foothold in the wet shoreline. Over a period of years, the filling continues and the shoreline moves farther and farther out into the lake. Eventually, the marsh area is invaded by red maples and other wet-soil plants. These species stabilize the marsh mat and enable climax species to repopulate the valley, converting the lake to a forest stream once again.

- A volcanic eruption, such as that recently observed on Mount St. Helens in Washington State, completely covers the mountainside forest environment with lava flows and volcanic ash. No soil remains, but the seeds of pioneer plants blown in from surrounding areas take root in the unstable ash deposits and in crevasses in the lava rock. Over a period of as little as a decade, signs of recovery from the complete devastation are evident. Many decades later, the forest ecosystem will undergo succession in the area until a stable, self-perpetuating climax community is established. However, the mineral content of the volcanic ash may lead to a climax community different from the one swept away by the eruption.

QUESTION SET 2.9-INTERDEPENDENCE OF LIVING THINGS (ANSWERS EXPLAINED, P. 317)

1. Which statement best describes some organisms in the food web shown below?



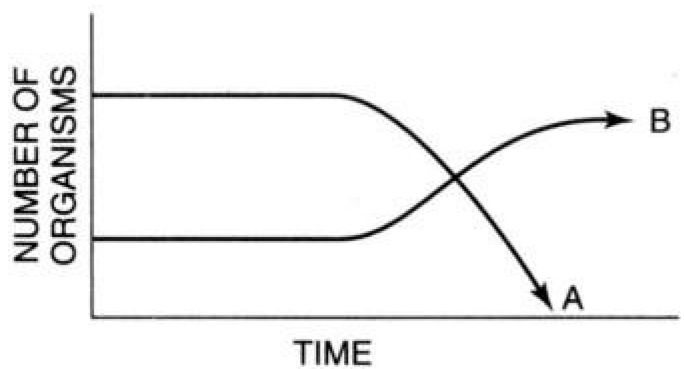
(1) Minnows and fish are primary consumers.

(2) Algae and floating plants are decomposers.

(3) Aquatic crustaceans are omnivorous.

(4) Raccoons, fish, and ducks are secondary consumers.

2. The graph below shows the changes in two populations of herbivores in a grassy field.



A possible reason for these changes is that

(1) all of the plant populations in this habitat decreased

(2) population B competed more successfully for food than population A did

(3) population A produced more offspring than population B did

(4) population A consumed the members of population B

3-5. For each description in questions 3 through 5, select the biome, chosen from the list below, that best fits that description. A biome may be used more than once or not at all.

Biomes

(1) Tundra

(2) Taiga

(3) Temperate deciduous forest

(4) Grassland

(5) Desert

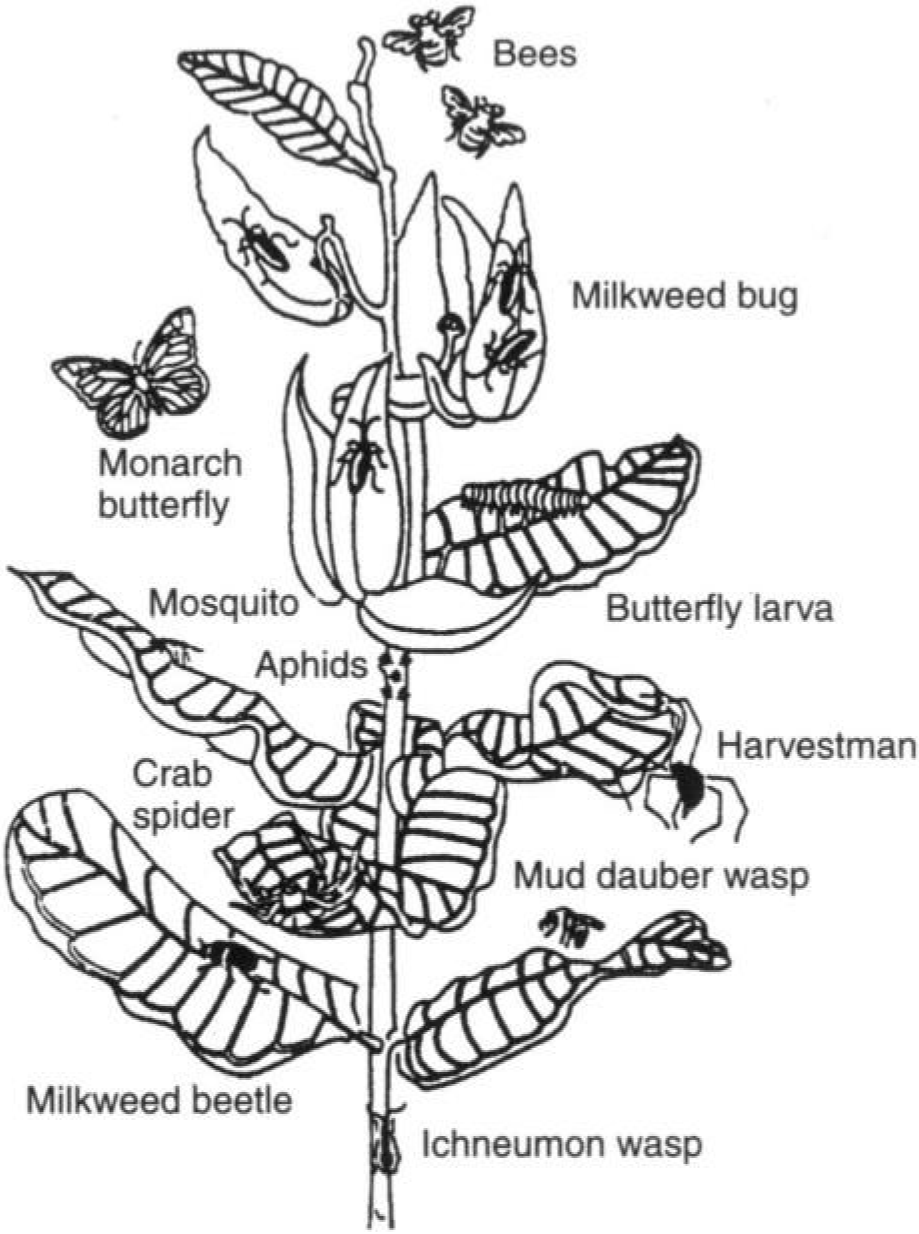
(6) Tropical forest

3. Lichens and mosses are present; subsoil permanently frozen.

4. Constant, warm temperature; abundant rainfall.

5. Wide variation in daily temperature; little rainfall.

6. The diagram below shows a milkweed plant and some of the insects that live on it or visit it.



Which term best describes the group of organisms in the diagram?

(1) biosphere

(2) community

(3) habitat

(4) biome

7. Hawks and owls living in the same area compete for the same type of mouse for food. Which situation would lead to the greatest problem in the food supply?

(1) an increase in the owl population

(2) an increase in the mouse population

(3) a decrease in the hawk population

(4) a decrease in the owl population

8. Which group represents a population?

(1) all the vertebrates living in New York State

(2) all the Homo sapiens living in New York State

(3) all the plant and animal species found in New York State

(4) all the flowering plants found in New York State

9. A student measured some abiotic factors present in an aquarium in a biology laboratory. Which data did the student most likely record?

(1) the weight and color of each type of scavenger

(2) the number of each type of green plant and each type of snail

(3) the size and number of each species of fish

(4) the temperature and oxygen content of the water

10. Energy stored in organic molecules is passed from producers to consumers. This statement best describes an event in

(1) the process of photosynthesis

(2) natural selection

(3) a food chain

(4) ecological succession

11. Which material cycle relies least on the processes of photosynthesis, transpiration, evaporation, respiration, and condensation?

(1) oxygen cycle

(2) nitrogen cycle

(3) water cycle

(4) carbon cycle

12-14. For each symbiotic relationship in questions 12 through 14, select the type of symbiosis, chosen from the list below, that best identifies that relationship. A number may be used more than once or not at all.

Types of Symbiosis

(1) Commensalism

(2) Mutualism

(3) Parasitism

12. A tapeworm lives in the digestive tract of a human.

13. Nitrogen-fixing bacteria live in the nodules on the roots of legumes.

14. A flea sucks blood from the skin of a dog.

15. By starting on bare rock, what is the usual ecological succession of organisms?

(1) grasses → shrubs → lichens → trees

(2) lichens → shrubs → grasses → trees

(3) grasses → lichens → shrubs → trees

(4) lichens → grasses → shrubs → trees

16. An ecosystem is represented in the diagram below.

This ecosystem will be self-sustaining if

(1) the organisms labeled A outnumber the organisms labeled B

(2) the organisms labeled A are equal in number to the organisms labeled B

(3) the type of organisms represented by B are eliminated

(4) materials cycle between the organisms labeled A and the organisms labeled B

17. A certain plant requires moisture, oxygen, carbon dioxide, light, and minerals in order to survive. This statement shows that a living organism depends on

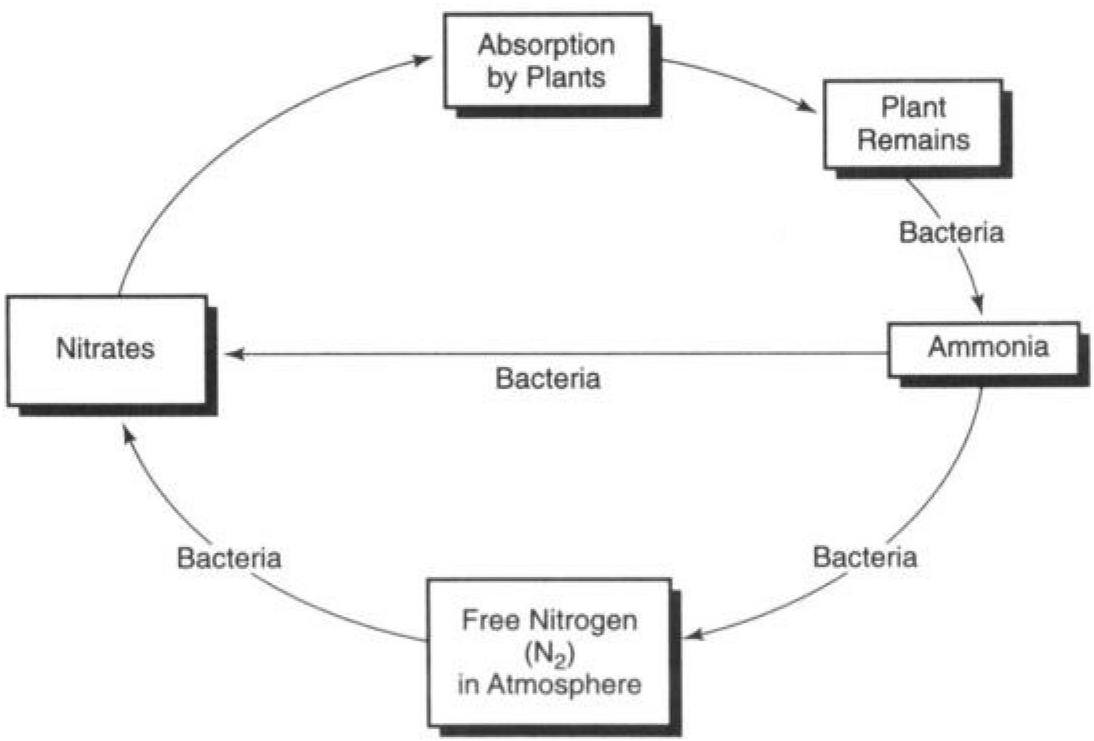
(1) biotic factors

(2) abiotic factors

(3) symbiotic relationships

(4) carnivore-herbivore relationships

18. Events that take place in a biome are shown in the diagram below



Which information is represented in the diagram?

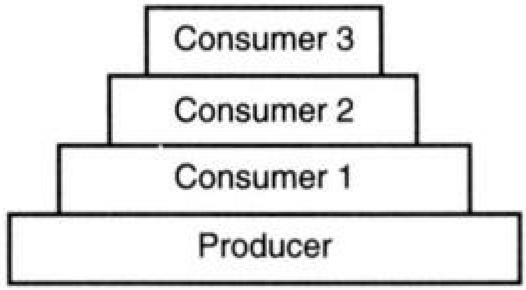
(1) Respiration and photosynthesis are interrelated.

(2) Transpiration and condensation are related to the water cycle.

(3) Decomposers release a material that is acted on by other organisms.

(4) Predators and their prey are involved in many interactions.

19. The diagram below represents an energy/biomass pyramid.



Which statement concerning the energy in this pyramid is correct?

(1) The producer organisms contain the least amount of stored energy.

(2) Stored energy decreases from consumer 2 to consumer 3.

(3) Consumer 3 contains the greatest amount of stored energy.

(4) Stored energy increases from the producer to consumer 1.

20. Which statement concerning the climax stage of an ecological succession is correct?

(1) It changes rapidly.

(2) It persists until the environment changes.

(3) It is the first community to inhabit an area.

(4) It consists entirely of plants.

21. Ina pond, which change would most likely lead to terrestrial succession?

(1) a decrease in the number of suspended particles in the pond water

(2) an-increase-in current velocity of the pond water

(3) a decrease in the number of diverse organisms in the shallow water of the pond

(4) an increase in sediment, fallen leaves, and tree limbs accumulating on the bottom of the pond

22. The most likely result of a group of squirrels relying on limited resources would be

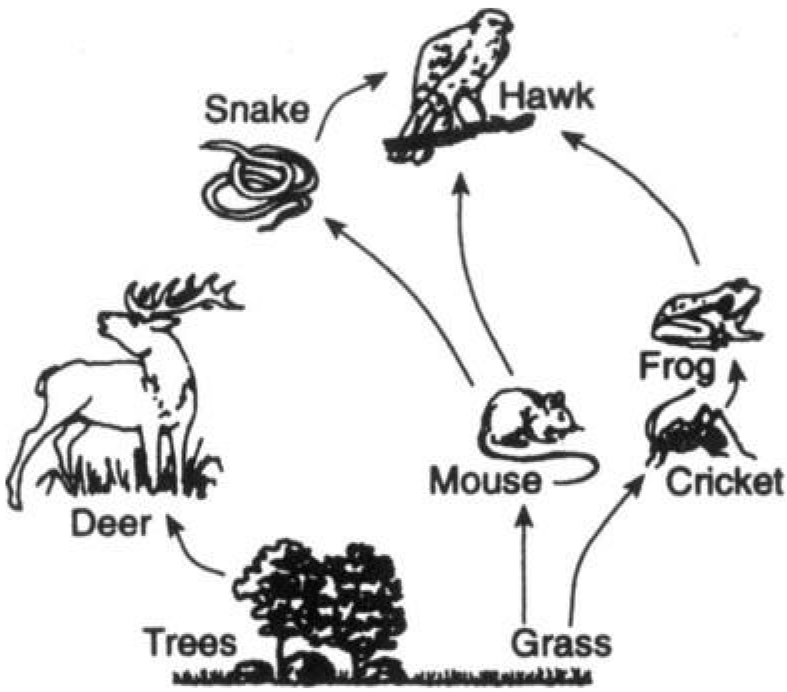
(1) an increase in the number of squirrels

(2) competition between the squirrels

(3) increased habitats for the squirrels

(4) a greater diversity of food for the squirrels

23. Nutritional relationships between organisms are shown in the diagram below.



Which organisms are primary consumers?

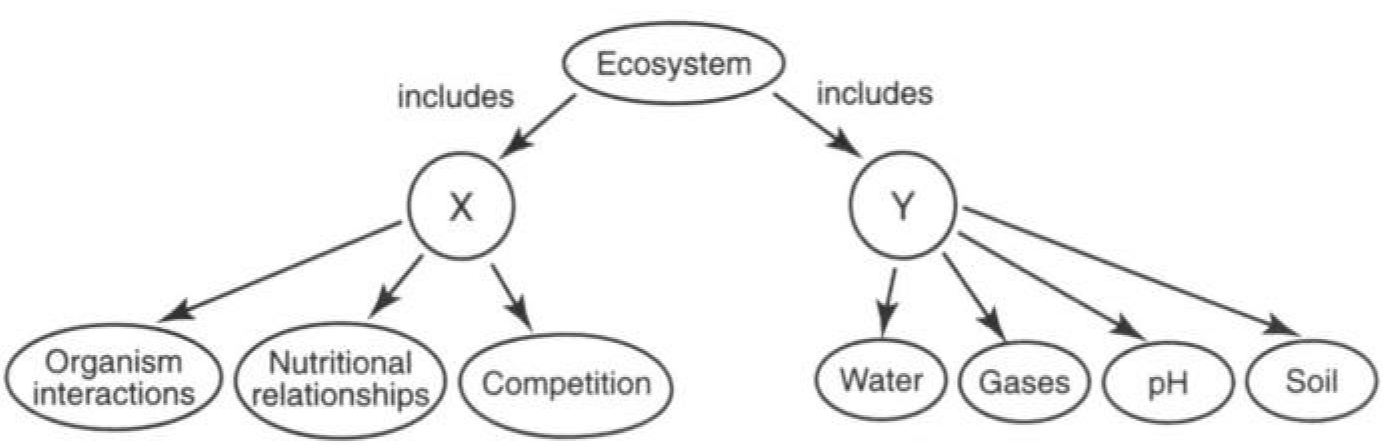
(1) mouse, snake, and hawk

(3) cricket, frog, and deer

(2) snake, hawk, and frog

(4) mouse, deer, and cricket

24. Information relating to an ecosystem is contained in the diagram shown below.



Which information belongs in areas X and Y?

(1) X-biotic factors; Y-abiotic factors

(2) X-ecological relationships; Y-biotic relationships

(3) X-abiotic factors; Y-interacting populations

(4) X-energy flow; Y-biotic factors

25. The American dogwood, a flowering tree of New York State's woodlands, has been attacked by a fungal disease specific to this tree species. Many dogwoods have died because fungicides have not proven effective in fighting the spread of this disease. Which term best describes the relationship between the dogwood trees and the fungus?

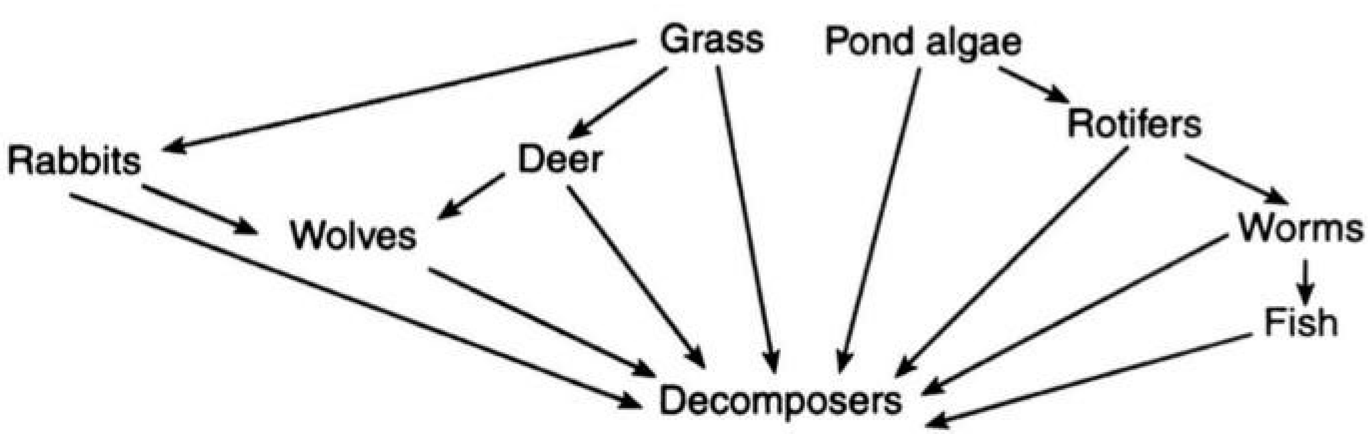
(1) commensalism

(2) mutualism

(3) parasitism

(4) saprophytism

26. The food web below shows some of the relationships that exist between organisms in a field and pond ecosystem.



a Write one or more paragraphs describing some of the relationships in this food web. In your answer, be sure to:

- identify a carnivore from the food web
- describe the complete path of energy from the Sun to that carnivore
- explain why decomposers are necessary in this food web

b A significant decrease in the wolf population occurs. After a period of one year, what change in the grass population would most likely be observed?

c A farmer sprayed pesticides onto a field next to the pond. By using one or more complete sentences, explain why several years later the fish population would contain higher pesticide levels than any other pond organisms would contain.

X. HUMAN IMPACT ON ECOSYSTEMS

KEY IDEA 7-HUMAN IMPACT ON THE ENVIRONMENT Human decisions and activities have had a profound impact on the physical and living environment.

The human species is unlike any other. Its population is growing virtually unchecked by the natural factors that limit other species populations. This population growth and its associated technologies have had significant impacts on the natural world. We are rapidly polluting the soil, air, and water upon which we depend for our survival. Our activities are increasingly displacing or destroying natural habitats and their ecological communities, reducing biodiversity and further endangering our future as a species.

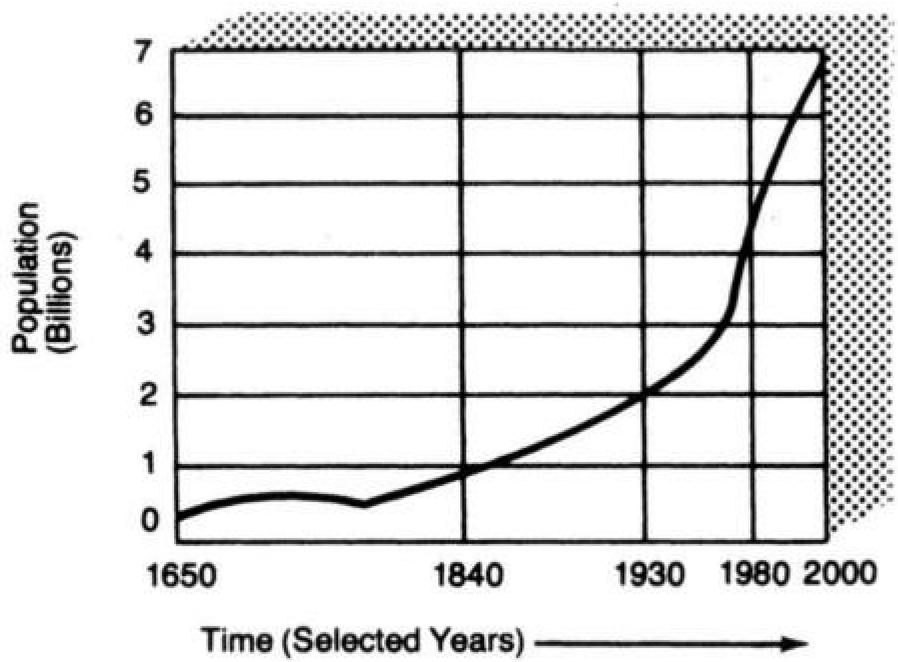
Resolving these issues is of major importance for this and future generations. While much progress in correcting environmental problems has been made, much is still to be done. Education and environmental awareness on a global level that impacts all levels of society is essential. Governments, industries, and the general public must begin to come to grips with the longrange impact of human activity that destroys the very fabric of biological life on Earth. Failure to understand the gravity of this situation could ultimately result in our destruction as a species.

Interdependence of Human and Natural Systems

Performance Indicator 7.1 The student should be able to describe the range of interrelationships of humans with the living and nonliving environment.

The Earth has finite resources. Increasing human consumption of resources places stress onto the natural processes that renew some resources and deplete those resources that cannot be renewed. Human population growth, unlike that of other species, has risen at a rapid rate over the past several centuries. As human technology has developed, many of the limiting factors (for example, disease, predation, hunger, exposure) have been progressively eliminated as checks on human population growth. In many areas on the world, therefore, the human population has grown faster than the food supply, a condition that threatens to eliminate large portions of the population in these areas. In addition, the natural resources that support our technologies are being depleted at a rapid rate, imperiling our ability to maintain our advantage against nature's limiting factors. Apparently, the human species is rapidly approaching a point at which it will be unable to sustain continued growth.

The trends in human population growth are illustrated by the following graph.



Human Population Growth

In addition to food resources, humans have used other natural resources at an alarming rate and with little thought of reuse. Paper (timber resources) is used in print media and packaging; only a small percentage of paper is recycled into new paper products. Plastic (petroleum resources) has become widely used in many consumer, industrial, and commercial processes; plastic is not biodegradable and is recycled at a very low rate. Metal containers (aluminum and iron resources) are recycled at a reasonable rate due to the expense of mining and refining metal ores; many of these products are still discarded, however. In addition to these consumer products, governments and industries annually consume billions of tons of raw materials of all kinds worldwide. Few of these resources are recycled unless their value is extreme (for example, gold, silver).

Some materials, such as timber resources, are renewable, meaning that more can be produced as long as we have the foresight to plant new trees and maintain their habitat. Other materials, such as petroleum and mineral resources, are nonrenewable, meaning that no processes can produce more of them. Logic tells us that there is a finite supply of economically retrievable nonrenewable raw materials on Earth. Once these nonrenewable resources are used up, no processes will produce more of them in the short term. Therefore, we should develop global policies to conserve these resources to ensure their availability into the future. Such policies should include recycling, conservation, and alternative technologies.

Impact of Human Beings on Natural Ecosystems

Natural ecosystems provide an array of basic processes that affect humans. Those processes include but are not limited to maintenance of the quality of the atmosphere, generation of soils, control of the water cycle, removal of wastes, energy flow, and recycling of nutrients. Humans are changing many of these basic processes, and the changes may be detrimental. Like other living organisms, human beings depend for survival on a balanced set of environmental conditions. Humans have been unique, however, in their ability to alter the very environment upon which they depend for their survival. The extent to which humans can learn to preserve and restore their environment will determine their survival as a species as well as the survival of most other species on Earth.

Negative Impact

The quality of the air determines how well we breathe and live. Air pollutants, including hydrocarbons and particulates, decrease air quality and make each breath a hazard to our health. Water is a substance vital to our survival. Its quality and its freedom from polluting materials, including pesticides, bacteria, heavy metals, and hydrocarbons, helps to determine our overall health. When our water becomes contaminated, our quality of life declines significantly. Soil contaminants may also affect us negatively when contaminants are absorbed by plants and move through the food chain to human food supplies. Because our entire food supply depends directly or indirectly on soil quality, we should be very concerned about the use of pesticides and other chemicals that potentially threaten the quality of agricultural soils in our country and in other parts of the world. Waste products of our residential and industrial processes are deposited in ways that are unsafe and can potentially threaten our soil, air, and water quality. We need to be alert to the methods by which wastes are handled and eventually processed to ensure that they do not contaminate our water and soil resources. By denuding the world of its forests and polluting its lakes and oceans, we are reducing the number of producer organisms that can absorb solar energy and convert it to a form usable by the cell. We must ensure that our marine, aquatic, and terrestrial biomes remain unpolluted and that the green plants and algae in them remain effective participants in this energy-conversion process.

The activities of a growing human population have had a tremendous impact on the natural environment over the past several centuries. Unlike most other species, human beings have systematically altered that environment for their own ends. In the past, most of this alteration has had negative effects on the natural environment. In recent years, however, there has been an attempt to correct some of the abuses of the past.

Human beings are part of the Earth's ecosystems. Human activities can, deliberately or inadvertently, alter the equilibrium in ecosystems. Humans modify ecosystems as a result of population growth, consumption, and technology. Human destruction of habitats through direct harvesting, pollution, atmospheric changes, and other factors is threatening current global stability. If not addressed, ecosystems may be irreversibly affected. Much of the negative impact of human activity on the natural environment has been because human beings have lacked a good understanding of their role in nature. We have long understood our impact on other living things. What we have failed to understand is that we, in turn, are affected by and entirely dependent on other species for our continued survival. The ecosystem has repeatedly demonstrated an ability to recover from minor natural disturbances and, given time, an ability to recover from major ones as well. The disruptions caused by human technology, however, have been of a fundamentally different kind from those due to natural forces. This technology has frequently resulted in the production of substances completely foreign to the natural environment. Their presence has introduced to the environment new selection pressures never before encountered by living things in their 3-billionyear history. Some examples include the following.

- Biocide use has introduced tremendous quantities of poisonous chemicals into the environment. Biocides (pesticides and herbicides) are used to control pests of various types that interfere with human activities. Once introduced into the environment, however, many of these biocides enter the food web and are passed from organism to organism, becoming more highly concentrated at each trophic level. In addition, their residues have increased pollution of soil and water resources. The biocide DDT, for instance, widely used in the midtwentieth century to control insect pests, disrupted the embryological processes of the bald eagle and other bird species.

- Disposal problems have resulted from the consumer-oriented societies of many technological nations. The products manufactured for consumption require the use of natural resources from all over the world, many of which are being depleted at an alarming rate. These products and their packaging materials are eventually discarded, adding to the solid-waste disposal problem. When discarded, often in a landfill or in the ocean, all the materials and the energy required to manufacture and distribute them is lost. In addition, many of these products and the processes used to manufacture them leave chemical residues known to be toxic to living things, including human beings. Finding a safe method for disposing of such toxic residues is a problem modern society must solve. To an increasing degree, the safe disposal of waste from nuclear power plants is becoming a problem of global proportions.

Every component of the ecosystem is connected to every other component in a dynamic equilibrium. A disruption of one component of the ecosystem ultimately has an effect on many other components because of these connections. A large number of shifts may occur before the equilibrium is reestablished. When human activities remove native vegetation, introduce toxic pollutants, change the consistency of rainfall, and otherwise modify the environment, multiple disruptions result. The long-term effects of these disruptions can only be hypothesized. It is likely, however, that the overall effect will not be positive.

An early example of the effect of human activity on the environment is known to have occurred within the past 2,000 years in the area now known as the Sahara Desert of Northern Africa. Archeological and biological evidence suggests that the Sahara was once a lushly forested area with an abundance of rainfall and many diverse species of plants and animals. This balanced ecosystem likely existed for many thousands of years before human activity, beginning more than 2,000 years ago, removed large stands of trees for construction of urban dwellings and other uses. As more and more trees were removed from the area, soils once protected by plant roots and shaded by their branches were exposed to the drying action of sun and wind. Gradually, the environmental conditions in the Sahara began to change. The stable forest ecosystem was altered to become a desert ecosystem. As a result, the species common to the forest environment, including the human populations, were largely eliminated. Archeologists have discovered the ruins of large cities in this area, long abandoned to the desert sands. Even today, the Sahara Desert continues to expand across Northern Africa, destroying more and more nondesert habitat at the rate of hundreds of square miles per year.

Warning Signs of Environmental Contamination

Many warning signs exist of the disequilibrium being created in our ecosystems in modem times. For example, in recent years, dramatic and mysterious declines in frog populations have been observed worldwide. Disproportionately high numbers of deformed frogs have been discovered in rural areas. Some scientists attribute these trends to exposure to hormone-disrupting chemicals in agricultural runoff. As tadpoles become frogs, a profound reorganization of their structure and physiology takes place-a reorganization driven by hormone messages. Some researchers suspect that toxic heavy metals and pesticides building up in aquatic food chains, plus serious air pollution, may be what is killing some frogs, toads, and salamanders. Others hypothesize that increased ultraviolet radiation, caused by depletion of the ozone layer of the atmosphere, may be affecting frogs' eggs that absorb solar radiation while floating on the surface of the water. Aerosol propellants such as chloroflourocarbons (CFCs) are known to destroy atmospheric ozone.

Among our own species, the declining health of our children may be signaling dangerous levels of environmental contamination. Adverse health effects linked to chemical exposures are beginning to be widely expressed among the general population and particularly among children. More than 30 types of birth defects are currently on the rise, as is childhood cancer, which is now the second leading cause of childhood deaths. Other health problems being experienced today by children living in contaminated communities include chronic lung disease, childhood asthma, attention deficit disorder and learning disabilities, and too-early or delayed sexual maturation.

Infancy and early childhood are periods of unique and extraordinary vulnerability to environmental pollution. Because they expend more energy and require more food, water, and oxygen for growing, children eat, drink, and breathe more per pound of body weight than adults. Because their metabolic systems are immature, they are unable to break down and excrete environ mental toxins they ingest or absorb through their skin. Toxins damage rapidly dividing cells more than those in a resting state. During children's early growing years, almost all cells are dividing much more rapidly than those of adults.

Hormone-disrupting chemicals, such as dioxins and PCBs, pose a particular hazard before birth and early in life since hormone messages orchestrate many critical aspects of development, from sexual differentiation to brain organization. Dioxin, pesticides, lead, and solvents easily cross the placenta, exposing the developing fetus. Because breast milk is high in fat and fat is where dioxin accumulates in our food and in our bodies, a nursing newborn is exposed to one to two orders of magnitude more dioxin than are adults. The average adult daily dietary intake already exposes us to between 100 and 1,000 times more dioxin than the amount that would result in a one-in-a-million cancer risk.

Technological Oversight

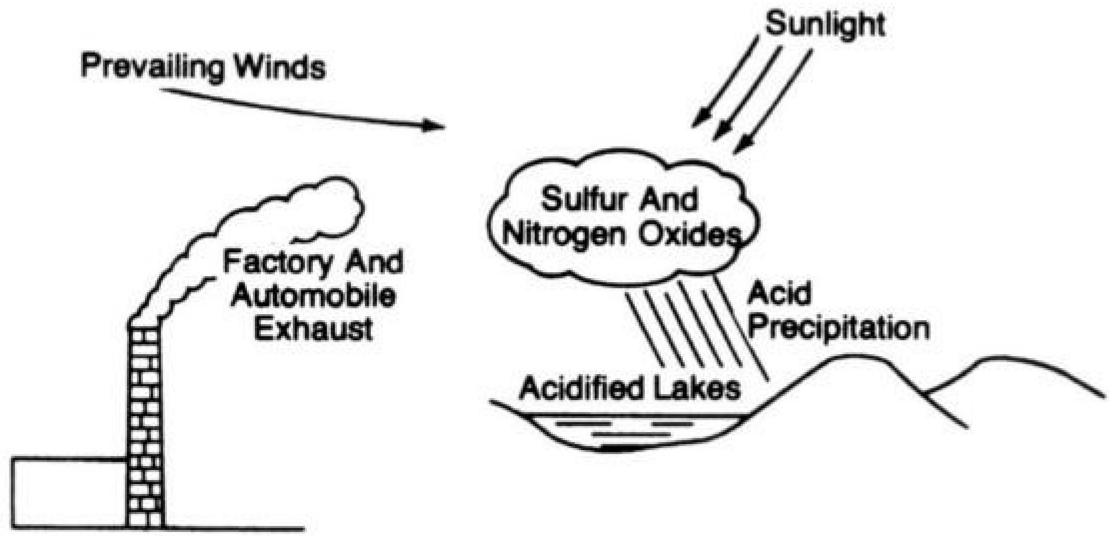
Performance Indicator 7.2 The student should be able to explain the impact of technological development and growth in the human population on the living and nonliving environment.

Human activities that degrade ecosystems result in a loss of diversity of the living and nonliving environment. For example, the influence of humans on other organisms occurs through land use and pollution. Land use decreases the space and resources available to other species. Pollution changes the chemical composition of air, soil, and water. When new technologies are developed, emphasis is often placed on their practical uses without careful consideration of their potential impacts on the natural environment. Many such technological oversights have resulted in unplanned ecological consequences, such as the pollution of our air, water, and soil resources. As these resources have become progressively more polluted, our quality of life has become imperiled, our health threatened, and our future as a species uncertain. Pollutants have also had a grave effect on other species around us, further threatening our existence.

- Land use management has become a problem in many urban areas. As the human population has grown, its need for living space has expanded. As cities and suburbs have developed, more and more open space and farmland have been used. This has resulted in the reduction of natural habitat important to native species, the outright elimination of many native species, the destabilization and erosion of soils, and the destruction of potential food-producing lands. Habitats reduced now to a small fraction of their former extent include tall-grass prairie, fresh water and saltwater wetlands, old growth forests of most types, freeflowing rivers, coral reefs, undisturbed sandy beaches, and others.

- Water pollution has been worsened by the addition to our surface waters and ground water of such pollutants as heat, sewage, chemical phos phates, heavy metals (for example, mercury), polychlorinated biphenols (PCBs), dioxin, and other substances resulting from manufacturing and maintenance activities. These materials destroy both aquatic and terrestrial life-forms that come into contact with polluted water.

- Air pollution has been worsened by the addition to our atmosphere of such pollutants as carbon monoxide, hydrocarbons, and particulate matter (from the burning of coal, oil, and gasoline). Nitrogen oxides and sulfur oxides, also produced from the burning of coal and petroleum products, have been found to combine photochemically with water in the atmosphere to form acid precipitation. Acid precipitation is thought to be responsible for the destruction of populations of lake fish and forest trees in both North America and Europe. Recent studies conducted in New York State lakes indicate that as many as 20 percent of Adirondack lakes are biologically dead from the effects of acid precipitation and that as many as 50 percent will be dead by the year 2040.



Acid Precipitation

Loss of Biodiversity

These and other human impacts on the Earth's ecosystems are already resulting in widespread loss of biodiversity. Scientists commonly estimate that the current rate at which species are becoming extinct exceeds the background (normal) rate by a factor that ranges from 100 to 10,000. If the estimate of the number of species currently existing on Earth were 20 million, the background rate of extinction would be around 20 species per year, and the current rate of extinction would be somewhere between 2,000 and 200,000 species per year. This is roughly comparable to the rate of species extinction experienced during the five great episodes of extinction in the geologic past. Here are a few examples of species currently suffering isolated die-offs or widespread declines or that have been brought to the verge of extinction in recent years.

- Recent marine mammal epidemics, which resulted in massive die-offs of whales, dolphins, and seals in the Baltic and North Seas, the Mediter ranean, the Gulf of Mexico, the North Atlantic, the eastern coast of Australia, and Lake Baikal in Siberia, were caused by distemper-like viruses, bacteria, and fungi. Contaminant-induced immune suppression may have rendered these populations especially vulnerable to infection.

- Many migratory bird species have shown recent alarming declines. Sanderlings, for example, winter on sandy beaches in Peru and Chile where rivers and streams from intensively cultivated river valleys empty into the sea. As the birds put on weight in preparation for heading north, they ingest large amounts of pesticides that may be disrupting reproduction, steering birds off course, or killing the birds outright.

- The range of the endangered Florida panther, downstream from major agricultural areas, is heavily polluted by pesticides and fertilizers. A study in 1989 found pervasive feminization of male panthers, including an extraordinary level of sperm abnormalities, low sperm count, evidence of impaired immune response, malfunctioning thyroid glands, and elevated levels of estradiol, a form of estrogen, in their blood.

Habitat Destruction

When humans alter ecosystems either by adding or removing specific organisms, serious consequences may result. For example, planting large expanses of one crop reduces the biodiversity of the area. Human activities of various kinds have had a direct impact on the biotic portion of many ecosystems, leading to the endangerment or premature extinction of many species of plants and animals. Indirect impacts, which also affect the survival of species, include habitat destruction and single crop planting methods. Some examples of this problem include the following.

- Overhunting of animals, uncontrolled by game laws, has resulted in the extinction of many species and has endangered still others. This activity still continues in many parts of the world despite national and international laws prohibiting it. Examples of species driven to extinction include the dodo bird and passenger pigeon. An example of an endangered species is the blue whale, threatened by international whalers.

- Organisms harmful to a particular environment have intentionally or unintentionally been introduced into that environment from other parts of the world where they are native. Because they often have no natural enemies, these newly introduced organisms have disrupted local communities of other organisms and, in some cases, totally eliminated native species. Examples of such imported organisms include the Japanese beetle, gypsy moth, and a virus that causes Dutch elm disease.

- Exploitation of organisms by commercial trade in exotic plants and animals or their body parts has resulted in the endangerment or elimination of many species worldwide as well as the disruption of their habitats. Examples of organisms exploited in this way include the African elephant, Pacific walrus, Colombian parrot, and tropical hardwood trees. • Overcropping is the failure to allow_ soil to recover nutrients and humus content between plantings.

- Overgrazing is the practice of allowing a large number of animals to graze on an area too small to support them.

- Failure to use covercrops exposes bare soil to erosion cycles in between plantings of cash crops.

Energy Consumption

Industrialization brings an increased demand for and use of energy and other resources including fossil and nuclear fuels. This usage can have positive and negative effects on humans and ecosystems. The world's industrialized nations use tremendous quantities of energy to fuel their economies. Over time, the source of this energy has changed. It has included wind power, water power, steam power, fossil fuel power, nuclear power, solar energy, and fuel cell technologies. Each power source has its advantages and its disadvantages for application in a particular industry. However, the cost per energy unit and availability of the power source have always been prime determiners of the choices made.

Fossil fuel, commonly used as an energy source in today's industrial nations, includes natural materials such as oil, coal, and natural gas. These fuels are drawn from underground deposits millions of years old. Fossil fuel deposits are not being replenished by geologic processes today. As a result, the supply of these fuels is finite and will someday be depleted. Fossil fuels are burned to power internal combustion engines or to produce steam for running electrical turbines. Their hydrocarbon chemistry results in the emission of carbon dioxide and carbon monoxide gases when they are burned. Impurities in these fuels may also result in the emission of particulate matter, sulfur oxides, and nitrogen oxides. These chemical by-products of combustion are released into the air and contribute to the worldwide air pollution problem as well as the phenomenon known as acid precipitation.

Nuclear fuel (plutonium) is a highly refined and concentrated form of the radioactive mineral uranium. In a containment vessel specially designed to promote it, the plutonium emits high-energy particles that collide with atoms, forcing them to emit neutrons that, in turn, collide with other atoms in a chain reaction. This reaction produces tremendous heat, which is used to make steam for running electrical turbines. The wastes of this process are heat and radioactive material from depleted fuel rods. Disposal of these wastes can be disruptive to natural environments and dangerous to human health. Waste heat can disrupt water environments by raising the temperature of those systems to unnatural levels, killing fish and other aquatic life in the process. Radiation can contaminate soils and water and can kill or cause mutations and cancers in living organisms.

Individual Choices and Social Actions

Performance Indicator 73 The student should be able to explain how individual choices and social actions can contribute to improving the environment.

Societies must decide on proposals that involve the introduction of new technologies. Individuals need to make decisions that will assess risks, costs, benefits, and trade-offs. Our survival as a species depends on our developing a clear understanding of the natural environment and our place in it. Human beings have, for many years, neglected and abused the environment and its resources; the natural habitats of many species have suffered as a result of this abuse. More recently, we have come to realize that our past behaviors must change to avoid poisoning the very air we breathe, water we drink, and soil we depend on for our food. We must realize that we share this planet with diverse species that together make up the living community and that this diversity promotes the general health and stability of the ecosystem. We cannot afford to lose a single species to extinction caused by environmental abuse, lest we threaten our own existence. We must also remain careful that we do not revert to the dangerous practices of the past but continue to improve the ways in which we care for and understand our natural environment.

This requires that we become informed about environmental issues, so that as new technologies are developed we can ask critical questions about their impact on environmental systems. We must also support research that is aimed at studying the effects of these technologies on human health as well as that of other species. This information should then be weighed against the benefits that this technology would bring to society. If the benefits outweigh the risks, then the technology should be implemented with appropriate precautions to guard against unanticipated effects. If the risks outweigh the benefits, then the technology should be set aside until adequate safeguards can be developed.

If no direct evidence can be provided from this research that points clearly toward product safety, it is prudent to set the technology aside indefinitely until it is proven safe. Some cause and effect relationships are impossible to establish scientifically. Multiple factors contribute to adverse health effects. Additionally, we cannot ethically conduct experiments to determine toxicity to humans by deliberately exposing people to probable carcinogens. In the absence of scientific certainty, we should take prudent measures to avoid probable harm.

Dangers of Dioxin For instance, when paper mills use chlorine to bleach the pulp and make white paper products, a dangerous chemical called dioxin is produced and discharged with wastewater into rivers. Dioxin is one of the most toxic chemicals known to science and has adverse effects on the health of both humans and wildlife at unthinkably low levels of exposure. Recently, the U.S. Environmental Protection Agency (EPA) mandated that paper mills convert to a process for bleaching paper that uses chlorine dioxide because it produces less dioxin than the use of elemental chlorine.

However, dioxin is a lipophilic (fat-loving) chemical, soluble in fat rather than in water. It is stored in the fat cells of fish and other animals for many years. A predator fish species accumulates the dioxin stored in all the smaller fish it eats over its lifetime. This process is called bioaccumulation or bio- concentration. Consequently, barely measurable quantities of dioxin in a paper mill's wastewater discharge can make the fish caught downstream unsafe to eat.

At the time that the EPA was debating how strictly to regulate dioxin levels in wastewater discharge from the pulp and paper industry, environmental activists made the case for requiring mills to move to a closed-loop system. This technology uses hydrogen peroxide, fully eliminates dioxin releases, and also conserves water resources. However, conversion to closed-loop technology would require mills to make a costly capital investment in new machinery, whereas substituting chlorine dioxide would not. The pulp and paper industry argued that the higher cost of production would result in higher paper prices, placing American paper manufacturers at a competitive disadvantage in the global marketplace.

Because scientists did not completely agree about the level of dioxin exposure that could be considered safe, the EPA decided to take the middle road in its new regulations. It opted in favor of the technology that greatly reduces, but does not eliminate, the release of dioxin into the environment.

Environmental Responsibility

The decisions of one generation both provide and limit the range of possibilities open to the next generation. The technological advances of human beings have often had a negative impact on the environment. Increasing awareness of the role of humans and all other organisms in the ecosystem, however, has begun to reverse this negative trend. Only through continued efforts to protect wild species, conserve resources, preserve natural habitats, control human population growth, and value all life-forms as essential contributors to the maintenance of a healthy environment will we, as a global ecological community, survive and provide suitable living conditions for future generations.

For example, we are dealing today with waste disposal dilemmas created by preceding generations. After World War II, Germany's chemical technology became available to American companies, and our chemical industry expanded greatly. Now 100,000 different synthetic chemicals are being marketed worldwide, with 1,000 new ones being introduced into commercial use every year. Until the 1970s, the new chemical molecules were managed at manufacturing sites as factory wastes had always been handled: thrown into the river, burned on a back lot, or buried in a shallow pit, without regard for the fact that the new waste products were much more dangerous and long lasting in the environment. As old dumps filled up, they were covered over and, often, neighborhoods and schools were built on top.

Today, we are faced with Superfund dumps that cannot be cleaned up at any reasonable price, entire communities that must be relocated, declining fisheries, acid rain, and the dilemma of where to store growing mountains of radioactive debris. Barges filled with toxic waste roam the oceans, unable to find any country willing to provide a resting place for the hazardous cargo.

As it becomes increasingly clear that the solution to pollution is to avoid creating hazardous wastes in the first place, today's generation is trying to open up more possibilities for those that follow. We are examining manufacturing processes more closely, demanding that industry use as few toxic inputs as possible and produce little or no toxic wastes. Grassroots activists are making it so difficult and expensive for industry to dump its hazardous waste that cleaning up production processes becomes more cost-effective by comparison. Consumers are beginning to show a preference for products that create less waste by demanding minimal packaging, choosing recyclable containers, and substituting reusable for disposable products.

QUESTION SET 2.10-HUMAN IMPACT ON ECOSYSTEMS (ANSWERS EXPLAINED, P. 325)

1. The use of ladybugs and preying mantises to consume insect pests in gardens is an example of

    (1) biological control of insect pests

    (2) exploitation of insect pests

    (3) abiotic control of insect pests

    (4) use of biocides to control insect pests

2. The creation of wildlife refuges and the enforcement of game laws are conservation measures that promote increased

(1) use of biocides

(2) preservation of species

(3) use of biological controls

(4) exploitation of species

3. One practice that has successfully increased the number of bald eagles in the United States is the

(1) protection of natural habitats

(2) importation of food to their nesting sites

(3) preservation of other eagle species that occupy the same niche

(4) increased use of pesticides

4. Which human activity would be more likely to have a negative impact on the environment than the other three?

(1) using reforestation and cover cropping to control soil erosion

(2) using insecticides to kill insects that compete with humans for food

(3) developing research aimed toward the preservation of endangered species

(4) investigating the use of biological controls for pests

5. Which human activity would most likely result in the addition of an organism to the endangered species list?

(1) cover cropping

(3) use of erosion controls

(2) use of pollution controls

(4) habitat destruction

6-10. Base your answers to questions 6 through 10 on the passage below and on your knowledge of biology.

The Mystery of Deformed Frogs

Deformities, such as legs protruding from stomachs, no legs at all, eyes on backs, and suction cup fingers growing from sides, are turning up with alarming frequency in North American frogs. Clusters of deformed frogs have been found in California, Oregon, Colorado, Idaho, Mississippi, Montana, Ohio, Vermont, and Quebec.

Scientists in Montreal have been studying frogs in more than 100 ponds in the St. Lawrence River Valley for the past four years. Normally, less than 1 percent of frogs are deformed. In ponds where pesticides are used on surrounding land, as many as 69 percent of the frogs were deformed. A molecular biologist from the University of California believes that the deformities may be linked to a new generation of chemicals that mimic growth hormones. The same kind of deformities found in the ponds have been replicated in laboratory experiments.

Some scientists have associated the deformities with a byproduct of retinoid, which is found in acne medication and skin rejuvenation creams. Retinoids inside a growing animal can cause deformities. For this reason, pregnant women are warned not use skin medicines that contain retinoids. Recent laboratory experiments have determined that a pesticide can mimic a retinoid.

A developmental biologist from Hartwick College in Oneonta, New York, questioned whether a chemical could be the culprit because no deformed fish or other animals were found in the ponds where the deformed frogs were captured. He believes par asites are the cause. When examining a three-legged frog from Vermont, the biologist found tiny-parasitic flatworms packed into the joint where a leg was missing. In a laboratory experiment, he demonstrated that the invasion of parasites in a tadpole caused the tadpole to sprout an extra leg as it developed. Scientists in Oregon have made similar observations.

6. Why are pregnant women advised not to use skin medicines containing retinoids?

(1) Retinoid by-products may cause fetal deformities.

(2) Retinoid by-products cause parasites to invade developing frogs

(3) Retinoid by-products mimic the effects of pesticides on fetal tissue.

(4) Retinoid by-products reduce abnormalities in maternal tissue.

7. Some scientists argue that pesticides may not be the cause of the frog deformities because

(1) pesticide use has decreased over the last four years

(2) new pesticides are used in skin-care products

(3) other animals in the ponds containing deformed frogs did not have abnormalities

(4) laboratory experiments have determined that a pesticide can mimic retinoids

8. A possible reason for the absence of deformed fish in the ponds that contained deformed frogs is that

(1) fish can swim away from chemicals introduced into the pond

(2) parasites that affect frogs usually do not affect fish

(3) fish cannot develop deformities

(4) frogs and fish are not found in the same habitat

9. Which inference can be made from the information in the passage?

(1) Only a few isolated incidents of frog deformities have been observed.

(2) If frog parasites are controlled, all frog deformities will stop.

(3) Deformities in frogs are of little significance.

(4) Factors that affect frogs may also affect other organisms.

10. By using one or more complete sentences, describe how pesticides could cause deformities in frogs.

____

____

11. Habitat destruction is an environmental problem that affects our own generation and will affect future -generations if not solved. Write an essay in which you identify a habitat that is being destroyed and explain how the destruction of this habitat relates to humans and the overall ecosystem. Your essay must include at least:

- two human activities that contribute to the destruction of this habitat
- three ways the destruction of this habitat has affected plants, humans, and other animals
- two ways to limit further destruction of this habitat

12-13. Base your answers to questions 12 and 13 on the information below and on your knowledge of biology.

In July 1997, about 25,000 Galerucella pusilla beetles were released at Montezuma National Wildlife Refuge in western New York State. These beetles eat purple loosestrife, a beautiful but rapidly spreading weed that chokes wetlands. Purple loosestrife is native to Europe, but here it crowds out native wetland plants, such as cattails, and does not support wildlife the way that native plants do. Purple loosestrife grows too thick to allow birds to nest. Most native insects do not eat it, leaving little for insect-eating birds to feed on. Bernd Blossey, a professor at Cornell University, spent 6 years in Europe trying to find out what limited the loosestrife population there.

12. By using one or more complete sentences, explain why the introduction of the beetle is an advantage over the use of herbicides to control the purple loosestrife population.

____

13. By using one or more complete sentences, describe one possible environmental problem that may result from the introduction of this beetle.

____

____

14-16. Base your answers to questions 14 through 16 on the information below. -

In a rural area is a wetland with a large population of mosquitoes. Nearby residents are concerned because the mosquitoes are always annoying and occasionally carry diseases. The community decides to have an insecticide sprayed from an airplane onto the area during the prime mosquito season. Whenever they stop spraying, the mosquito population quickly rebounds to a higher level than existed before the spraying program began. After 10 years, the spraying became much less effective at reducing the mosquito population. Higher doses of insecticide were required to accomplish the same population decreases.

14. State one possible disadvantage of spraying the insecticide from the airplane.

____

15. State one alternative method of mosquito control that may have a more lasting impact on the mosquito population.

____

16. Give one positive effect or one negative effect, other than killing mosquitoes, of the alternative method of mosquito control you stated in question 15.

____

____

APPENDIX

Answers to Question Sets

UNIT ONE

Question Set 1.1

1. 2
2. 2
3. 1
4. 1
5. 2
6. 3
7. 4
8. 2
9. 4
10. see Answers

Explained

11. 3
12. 1
13. 2
14. 1
15. 1

Question Set 1.2

1-4. see Answers

Explained

5. 4

6. 1

7. 4

8-10. see Answers

Explained

11. 1

12. 4

13. 2

14. see Answers

Explained

15. 3

16-21. see Answers

Explained

Question Set 1.3

1. see Answers Explained

2. 1

3. 3

4. 1

5. 4

6. 2

7. see Answers

Explained

8. see Answers

Explained

9. see Answers

Explained

10. 4

11. 4

12. see Answers

Explained

Question Set 1.4

1.2

2. B

3. C

4. D

5.4

6.3

7. see Answers Explained

8. 1

9. 4

10. 2

11. 2

12. 4

13. 3

14. 1

15. 4

16. 1

17. 1

18. 3

19. 2

20. 8.9 cm

21. 1

22. 4

23. see Answers Explained

24. see Answers Explained

25. 2

26. 3

27. 4

28. see Answers Explained

29. see Answers Explained

30. see Answers Explained

31. see Answers Explained

32. see Answers Explained

33. see Answers Explained

34. 4

35. 1

36. 2

37. 3

38. 3

39. 3

40. 4

41.4

42. 2

Reading, Writing, and Current Events in Science

1.3

2. 1

3. 1

4. 2

5. 3

6. see Answers Explained

7. see Answers Explained

8. see Answers Explained

9. see Answers Explained

10. see Answers Explained

11. see Answers Explained

12. see Answers Explained

13. see Answers Explained

14. see Answers Explained

UNIT TWO

Question Set 2.1

1. 1

2. 4

3. 4

4. 4

5. 1

6. 4

7. 3

8. 1

9. 2

10. 1

11. 4

Question Set 2.2

1. 4

2. 1

3. 2

4. 2

5. 1

6. 4

7. 3

8. 2

9. 4

10. 2

Question Set 2.3

1. 1

2. 3

3. 3

4. see Answers

Explained

5. 1

6. 3

7. 2

8. 3

9. 3

10. 4

11. 2

12. 1

Question Set 2.4

1. 1

2. 2

3. 3

4. 4

5. 3

6. 3

7. 3

8. 3

9. 2

10. 3

11. 2

12. 1

Question Set 2.5

1. 1
2. 4
3. 4
4. 1
5. 2
6. 3
7. 4
8. 3
9. 3
10. 2
11. 1
12. 4
13. 2
14. 3
15. 1
16. 2
17. 4
18. 3
19. 3
20. 3
21. 4
22. 1
23. 2

24. 1

25. 3

26. 2

27. see Answers

Explained

Question Set 2.6

1. 4

2. 3

3. 1

4. 1

5. 4

6. 2

7. 3

8. 1

9. 3

10. 4

11. 2

12. see Answers

Explained

13. see Answers

Explained

Question Set 2.7

1. 1
2. 4
3. 1
4. 4
5. 3
6. 2

7. 3
8. 4
9. 2
10. 1
11. 3
12. 4

13. 1
14. 3
15. 1

16-19. see Answers Explained

Question Set 2.8

1. 2
2. 2
3. 4
4. 2
5. 2

6. 1

7. 2

8. 2

9. 4

10-11. see Answers

Explained

12. 2

13. 4

14. 4

15. 1

16. 4

17. 1

18. 2

19. see Answers

Explained

20. 2

21. 3

22. 4

23. 2

24-30. see Answers

Explained

Question Set 2.9

1. 4

2. 2

3. 1

4. 6

5. 5

6. 2

7. 1

8. 2

9. 4

10. 3

11. 2

12. 3

13. 2

14. 3

15. 4

16. 4

17. 2

18. 3

19. 2

20. 2

21. 4

22. 2

23. 4

24. 1

25. 3

26. see Answers

Explained

Question Set 2.10

1. 1
2. 2
3. 1
4. 2

5. 4

6. 1
7. 3
8. 2

9. 4

10-16. see Answers

Explained

ANSWERS EXPLAINED

UNIT ONE

Question Set 1.1 (p. 13)

1. 2 The biologist should observe a large number of frogs in their natural habitat. The large sample will help to ensure the probability that the sample will be representative of the species's behavior. Observing the frogs in their natural habitat will ensure that no unusual conditions exist that may influence how the frogs react to each other.

Wrong Choices Explained

(1) Observing a small number of frogs in their natural habitat will not ensure that a representative sample has been taken. If a few of the frogs in a small sample behave in an unusual way, they will represent a larger percentage of a small sample than they would of a large sample.

(3), (4) Observing several groups of frogs maintained in different temperatures in the laboratory or several groups of frogs maintained on different diets in the laboratory will introduce variables that interfere with the natural behaviors of the frogs. Changes in temperature or diet may affect the frogs' behavior greatly, making the observations dependent on these experimental conditions instead of the natural factors that affect the frogs' behavior.

2. 2 Counting the number of lines on the cylinder between the meniscus at A and the meniscus at B yields the number 4. Since a total of 8 milliliters was removed, the graduations on the cylinder must be 2 milliliters each.

Wrong Choices Explained

(1) Graduations of 1 milliliter would yield eight lines with the removal of 8 milliliters from the cylinder.

(3) Graduations of 8 milliliters would yield one line with the removal of 8 milliliters from the cylinder.

(4) Graduations of 4 milliliters would yield two lines with the removal of 8 milliliters from the cylinder.

3. 1 The statement environmental conditions affect germination represents a hypothesis. This statement contains a belief about the outcome of an investigation in which a dependent variable (germination) is changed by an experimental variable (environmental conditions). Although very general, the statement still predicts an outcome and therefore meets the definition of a hypothesis.

Wrong Choices Explained

(2) The statement boil 100 milliliters of water, let it cool, and then add ten seeds to the water represents an experimental procedure, not a hypothesis.

(3) The statement is water depth in a lake related to available light in the water? represents an experimental question, not a hypothesis.

(4) The statement a lamp, two beakers, and elodea plants are selected for the investigation represents a materials list for an experiment, not a hypothesis.

4. 1 The millimeter is the unit of measure most appropriate to perform this measurement. About 25.4 millimeters make up one inch.

Wrong Choices Explained

(2) The micrometer is a unit of measure used to describe the sizes of very small objects, such as cell organelles. It is not an appropriate unit of measure for an object of this size.

(3), (4) The foot and the meter are too large to be used to measure an object of this size, since the measurements would be fractional.

5. 2 A millimeter is made up of 1,000 micrometers. The number of whole millimeters shown in the diagram is 3 (3,000 micrometers). The amount of distance left to the right of the third millimeter is a little larger than half of a millimeter (about 70 micrometers). The total distance across the diameter, therefore, is approximately 3,700 micrometers. (HINT: remember to count as 1,000 micrometers the distance from the left edge of one millimeter mark to the left edge of the next millimeter mark.)

Wrong Choices Explained

(l), (3), (4) Each of these distracters has been chosen to catch the unwary student. Count carefully and mark on the test booklet if that will assist you.

6. 3 It differs in the one variable being tested is the way that the control setup differs from the experimental setups in the same experiment. In all other respects, it is identical to the experimental setups. For example, in an experiment testing how varying concentrations of enzymes affect the rate of hydrolysis of a substrate, an appropriate control would be a setup containing water, only, but identical to the experimental tubes in all other respects. This control assures that the water in which the enzyme is dissolved has no effect on the hydrolytic action.

Wrong Choices Explained

(1), (2), (4) The statements it tests a different hypothesis, it has more variables, and it utilizes a different method of data collection are not true of a control group in a properly designed experiment. The experimental design should seek to eliminate the differences between the experimental setups and the control setup. The more variables and differences between the control and experimental setups, the less reliable the results of, and the conclusions drawn from, the experiment.

7. 4 The experimental variable is the condition changed (varied) by the experimenter. In this experiment, the condition varied is the distance of the plant from light.

Wrong Choices Explained

(1) No measure is being made of the concentration of gas in the water. If this condition is changing, it is incidental to the experiment.

(2) The aquatic plant type, in this case elodea, is a constant in the experiment as described.

(3) No measure is made of the amount of water in the test tube. If this condition is changing, it is incidental to the experiment.

8. 2 Lugol's solution will test for the presence of starch in foods. It turns blue black in the presence of starch.

Wrong Choices Explained

(1) pH paper is used to test how acidic or alkaline a solution is.

(3) Methylene blue is a commonly used stain in preparing wet-mount microscope slides.

(4) Bromthymol blue is used to detect the presence of carbon dioxide in a solution.

9. 4 Before a scientist begins to study a natural phenomenon, he/she must first pose a question to be answered or a problem to be solved. If this step is skipped, much time is wasted in the laboratory studying factors that may have no direct bearing on the object of study.

Wrong Choices Explained

(1), (2), (3) An appropriate sequence for conducting a scientific investigation is as follows:

—state the problem
—*formulate a hypothesis* (educated guess)
—define the experimental method
—*perform the experiment*
—gather experimental data
—*analyze the experimental data*
—draw inferences

10. Goggles should he worn. OR Gloves should be worn. OR The student should take care not to touch the sharp scalpel to his skin.

(NOTE: The preceding answers represent acceptable responses. Other complete-sentence responses are acceptable as long as they give correct information.)

11. 3 The control group in an experiment duplicates all aspects of the experiment except the independent variable (the variable being tested). In this case, the drug is the independent variable, so the group given pills without the drug, but with glucose, is considered the control group.

Wrong Choices Explained

(1) The experimental group is the group that receives pills containing the drug rather than pills containing glucose.

(2) The term limiting factor relates to environmental conditions that limit the survival of individuals or populations.

(4) An indicator is a chemical that helps to determine the chemical characteristics of biological samples. Examples of indicators include bromthymol blue and litmus.

12. 1 Of those given, the hypothesis light intensity affects the growth of algae best explains the observations reported. The intensity of natural light affects the depth to which it can penetrate the lake water. Algae can photosynthesize only in the presence of adequate light intensity. Therefore, we are led to the conclusion that the presence (or growth) of algae depends on the degree to which light is available (its intensity) in the environment.

Wrong Choices Explained

(2) The hypothesis wind currents affect the growth of algae has no basis for support in the reported observations. Not only is wind not mentioned as a variable, but logical analysis of the situation would indicate that wind is unlikely to directly affect algae I to 6 meters below the surface of the lake.

(3) The hypothesis nitrogen concentration affects the growth of algae has no basis for support in the reported observations. Nitrogen concentration is not mentioned as a variable in this experiment.

(4) The hypothesis precipitation affects the growth of algae has no basis for support in the reported observations. Precipitation is not mentioned as a variable in this experiment.

13. 2 Diagram 2 illustrates how the hydra will appear to move under the compound light microscope. The optics of this instrument invert the image of what is seen in the field of view, so that everything appears upside down. As the hydra moves right, its image will appear to move left. If the hydra moves away from the observer, its image will appear to move toward the observer, and so on.

Wrong Choices Explained

(1), (3), (4) These diagrams all represent incorrect illustrations of how the image will move in the field of view under the conditions stipulated.

14. 1 The approximate length of a nucleus of one of these cells is 100 um. Two nuclei are visible as dark ovals within each of the two cells illustrated. Care should be taken to read the question carefully so that the correct object is measured.

Wrong Choices Explained

(2) 500 ,um is the approximate length of one cell.

(3) 1,000 μm is the approximate length of both cells end to end.

(4) 1,500 pin is the approximate diameter of the field of view (actually closer to 1,600 μm).

15. 1 The difference in length between leaves A and B is closest to 20 mm. Leaf A is approximately 55 mm long, while leaf B is approximately 33 mm long. The difference, 22 mm, is closest to 20 mm.

Wrong Choices Explained

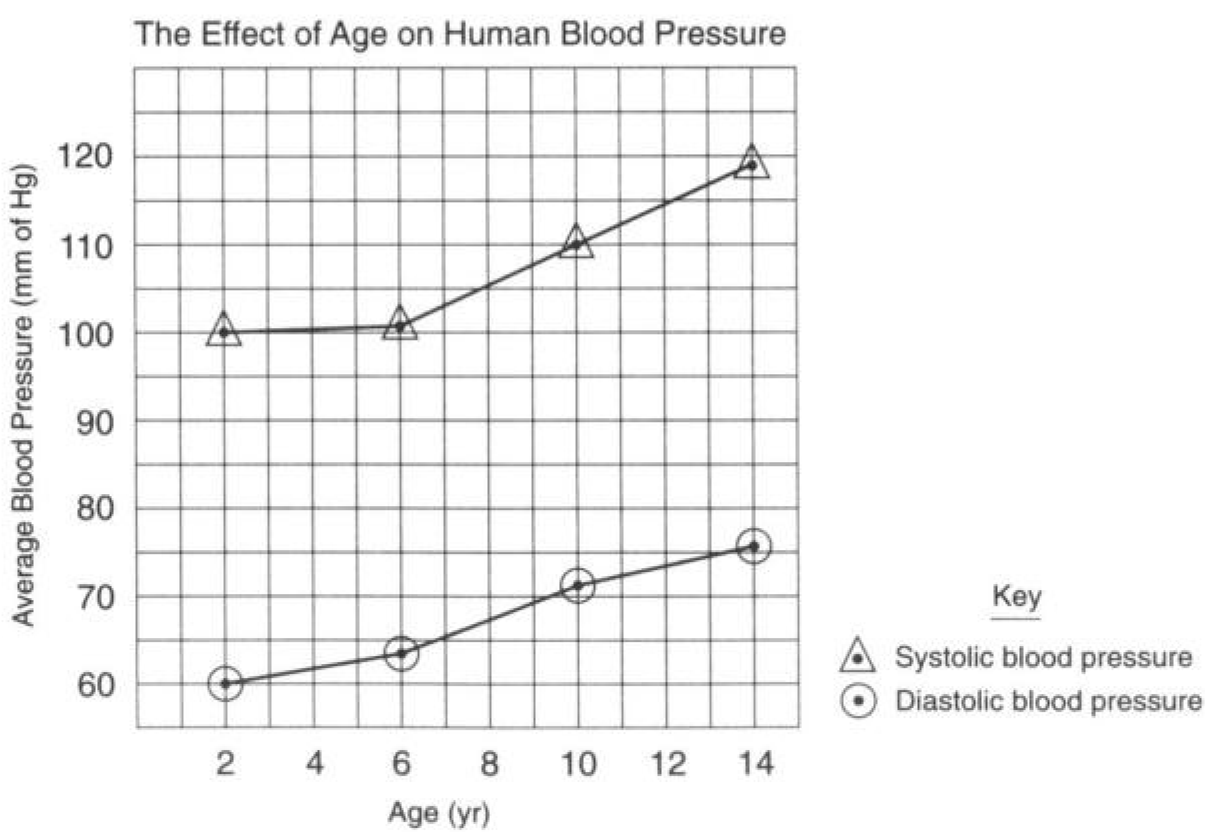
(2) 20 cm is ten times the correct measurement. Students should take care that the correct units are used in determining the lengths of these specimens.

(3) 0.65 m is a measurement equal to 650 cm or 6,500 mm (more than 2 feet) in length. These specimens are much smaller than this measurement.

(4) 1.6 μm is a measurement equal to 0.0016 mm or 0.00016 cm. These specimens are much larger than this measurement.

Question Set 1.2 (p. 25)

1–3.



4. Systolic pressure is higher than diastolic pressure. OR Both systolic pressure and diastolic pressure increase between the ages of 2 and 14.

(NOTE: Other correct, complete-sentence responses are acceptable.)

5. 4 Brook trout growth is represented by the lighter solid line in the graph. By tracing along the horizontal axis to 16°C and then tracing up to the point at which the brook trout line is encountered, we see that the growth rate is between 80% and 100% but closer to 100%. Estimate about 95%.

Wrong Choices Explained

(1) Brook trout growth rate is at 30% when the water temperature is about 18°C. Largemouth bass growth rate is about 30% at 16°C.

(2) None of the species indicated have growth rates of 55% at 16°C. Brook trout growth rate is at 55% at about 17.5°C.

(3) Brook trout growth rate falls to 75% at about 17°C. The growth rate of northern pike is at 75% at about 16°C.

6. 1 The diagram represents an experiment in cloning. Since the nucleus (which contains the genetic material) used in this experiment comes from a tadpole, the egg will produce new cells that have genetic characteristics identical to those of the tadpole.

Wrong Choices Explained

(2) It is unclear from this diagram how frog A came into being.

(3) This conclusion is refuted by the results of this experiment; a new frog was created without the use of fertilization.

(4) This conclusion is refuted by the results of this experiment. The tadpole nucleus was taken from an intestinal cell, which is a body cell.

7. 4 The chart on the left shows that a man 6'0" tall with a small frame has an ideal weight range of 149-160 pounds. Of the choices given, the closest comparison can be made to the ideal weight range of a 6'0" woman with a medium frame at 148-162 pounds.

Wrong Choices Explained

(1) The weight range shown for a 5'10" man with a medium frame is 151-163 pounds.

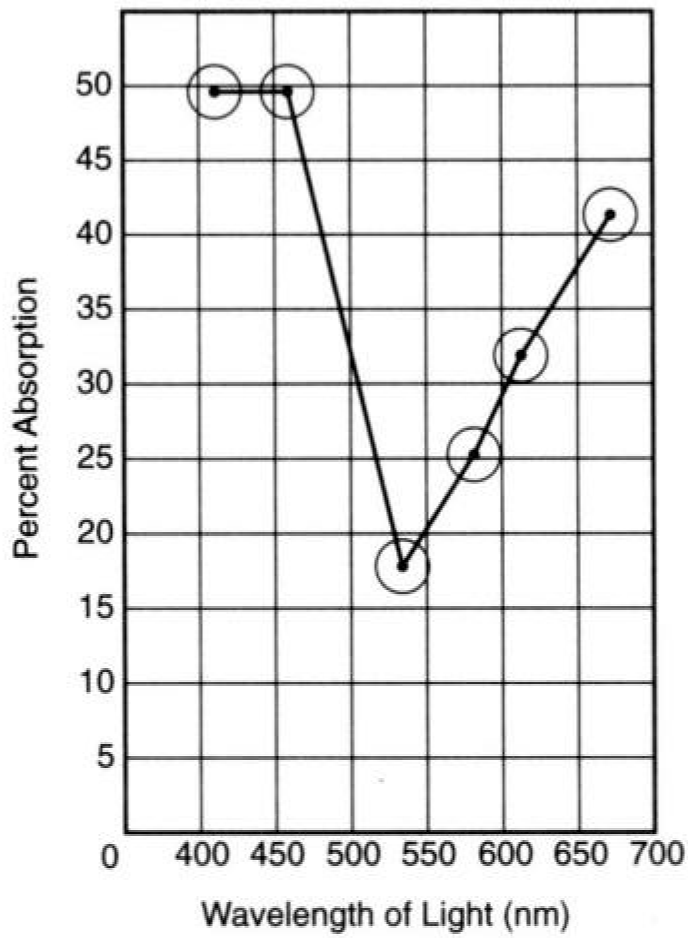
(2) The weight range shown for a 5'9" woman with a large frame is 149-170 pounds.

(3) The weight range shown for a 6'0" man with a medium frame is 157-170 pounds.

8.

Color of Light	Wavelength of Light (nm)	Percent Absorption by Spinach Extract
Violet	412	49.8
Blue	457	49.8
Green	533	17.8
Yellow	585	25.8
Orange	616	32.1
Red	674	41.0

9–10.



11. 1 The statement photosynthetic pigments in spinach plants absorb blue light and violet light more efficiently than red light is a valid conclusion that can be drawn from the data. The high point of the chart/graph data is very clearly shown to be over the blue and violet wavelengths of light.

Wrong Choices Explained

(2) The statement the data would be the same for all pigments in spinach plants is not supported by the results of this experiment. The chart/graph data show considerable variation in the experimental results as the wavelength of light varies.

(3) The statement green and yellow light are not absorbed by spinach plants is not supported by the results of this experiment. Although the chart/graph data show a lower absorption rate in these wavelengths, there is still some absorption in this range.

(4) The statement all plants are efficient at absorbing violet and red light is not supported by the results of this experiment. The experimental data is limited to the absorption of light by pigments found in one type of plant. This data cannot be extended to all plants unless all other types of plants are tested under the same experimental conditions and the results are found to be similar.

12. 4 Of those given, refrigeration will most likely slow the growth of these bacteria is the most reasonable inference that can be made from the graph data. The graph clearly shows a slower rate of growth (reproduction) at 5°C than at either 10°C or 15°C.

Wrong Choices Explained

(1) The inference that temperature is unrelated to reproductive rate of bacteria is not supported by the data. Temperature is the independent (experimental) variable in this study. It clearly has an influence on the bacterial reproductive rate.

(2) The inference that bacteria cannot grow at a temperature of 5°C is not supported by the data. The graph clearly shows that growth at this temperature, while slow, occurs at a steady pace.

(3) The inference that life activities in bacteria slow down at high temperatures is not supported by the data. The data indicates that, if anything, bacterial activity increases with increasing temperature. No data is shown for bacterial growth under temperatures above 15°C, so we cannot draw any inference about what will happen to the rate of bacterial growth at these extremes.

13. 2 These researchers should make sure the conditions are identical to those in the first study. The validity of any scientific experiment can be verified only if the same results are obtained under the same experimental conditions. Any change in these conditions will invalidate the results of the verification study.

Wrong Choices Explained

(1) If the researchers give growth solution to both groups, there will be no control group against which to compare the experimental group. The results of the verification study will be invalid since experimental conditions will have changed.

(3) If the researchers give an increased amount of light to both groups of plants, the original experimental method will be altered. The results of the verification study will be invalid since experimental conditions will have changed.

(4) If the researchers double the amount of growth solution given to the first group, the original experimental method will not be followed. The results of the verification study will be invalid since experimental conditions will have changed.

14. 130. The number of turns in the waggle dance decreases as the distance of the food supply from the hive increases. OR The closer to the hive the food source is located, the more turns there are in the waggle dance.

(NOTE: Any correct, complete-sentence answer is acceptable.)

15. 3 Other biologists in other laboratories should be able to perform the same experiment and obtain the same results if the experimental results are valid. Any experimental results obtained by one scientist must be validated by independent research by other scientists following the same procedures.

Wrong Choices Explained

(1), (4) If different scientists perform an experiment with a different variable and obtain the same results or an experiment under different conditions and obtain the same results, they will have neither validated nor invalidated the results of the original experiment. All variables and conditions must be kept the same if the experimental results are to be properly tested.

(2) If different scientists perform the same experiment and obtain different results, the original experimental results will have been invalidated.

16. Step 1: Determine the values of d (deviation from expected results) and e (expected results). Since 75% of the offspring are expected to be round seed, we expect 750 (e) offspring to display the trait out of every 1,000 individuals sampled. In fact only 732 plants show this trait, 18 less than expected, so the deviation is -18 (d1) for the first condition. We also expect that 25%, or 250 (e2), of the sampled offspring will display wrinkled seed. The data indicated that 268 plants were sampled with this trait, 18 more than expected, so the deviation for this condition is +18 (d2).

Step 2: Substitute the values of d and e into the formula for chi square (X2).

Step 3: Perform mathematical operations indicated in the formula to determine the value of x2.

$$
\begin{aligned}
\chi^2 &= \Sigma(d^2/e) \\
&= (d_1^{\ 2}/e_1) + (d_2^{\ 2}/e_2) \\
&= (-18^2/750) + (18^2/250) \\
&= 324/750 + 324/250 \\
&= 0.432 + 1.296 \\
&= 1.73 \text{ (rounded)}
\end{aligned}
$$

17. Determine the value of probability (p) using the chart for one degree of freedom shown in the section about statistical analysis. The range of probabilities (p) for this trial is between 0.20 and 0.10 but much closer to 0.20 (1 in 5).

(NOTE: Any correct, complete-sentence answer is acceptable.)

18. Step 5: Analyze the results based on the value of p and other information in the chart in the section about statistical analysis. The deviation from expected results for this trial was highly insignificant statistically. OR The chi-square analysis of this data results in a high level of confidence that the results are consistent with random occurrence rather than experimental bias. (NOTE: Any correct, complete-sentence answer is acceptable.)

19. Step 1: Determine the values of d (deviation from expected results) and e (expected results). Since 75% of the moths are expected to be dark, we expect 7,500 (e) offspring to display the trait out of every 10,000 individuals sampled. In fact 8,500 moths sampled show this trait, 1,000 more than expected. Therefore, the deviation is +1,000 (d) for the first condition. We also expect that 25%, or 2,500 (e2), of the sampled moths will display light coloration. The data indicated that only 1,500 moths were sampled with this trait, 1,000 less than expected; so the deviation for this condition is -1,000 (d).

Step 2: Substitute the values of d and e into the formula for chi square (%').

Step 3: Perform the mathematical operations indicated in the formula to determine the value of x2.

$$
\begin{aligned}
\chi^2 &= \Sigma(d^2/e) \\
&= (d_1{}^2/e_1) + (d_2{}^2/e_2) \\
&= (1{,}000^2/7{,}500) + (-1{,}000^2/2{,}500) \\
&= 1{,}000{,}000/7{,}500 + 1{,}000{,}000/2{,}500 \\
&= 133.33 + 400.00 \\
&= 533.33
\end{aligned}
$$

20. Determine the value of probability (p) using the chart for one degree of freedom shown in the section about statistical analysis. The range of probabilities (p) for this trial is much below 0.001 (1 in 1,000).

(NOTE: Any correct, complete-sentence answer is acceptable.)

21. Analyze the results based on the value of p and other information in the chart in the section about statistical analysis. The deviation from expected results for this trial was highly significant statistically. OR The chi-square analysis of this data results in a low level of confidence that the results are due to chance. OR It is highly unlikely that the incidence of the dark coloration in moths is the result of chance alone.

(NOTE: Any correct, complete-sentence answer is acceptable.)

Question Set 1.3 (p. 39)

1. Two credits are awarded for a correct two-part response that correctly identifies the finch species most affected and the reason for this effect. Acceptable responses may include:

- The small ground finch [1] because the sharp-billed ground finch looks for the same kinds of food. [11

• The native finch species most probably strongly affected will be the small ground finch. [11 The reason for this is that both the small ground finch and the sharp-billed ground finch depend on the same food source (small seeds). [1]

- My hypothesis is that the small ground finch will be most affected by the introduction of the sharp-billed ground finch. [1] The chart shows that both species are ground feeding seedeaters and have similar bill shapes, indicating that they will compete for the same types of available seeds. [1]

2. 1 The large ground finch will have the greatest adaptive advantage under the changed environmental conditions described. According to the chart, the large ground finch is well-adapted for crushing the shells of large, thick-walled seeds. Since these seeds will be in abundance in the changed environment, it is expected that the large ground finch will thrive compared to the other species native to the island.

Wrong Choices Explained

(2) The small ground finch, with its small beak, is specifically adapted for picking up and eating small seeds. It is poorly adapted for eating large, thickwalled seeds. It is likely that this species will not thrive under the conditions of environmental change described.

(3), (4) According to the chart, the large tree finch and the small tree finch are adapted to feed on insects in an environment different from that of the other native finch species. It is unlikely that this environmental change will either significantly advantage or disadvantage insect-eating finch species.

3. 3 Interspecies competition occurs when one species tries to gain an advantage over another species in the same environment. Interspecies (between-species) competition may occur when any shared resource, including food, territorial area, nesting sites, or other habitat, is in short supply.

Wrong Choices Explained

(1) Variation within a species is not represented by one finch species gaining an advantage over other species in the same habitat. This term refers to the concept that each naturally occurring species contains differences (variations) among its individual members. Such variations are thought to be the basis of the ongoing evolution in all species by means of natural selection.

(2) Environmental change is not represented by one finch species gaining an advantage over other species in the same habitat. This term refers to any alteration (such as rainfall or temperature) in the set of environmental conditions that exist in a particular habitat.

(4) Mutagenic agents are not represented by one finch species gaining an advantage over other species in the same habitat. This term refers to forces in nature (such as radiation and chemicals) that

are able to alter the genetic makeup of living things.

4. 1 CUU-GUU-ACU-GAA-CAU-CAU-CCC-GUU is the mRNA codon sequence that will result from this DNA sequence. In the formation of mRNA, ribonucleotides position themselves on the DNA template such that complementary nitrogenous bases link together. DNA bases C, G, A, and T link with RNA bases G, C, U, and A, respectively.

Wrong Choices Explained

(2), (3), (4) GAA-CAA-UGA-CUU-GUA-GUA-GGG-CAA, CTT-GTTACT-GAA-CAT-CAT-CCC-GTT, and UGG-AGG-CUG-ACC-UCG-UCGUUU-AGG are not mRNA codon sequences that will result from this DNA sequence. Each of these sequences violates the rules of complementarity referenced above or includes the nitrogenous base T (thymine) instead of U (uracil) in its structure.

5. 4 Leu-Val-Thr-Glu-His-His-Pro-Val is the amino acid sequence that will result from this DNA sequence. In the synthesis of a protein strand on the ribosome, each amino acid is positioned according to the sequence of codons on the mRNA strand (which in turn derived its sequence from the DNA template in the nucleus). For example, the amino acid Leu (leucine) attaches at the mRNA codon CUU or CUG (which in turn is encoded by the DNA template codon GAA or GAC). Following this example through the entire DNA codon sequence leads to the sequencing of amino acid units as shown above.

Wrong Choices Explained

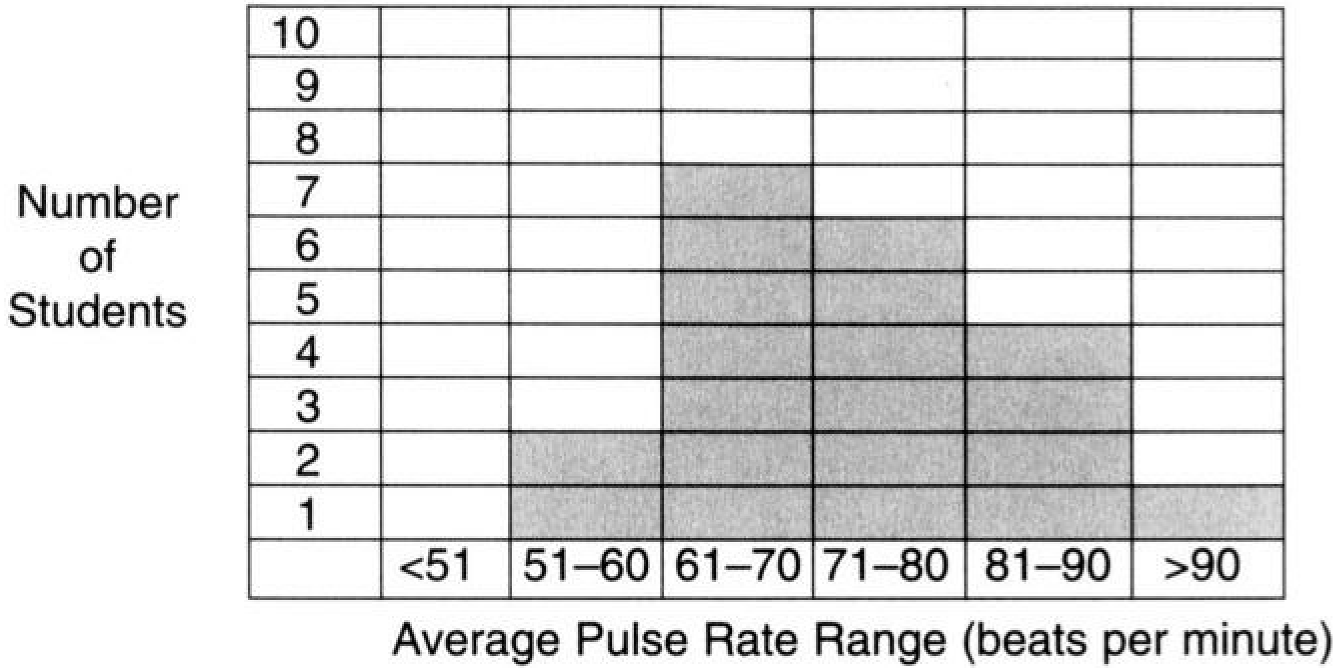
(1), (2), (3) Leu-Glu-His-Pro-Val-Val-Pro-Val, Leu-Val-Thr-Leu-Glu-GluHis-Pro, and Leu-Pro-His-Val-Thr-Thr-Glu-Pro are not amino acid sequences that will result from this DNA sequence. Each of these sequences violates the rules of amino acid encoding referenced above and data shown in the Partial Genetic Code Chart.

6. 2 Species X produces a protein segment most similar to that produced by S. hunta. Because each of the amino acids in this segment can be encoded by more than one DNA code, the slight variations in this gene between the two species still result in the same amino acid sequence (Leu-Val-Thr-GluHis-His-Pro-Val).

Wrong Choices Explained

(1), (2), (3) Leu-Glu-His-Pro-Val-Val-Pro-Val, Leu-Val-Thr-Leu-Glu-GluHis-Pro, and Leu-Pro-His-Val-Thr-Thr-Glu-Pro are not amino acid sequences that will result from this DNA sequence. Each of these sequences violates the rules of amino acid encoding referenced above and data shown in the Partial Genetic Code Chart.

7. One credit is awarded for a correctly completed histogram, as shown below:



8. One credit is awarded for a complete sentence that correctly describes one pattern that is evident in the data that would help someone to understand how pulse rate is distributed among these 20 students. Answers may include:

- Nearly two-thirds (65%) of this class has resting heart rates between 61 and 80 beats per minute.
- The average (mean) pulse rate for this class is 73.35 beats per minute.
- The distribution of heart rates for this class follows a bell curve that skews slightly to the left.
- Generally, the female members of this class have lower pulse rates than the males.

9. One credit is awarded for a complete sentence that correctly states an experimental question about pulse rate that could be answered by further study of these 20 students. Answers may include:

- What is the average pulse rate for males versus females in this class?
- How do the distribution curves differ for resting heart rate in females versus males?
- What is the relationship between resting pulse rate and body mass index (BMI)?
- What is the relationship between heart rate and amount of daily exercise among these students?
- What are the three-trial average pulse rates of these students after 5 minutes of moderate exercise?

10. 4 The difference between the fluids in the initial and final setups is that glucose has diffused from the fluid inside the dialysis tubing, across the membrane, and into the beaker fluid. In the initial stage chemical test with Benedict's solution, the dialysis tubing was shown to contain glucose, whereas the beaker water was not. When' the same test was performed on the setup in the final stage,

glucose was detected in both the dialysis tubing and the beaker water. Since the dialysis tubing is a semipermeable membrane, it can be concluded that the small molecular size of glucose allowed it to diffuse through the membrane from a region of higher concentration (inside the tubing) to a region of lower concentration (outside the tubing).

Wrong Choices Explained

(1) Lugol's solution has been converted to Benedict's solution does not describe the difference between the initial and final setups. Lugol's solution is a mixture of potassium salt, iodine, and water. Benedict's solution is a mixture of various sodium and copper salts dissolved in water. It is chemically impossible for Lugols's solution to be converted to Benedict's solution.

(2) Starch has been converted to glucose by the indicator solutions does not describe the difference between the initial and final setups. The conversion of starch to glucose requires the catalytic action of the enzymes amylase and maltase. Lugol's and Benedict's solutions contain no such enzymes.

(3) Starch has diffused from the fluid inside the dialysis tubing, across the membrane, and into the beaker fluid does not describe the difference between the initial and final setups. Starch is a polymer whose molecules are too large to diffuse through the dialysis tubing. Had this occurred, the final setup beaker water would have tested positive for the presence of starch (turned blue-black) in the presence of Lugol's solution.

11. 4 More water moving out of the cell than into the cell is the most likely cause of the change in appearance illustrated in diagram B. Under normal conditions, the cell cytoplasm and the watery environment have nearly identical salt concentrations, allowing water molecules to diffuse into and out of the cytoplasm at equal rates, as shown in A. When salt is added to the watery medium, the relative concentration of water decreases compared to the water concentration inside the cell. Under these conditions, water molecules diffuse out of the cell more rapidly than they diffuse into the cell, causing the cytoplasm to shrink, as shown in B.

Wrong Choices Explained

(1), (2) More salt moving out of the cell than into the cell and more salt moving into the cell than out of the cell are not probable causes of the condition shown in diagram B. Salt does not normally diffuse into or out of the cell. Rather, water is the substance that moves by osmosis in response to the concentration gradient.

(3) More water moving into the cell than out of the cell is not a probable cause of the condition shown in diagram B. If this were the case, the cytoplasm inside the cell would increase, rather than decrease, in volume.

12. Four credits are awarded for a paragraph, containing complete sentences, that correctly describes the biological explanation for the farmer's observations of the corn plants in field B. Sample paragraph:

When the farmer irrigated field B with the 10% salt solution on day 1, the ground around the roots became saturated with it. This created a situation in which the concentration of water inside the corn root cells was higher (>99%) than the concentration of water in the ground outside the corn root cells (90%). [1] As a result, water moved by osmosis (diffusion of water from a region of high relative concentration toward a region of low relative concentration) [1] from the inside to the outside of the corn-plants.-

On day 2, the rainfall washed the salt away from the soil around the roots of the corn plants sufficiently to allow the equilibrium (equal concentrations of water both inside and outside the cell) [I] to become reestablished, enabling the corn plant root cells to absorb water and the plants to regain their healthy appearance. [1]

Question Set 1.4 (on Laboratory Skills) (p. 51)

1. 2 The student's suggestion is considered to be a hypothesis. A hypothesis is an "educated guess" as to the scientific reason behind an observed phenomenon. The student is making this suggestion based on a hunch rather than on direct observation. To test the hypothesis, the student would need to design an experiment, collect data, analyze the data, and draw inferences and conclusions concerning the results.

Wrong Choices Explained

(1) The student's suggestion is not considered to be a control. A control is a laboratory setup created by the researcher in a scientific experiment that duplicates the experimental setup in every way except for the variable being tested.

(3) The student's suggestion is not considered to be an observation. An observation is an action taken by the researcher during a scientific experiment that normally results in the generation of data.

(4) The student's suggestion is not considered to be a variable. A variable is a condition that changes in a scientific experiment either because it is manipulated by the researcher or because it changes in response to the manipulated variable.

2. B A student testing for the presence of a carbohydrate in food should select set B. This laboratory setup contains two indicators (Benedict's solution and iodine) that are specialized to indicate the presence of specific carbohydrates (simple sugars and complex starches, respectively) in foods. The assorted glassware is needed to hold the foods being tested, and the heat source is used to heat the Benedict's solution in the presence of simple sugars. Goggles protect the eyes from accidental exposure to heated liquids.

Wrong Choices Explained

(A) The student should not select set A, which would probably be best used to determine the effect of different colors (wavelengths) of light on the rate of photosynthesis in a water plant.

(C) The student should not select set C, which would probably be best used to dissect a biological specimen in order to facilitate a study of gross anatomical features.

(D) The student should not select set D, which would probably be best used to study the microscopic features of very small biological specimens such as the organelles of a cell.

3. C A student determining the location of the aortic arches of the earthworm should select set C. This laboratory setup contains dissection instruments and a wax pan in which dissection of an earthworm can be carried out. The stereomicroscope is used to magnify the small anatomical features of the earthworm (in this case, aortic arches) for closer study. Goggles protect the eyes from accidental exposure to preservative chemicals and sharp instruments.

Wrong Choices Explained

(A) The student should not select set A, which would probably be best used to determine the effect of different colors (wavelengths) of light on the rate of photosynthesis in a water plant.

(B) The student should not select set B, which would probably be best used to determine the presence of various carbohydrates in foods.

(D) The student should not select set D, which would probably be best used to study the microscopic features of very small biological specimens such as the organelles of a cell.

4. D A student observing the chloroplasts in elodea should select set D. This laboratory setup contains a compound light microscope used to magnify the microscopic features of cells for closer study. The slide and water are used to provide a transparent viewing surface, and the forceps are used to manipulate the very small elodea leaf.

Wrong Choices Explained

(A) The student should not select set A, which would probably be best used to determine the effect of different colors (wavelengths) of light on the rate of photosynthesis in a water plant.

(B) The student should not select set B, which would probably be best used to determine the presence of various carbohydrates in foods.

(C) The student should not select set C, which would probably be best used to dissect a biological specimen in order to facilitate a study of gross anatomical features.

5. 4 The corresponding control group would most likely consist of truck drivers who drove daily for 8 hours in very light traffic. A control is a setup created by the researcher in a scientific experiment that duplicates the experimental setup in every way except for the variable being tested. Because the variable being tested is the stress of driving for 8-hour periods in heavy traffic, the stress factors that would contrast with these would be either reduced exposure to time driving in heavy traffic (not offered as a choice) or reduced exposure to traffic stresses for the same time duration

(choice 4).

Wrong Choices Explained

(1) Truck drivers who drove daily for 12 hours in very heavy traffic is not the likely control group for this experiment. Because the experimental group is already considered by the researcher to be stressed with 8 hours in very heavy traffic, the control group would not be set up to receive even more time exposure to this stressful situation.

(2), (3) Truck drivers who drove every third day for 8 hours in very heavy traffic or who drove every other day for 12 hours in very light traffic are not the likely control groups for this experiment. The introduction of a third variable (intermittent exposure) in these groups would tend to confuse the research and raise questions about which variable of the three is really responsible for the stresses being observed in the experimental group.

6. 3 Temperature is a variable in this experiment. A variable is a condition that changes in a scientific experiment either because it is manipulated by the researcher or because it changes in response to the manipulated (experimental) variable. Of the conditions listed, only temperature changes in the experiment. The researcher places each of the five test tubes in a different temperature-controlled environment (0°C, 10°C, 20°C, 30°C, and 40°C), and so temperature is the experimental variable. The other variable in the experiment is the amount of egg white digested in each tube.

Wrong Choices Explained

(1), (2), (4) Gastric fluid, length of glass tubing, and time are not variables (conditions that change) in this experiment. These conditions remain constant throughout the experiment for all five laboratory setups.

7. (1) The coarse adjustment knob is used to provide general focus on the specimen being viewed.

(2) The fine adjustment knob is used to adjust focus on an object more precisely and in finer detail than can be obtained under coarse adjustment.

(3) The objective contains optical lenses that permit magnification of the image of the specimen.

(4) The diaphragm is used to adjust the amount of light passing through the specimen to the objective.

8. 1 The student should have focused under low power using the coarse and fine adjustments, and then under high power using only the fine adjustment. Following this procedure will allow the student to locate the portion of the specimen to be studied and then to focus on and study a small part of the specimen in detail. A compound light microscope should never be focused with the coarse adjustment when the high-power objective is in place. Even minor adjustments of the coarse adjustment knob under these conditions could crush the specimen and break the slide.

Wrong Choices Explained

(2) The student should not have focused under high power first, then under low power using only the fine adjustment. The high power objective should not be used to locate the general area of the specimen to study, but rather the low-power objective should be used first for this purpose.

(3) The student should not have focused under low power using the coarse and fine adjustments, and then under high power using the coarse and fine adjustments. A compound light microscope should never be focused with the coarse adjustment when the high-power objective is in place. Even minor adjustments of the coarse adjustment knob under these conditions could crush the specimen and break the slide.

(4) The student should not have focused under low power using the fine adjustment, and then under high power using only the fine adjustment. The fine adjustment is designed to move the objective very small distances and is not effective when used on low power unless the coarse adjustment has been used previously to gain general focus at this level of magnification.

9. 4 The diameter of the low-power field of vision is 2,000 micrometers (μm). By definition, a micrometer is one/one millionth (1/1,000,000) of a meter (m). Because there are 1,000 millimeters (mm) in a meter, each millimeter must contain 1,000 micrometers (1,000 mm x 1,000 μm/mm = 1,000,000 μm = 1 m). Because there are 2 millimeters that span the lowpower field of view illustrated in this diagram, the total low-power-field diameter must be 2,000 micrometers (2 mm x 1,000 μm/mm = 2,000 μm).

Wrong Choices Explained

(1), (2), (3) The diameter of the low-power field in the illustration is not 1 micrometer, 2 micrometers, or 1,000 micrometers. See explanation above.

10. 2 The diameter of the high-power field of vision in this illustration would be closest to 0.5 mm (millimeters). The ratio of magnification between the low-power and high-power objectives is 1:4. With the formula below, the high-power-field diameter can be calculated to be one fourth of the 2-mm low-power-field diameter, or 0.5 mm:

$$\frac{\text{Low-power objective magnification } (10\times)}{\text{High-power objective magnification } (40\times)} = \frac{\text{High-power-field diameter } (D \text{ mm})}{\text{Low-power-field diameter } (2 \text{ mm})}$$

$$40D = 2 \text{ mm} \times 10 = 20 \text{ mm}$$

$$D = 20 \text{ mm}/40 \text{ mm} = 1/2 \text{ mm} = 0.5 \text{ mm}$$

Wrong Choices Explained

(1), (3), (4) The diameter of the low-power field is not 0.05 mm, 5 mm, or 500 mm. Each of these answers is a multiple of the correct answer. See explanation above.

11. 2 Iodine solution is the substance that, when added to a wet mount containing starch grains, would react with the starch grains and make them more visible. Also known as Lugol's solution, this tan indicator turns blueblack when it contacts a substance containing starch.

Wrong Choices Explained

(1) Litmus solution would not react with the starch grains by changing color. Litmus changes color in reaction to acidic and basic solutions, not to solutions containing starch. Litmus turns blue in the presence of bases and red/pink in the presence of acids.

(3) Distilled water would not react with the starch grains by changing color. Distilled water is a neutral substance that normally does not react with any substance to produce a color change.

(4) Bromthymol blue would not react with the starch grains by changing color. Bromthymol blue is an indicator that turns brick red when heated in the presence of simple sugars such as glucose.

12. 4 The formation of bubbles on slide A could have been prevented by bringing one edge of the coverslip into contact with the water and lowering the opposite edge slowly. This technique allows air to escape from under the coverslip as it is lowered onto the slide, preventing the formation of air bubbles.

Wrong Choices Explained

(1) Using a thicker piece of potato and less water would not prevent the formation of air bubbles on slide A. The thicker specimen would tend to suspend the coverslip off the water surface and could actually increase the likelihood of bubble formation.

(2) Using a longer piece of potato and a coverslip with holes in it would not prevent the formation of air bubbles on slide A. The length of the specimen would not affect the formation of bubbles. However, a coverslip with holes in it would allow air to enter the area between the coverslip and slide, leading to the formation of air bubbles.

(3) Holding the coverslip parallel to the slide and dropping it directly onto the potato would not prevent the formation of air bubbles on slide A. This technique would not allow trapped air to escape from under the coverslip, increasing the likelihood that air bubbles will form and remain trapped.

13. 3 It allows the stain to penetrate the potato tissue without the removal of the coverslip is the statement that best describes the purpose of the procedure. This technique takes advantage of capillary forces to pull the liquid stain under the coverslip as water is being removed by the absorbent paper on the opposite side of the coverslip. When the stain comes into contact with the potato tissue, some of it is absorbed by the cells of the tissue, staining it for study.

Wrong Choices Explained

(1) It prevents the stain from getting on the ocular of the microscope is not the statement that best describes the purpose of the procedure. The ocular lens should never be exposed to chemical stains, as a stain can coat the lens, obscuring visual observation of the specimen by the researcher. This procedure should be conducted away from the proximity of the ocular lens.

(2) It prevents the water on the slide from penetrating the potato tissue is not the statement that best describes the purpose of the procedure. By drawing the stain under the coverslip, this technique helps to ensure that this penetration will occur.

(4) It helps to increase the osmotic pressure of the solution is not the statement that best describes the purpose of the procedure. Although the active ingredient of many stains is a form of salt, and although this salt can have the effect of altering the osmotic gradient in a system, the main purpose of the procedure is to introduce the stain into proximity of the tissues to be stained, not to increase the osmotic pressure of the solution.

14. 1 Onion epidermal cells most likely make up the tissue represented in the drawing. The blocklike arrangement of the cells and the wall-like divisions between them are typical of a plant tissue. Iodine stain would tend to darkly stain the starch in vacuoles and the cellulose in the cell walls of these cells.

Wrong Choices Explained

(2) Ciliated protists do not most likely make up the tissue represented in the drawing. Most ciliated protests are not colonial but free-living, whereas this tissue clearly shows a structure of contiguous blocks. Cilia are not apparent on any of the cells in the drawing.

(3) Cardiac muscle cells do not most likely make up the tissue represented in the drawing. Such cells are shaped like interlocking spindles and show a prominent striped pattern within each cell. Muscle cells lack cell walls, whereas the cells in the diagram clearly contain cell walls.

(4) Blue-green algae do not most likely make up the tissue represented in the drawing. Blue-green algae are among the most primitive of life forms, lacking organized nuclei. Structure A in the diagram is most likely an organized nucleus.

15. 4 The organelle labeled B in the diagram is most likely a cell wall. The thick, well-defined, rigid cell boundary illustrated in the diagram is typical of the cell walls of typical plant cells.

Wrong Choices Explained

(1) The organelle labeled B is not likely a mitochondrion. Mitochondria are too small to be clearly visible under typical laboratory high-power (400 x-430x) magnification.

(2) The organelle labeled B is not likely a centriole. Centrioles are too small to be clearly visible under typical laboratory high-power (400x-430x) magnification. Centrioles are rod-shaped and are found only in animal cells.

(3) The organelle labeled B is not likely a lysosome. Lysosomes are specialized vacuoles that contain digestive enzymes used to break down complex molecules into small, soluble molecules. Lysosomes are irregularly spherical in shape.

16. 1 The tissue is composed of more than one layer of cells is the best conclusion to be made from these observations. In diagram A, the microscope is focused on the cell walls and nuclei of one cell layer, whereas the second layer remains out of focus in the foreground. As the fine adjustment knob is turned slowly, the second layer is brought into sharp focus, while the first layer is put out of focus in the background. This is illustrated in diagram B.

Wrong Choices Explained

(2) The tissue is composed of multinucleated cells is not the best conclusion to be made from these observations. A characteristic of a multinucleated cell is that it contains two or more nuclei. None of the cells in the diagrams have more than one nucleus.

(3) The cells are undergoing mitotic cell division is not the best conclusion to be made from these observations. In tissues undergoing mitotic cell division, additional cells are created. The diagrams do not show additional cells being created.

(4) The cells are undergoing photosynthesis is not the best conclusion to be made from these observations. The cells in the diagrams may or may not ,be carrying on photosynthetic activity, but this activity would not be responsible for the different views illustrated in diagrams A and B.

17. 1 The presence of carbon dioxide would be indicated by a color change in the solution. Bromthymol blue is blue in a slightly basic solution but turns yellow in a slightly acidic solution. When the student exhales through a straw into the bromthymol blue solution, carbon dioxide molecules in the exhaled air combine with water to form weak carbonic acid. As the acidity of the solution increases, the indicator reacts by changing from blue to yellow.

Wrong Choices Explained

(2) A change in atmospheric pressure would not indicate the presence of carbon dioxide in the exhaled air. This phenomenon occurs for meteorological reasons independent of the laboratory.

(3) The formation of a precipitate in the solution would not indicate the presence of carbon dioxide in the exhaled air. This is not a characteristic of the indicator bromthymol blue.

(4) The release of bubbles from the solution would not indicate the presence of carbon dioxide in the exhaled air. Bubbles of any gas that is less dense than water will rise to the surface when released

in the water. This is not a characteristic of the indicator bromthymol blue.

18. 3 Benedict's solution is the indicator used to detect the presence of glucose and other simple sugars. When heated in the presence of glucose, blue Benedict's solution changes to brick red.

Wrong Choices Explained

(1) Iodine solution would not indicate the presence of glucose in the container. Iodine (Lugol's) solution is used to detect the presence of starch in foods.

(2) Bromthymol blue would not indicate the presence of glucose in the container. Bromthymol blue is used to detect the presence of carbon dioxide in solution.

(4) pH paper would not indicate the presence of glucose in the container. pH paper is used to detect the presence of acids or bases.

19. 2 The total volume of water indicated in the diagram is 11 mL (milliliters). When reading the volume of liquid in a graduated cylinder, the observer should note the mark that corresponds to the bottom of the meniscus. In the diagram, the meniscus falls on the 11-mL mark.

Wrong Choices Explained

(1), (3), (4) The total volume indicated is not 10 mL, 12 mL, or 13 mL. Each of these readings falls either below or above the l 1-mL mark indicated at the bottom of the meniscus in the diagram.

20. 8.9 cm (or 89 mm or 0.089 m) In the illustration, the earthworm is laid out along the metric ruler so that the proboscis is positioned at the 2.0- cm mark. The posterior of the specimen is shown to extend to the 10.9-cm mark on the ruler. Subtracting 2.0 cm from 10.9 cm provides the specimen's total length of 8.9 cm.

21. 1 Micrometer, millimeter, centimeter, meter is the group of measurement units correctly arranged in order of increasing size. A meter contains 1,000,000 micrometers, 1,000 millimeters, or 100 centimeters.

Wrong Choices Explained

(2), (3), (4) The groups millimeter, micrometer, centimeter, meter; meter, micrometer, centimeter, millimeter; and micrometer, centimeter, millimeter, meter do not correctly arrange these units in order of increasing size. See explanation above.

22. 4 The nerve cord is ventral to the esophagus in earthworms and grasshoppers. The ventral surface of a bilaterally symmetrical animal is the surface normally oriented downward when the animal is in a horizontal position (except in humans and other upright-walking animals where it is located on the "front" of the body). This question requires a knowledge of the anatomy of these

organisms gained through dissection or other means.

Wrong Choices Explained

(1) The gizzard of the earthworm and grasshopper is located posterior, not ventral, to the esophagus.

(2) The brain of the earthworm and grasshopper is located anterior and dorsal, not ventral, to the esophagus.

(3) The intestine of the earthworm and grasshopper is located posterior, not ventral, to the esophagus.

23. Anther The stamen is the male part of the flower and is made up of the filament and the anther. The anther contains tissues that produce pollen. This question requires a knowledge of the anatomy of flowers gained through dissection or other means.

24. A scientifically accurate, complete-sentence response is required. Examples of acceptable responses include:

• This structure functions in the formation of pollen.

• The anther contains tissues that produce pollen.

25. 2 The student should discontinue heating and report the defect to the instructor. A crack in any piece of laboratory glassware is a sign of imminent failure. If the beaker had shattered while the student was near it, she could have been spattered and burned by the hot water in the beaker and burned or cut by hot broken glass. The instructor should remove and discard the beaker from the student's lab station and replace it with a new one for her use.

Wrong Choices Explained

(1), (3), (4) The student should not discontinue heating and attempt to seal the crack, discontinue heating and immediately take the beaker to the instructor, or continue heating as long as fluid does not seep from the crack. These actions are unsafe for both the student and others in the laboratory, as each could result in injury from hot broken glass and hot water.

26. 3 Rinse the eyes with water; then notify the teacher and ask for advice is the proper laboratory procedure to follow if some laboratory chemical splashed into a student's eyes. Because of the sensitivity of the eyes and skin surface to chemical burns, the student should not wait for direction from the teacher but should immediately flood the exposed areas with clean water. Each school science laboratory should have an eyewash station for this purpose. The student should then immediately report the incident to the teacher. The teacher in turn should immediately refer the student to the school nurse for examination and treatment as needed.

Wrong Choices Explained

(1) The student should not send someone to find the school nurse before thoroughly rinsing the exposed area and informing the teacher of the incident. This delay could cause severe damage to the eyes that could result in blindness.

(2) The student should not rinse the eyes with water and do not tell the teacher because he or she might become upset. Chemical exposures should always be treated by qualified medical personnel. If the exposed tissues are not thoroughly rinsed and examined, the chemical could cause severe damage to the eyes that could result in blindness.

(4) The student should not assume that the chemical is not harmful and no action is required. Until it is determined otherwise, all chemicals used in the laboratory should be considered dangerous. Chemical exposures should always be treated by qualified medical personnel. If the exposed tissues are not thoroughly rinsed and examined, the chemical could cause severe damage to the eyes that could result in blindness.

27. 4 When heating a liquid in a test tube, the student should always keep the mouth of the tube aimed away.from everybody. Doing so will minimize the risk that someone will be injured by the hot liquid in the test tube. If heated too quickly, the liquid in the tube could splash or boil from the open end of the tube and bum anyone close enough to be spattered by it.

Wrong Choices Explained

(1) The student should not keep the mouth of the tube corked with a rubber stopper. This action could result in the formation of hot, high-pressure gases inside the test tube that could eject the stopper at high speed or shatter the tube. Either of these events could cause injury to the student or someone standing nearby.

(2) The student should not keep the mouth of the tube pointed toward the student. This action may result in injury to the student. If heated too quickly, the liquid in the tube could splash or boil from the open end of the tube and bum the student.

(3) The mouth of the tube should not be allowed to cool. Good laboratory practice suggests that the student should heat the tube evenly along its entire length so as to avoid uneven expansion of the glass walls of the tube that could result in cracking. This practice also helps to ensure that the liquid in the tube will heat evenly, minimizing the probability of uncontrolled boiling and splashing.

28. One credit is allowed for appropriately labeling column III of the chart. Acceptable responses include:

• Height of Bean Plants (cm)

Bean Plant Height in Centimeters

29. One credit is allowed for appropriately organizing data on the chart. Students should complete the chart so that the values entered in column II are arranged in increasing order from top to bottom and that the corresponding bean plant measurement is entered in column III.

DATA TABLE

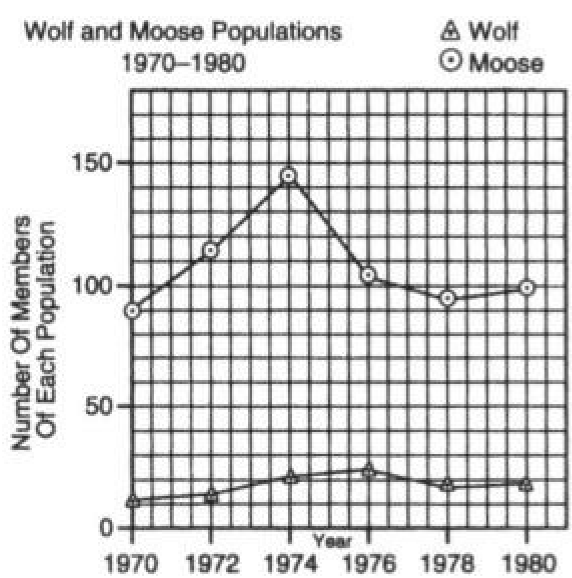
I	II	III
Group	Concentration of Substance X (%)	Height of bean plants (cm)
B	0	28.7
C	2	29.4
E	4	31.5
A	6	32.3
D	8	37.1
F	10	30.7

30. One credit is allowed for marking an appropriate scale on the axis labeled "Number of Members of Each Population." Students should be sure to start numbering from zero at the lower left corner of the grid and enter values along the vertical axis in equal increments up to 150, a value that just exceeds the highest recorded moose population.

31. One credit is allowed for marking an appropriate scale on the axis labeled "Year." Students should be sure to start numbering from 1970 at the lower left corner of the grid and enter values along the horizontal axis in equal increments up to 1980.

32. One credit is allowed for correctly plotting the data for the wolf population, surrounding each point with a small triangle, and connecting the points.

33. One credit is allowed for correctly plotting the data for the moose population, surrounding each point with a small circle, and connecting the points.



34. 4 According to the chart, lake trout can tolerate the highest level of acidity in their water environment. The chart shows that the survival rate for lake trout is strong at pH values ranging from 7.0 (neutral) to 5.5 (moderately acidic). At a pH value of 5.5, the survival rate for this species begins to decrease; at pH values below 5.0, the survival rate drops off drastically and reaches zero at a pH value of approximately 4.4.

Wrong Choices Explained

(1) Mussels do not tolerate the highest levels of acidity in their water environment. The chart shows that survival rates for this species begin to decrease at a pH value of 6.5 and reach zero at a pH value of approxi- mately-5.9.-

(2) Smallmouth bass do not tolerate the highest levels of acidity in their water environment. The chart shows that survival rates for this species begin to decrease at a pH value of 5.8 and reach zero at a pH value of approximately 5.3.

(3) Brown trout do not tolerate the highest levels of acidity in their water environment. The chart shows that survival rates for this species begin to decrease at a pH value of 5.5 and reach zero at a pH value of approximately 4.9.

35. 1 According to the chart, mussels would have been the first species eliminated from these lakes during the period from 1880 to 1980. The chart shows that survival rates for this species begin to decrease at a pH value of 6.5 and reach zero at a pH value of approximately 5.9. Assuming that lake acidification occurred at a constant rate throughout the period, by about 1930 a pH value of 5.9 would have been reached and mussels would have been eliminated from these lakes.

Wrong Choices Explained

(2) Smallmouth bass would not have been the first species to be eliminated from these lakes. The chart shows that survival rates for this species reach zero at a pH value of approximately 5.3. Assuming that lake acidification occurred at a constant rate throughout the period, by about 1960 a pH value of 5.3 would have been reached and smallmouth bass would have been eliminated.

(3) Brown trout would not have been the first species to be eliminated from these lakes. The chart shows that survival rates for this species reach zero at a pH value of approximately 4.9. Assuming that lake acidification occurred at a constant rate throughout the period, by about 1980 a pH value of 4.9 would have been reached and brown trout would have been eliminated.

(4) Lake trout would not have been the first species to be eliminated from these lakes. The chart shows that survival rates for this species reach zero at a pH value of approximately 4.4. As of 1980, the pH value in these lakes was approximately 4.9, and lake trout had presumably not yet been eliminated.

36. 2 The total change in the pH value of rainwater between 1880 and 1980 was 1.7. In 1880, the pH value was approximately 5.7; in 1980, the pH value was approximately 4.0. The numerical

difference between these values is found by carrying out the mathematical operation 5.7 - 4.0 = 1.7.

Wrong Choices Explained

(1), (3), (4) The total change in the pH value of rainwater between 1880 and 1980 was not 1.3, 5.3, or 9.7. These changes are incorrect according to the method described above.

37. 3 The total change in mass of the apple piece in the 10% sugar solution was a decrease of 0.30 gram. We assume that the natural sugar concentration of the apple slices is approximately 3%, a point at which the gain/loss in mass is at 0.0 gram on the graph. At a sugar concentration of 10%, the mass change shown on the graph is -0.3 gram.

Wrong Choices Explained

(1) A mass change is not shown as a decrease of 0.45 gram. This degree of mass change is indicated on the graph as corresponding to a sugar concentration of approximately 15%.

(2) A mass change is not shown as an increase of 0.30 gram. This degree of mass change is indicated on the graph as corresponding to a sugar concentration of approximately M.

(4) A mass change is not shown as an increase of 0.10 gram. This degree of mass change is not indicated on the graph as corresponding to any specific sugar concentration but can be inferred to occur at a sugar concentration of approximately 2%.

38. 3 The apple slices should neither lose nor gain weight at a sugar concentration of approximately 3%, a point at which the gain/loss in mass is at 0.0 gram on the graph. This value can be determined by drawing a curved line connecting the points on the graph and approximating the sugar concentration at the point where this line crosses the 0.0 mass change line.

Wrong Choices Explained

(1), (2), (4) According to the data shown in the graph, at sugar concentrations of 6%, 10%, and 20% the apple slices will lose total mass. All these values exceed the equilibrium concentration of 3%.

39. 3 Based on the graph, it can be correctly concluded that the pituitary extract affects the growth of rats over a 200-day period. The graph shows data on their growth in grams of two groups of rats: one group (the control group) untreated and the other group (the experimental group) treated with anterior pituitary extract. The two groups of rats appear to grow at the same rate until day 70, when the treated (experimental) group begins to show an increased growth rate compared to the untreated (control) group.

Wrong Choices Explained

(1) It cannot be correctly concluded that the pituitary extract is essential for life. It is obvious from the

data that the untreated rats have survived and grown over the 200-day period of this experiment, a fact indicating that the lack of extract does not lead to the death of these individuals.

(2) It cannot be correctly concluded that the pituitary extract determines when a rat will be born. There is no data on the graph concerning a measurement of the birthrates of rats.

(4) It cannot be correctly concluded that the pituitary extract affects the growth of all animals. Only rats, not "all animals," are being tested in this experiment. Further experiments involving other animal species may be conducted to provide this information, but the data from this experiment provides information only about the effect of anterior pituitary extract on rats.

40. 4 Based on the graph, it can be correctly concluded about plant hormones that they stimulate maximum root and stem growth at different concentrations. The graph shows data on the effect of relative plant hormone concentration on the relative degree of growth of roots and stems. The two types of plant tissues respond differently to the same concentrations of hormones. In general, root tissues are stimulated by low concentrations of hormones and inhibited by high concentrations of hormones, whereas stem tissues are stimulated by moderately high hormone concentrations and inhibited by very low and very high concentrations of hormones.

Wrong Choices Explained

(1) It cannot be correctly concluded that they stimulate maximum root growth and stem growth at the same concentration. It is obvious from the data that the relative degree of stimulation or inhibition is different in roots than in stems at any particular concentration (other than at the point where the graph lines cross).

(2) It cannot be correctly concluded that they stimulate maximum stem growth at low concentrations. The data in the graph show that moderately high hormone concentrations (up to a point) are needed to stimulate the highest degree of stem growth.

(3) It cannot be correctly concluded that they most strongly inhibit root growth at low concentrations. The data in the graph show that relatively low hormone concentrations are needed to stimulate the highest degree of root growth.

41. 4 Based on the data, it can be correctly concluded that as temperature increases from 15°C to 30°C, the number of compound eye sections in male Drosophila with bar-eyes decreases. The chart presents data on the effect of incubation temperature on the number of compound eye sections in male bar-eye Drosophila. The data show that, as the incubation temperature increases from 15°C to 30°C, the number of eye sections decreases from 270 to 74 in males of this specific species and variety.

Wrong Choices Explained

(1) The optimum temperature for culturing Drosophila is 15°C is not the best conclusion to be drawn from analysis of the data. The chart contains no general information concerning the effect of temperature on the culturing of this or other varieties of Drosophila.

(2) Drosophila cultured at 45°C will show a proportionate increase in the number of compound eye sections is not the best conclusion to be drawn from analysis of the data. The chart contains no information concerning the effect of an incubation temperature of 45°C on the number of eye sections in this or other varieties of Drosophila.

(3) Temperature determines eye shape in Drosophila is not the best conclusion to be drawn from analysis of the data. The chart contains no infor mation concerning the effect of incubation temperature on the expression of eye shape in varieties of Drosophila other than bar-eye.

42. 2 Based on the diagram, it can be correctly concluded that nuclei are more dense than mitochondria. At the very high spin rates of an ultracentrifuge, suspended organelles from broken cells are forced to separate into layers based on their relative densities. The more dense the organelle, the lower in the tube it concentrates. The diagram shows nuclei concentrated in a lower layer than mitochondria, indicating that nuclei are more dense than mitochondria.

Wrong Choices Explained

(1), (3) Ribosomes are more dense than mitochondria and mitochondria and ribosomes are equal in density are not the best conclusions to be drawn from analysis of the data. The diagram shows that ribosomes concentrate in a higher layer than mitochondria, indicating that ribosomes are less dense than mitochondria.

(4) The cell consists of only solid components is not the best conclusion to be drawn from analysis of the data. The diagram shows that the highest (least dense) layer in the ultracentrifuge tube contains cell fluid, indicating that cells contain a liquid component.

Question Set on Reading, Writing, and Current Events in Science (p. 65)

1. 3 There is not sufficient information given in the paragraph. The first section of the paragraph mentions that scientists are now able to splice human genes into bacteria, but there is no indication of the technical difficulties involved in this process.

2. 1 This statement is true according to the paragraph. The first sentence of the second section of the paragraph states that "bacteria reproduce rapidly under certain conditions."

3. 1 This statement is true according to the paragraph. The second sentence of the third section of the paragraph states that "continued use of [animal] insulin can trigger allergic reactions in some humans."

4. 2 This statement is false according to the paragraph. The first sentence of the fourth section of the paragraph states that "the bacteria used for these experiments are . . . common to the digestive systems of many humans."

5. 3 There is not sufficient information given in the paragraph. The fourth section of the paragraph

mentions that scientists have used E. coli for these experiments, but no information is given concerning the use or nonuse of other bacterial species.

6. One credit is allowed for a scientifically correct, complete-sentence response that describes a difference between gradualism and punctuated equilibrium. Acceptable responses include:

- Gradualism proposes that evolutionary change is continuous and slow, whereas punctuated equilibrium proposes that species undergo long periods without change and then undergo considerable change quickly.

- The theory of gradualism involves slow, gradual change, whereas the theory of punctuated equilibrium involves rapid, infrequent change.

- Gradualism is supported by the presence of transitional fossils, and punctuated equilibrium is supported by the lack of transitional fossils.

7. One credit is allowed for a scientifically correct, complete-sentence response that states what may result from the accumulation of small variations. Acceptable responses include:

- Gradualism theorizes that new species evolve as a result of the accumulation of many small genetic changes.

- The theory of gradualism states that the accumulation of many small genetic changes will eventually result in the formation of new species.

8. One credit is allowed for a scientifically correct, complete-sentence response that states what fossil evidence supports the theory of gradualism. Acceptable responses include:

- Gradualism is supported by fossil evidence that shows transitional forms.

- The theory of gradualism is supported by fossil evidence that includes transitional forms within an evolutionary line.

9. Three credits are allowed for listing three human structures and describing in a scientifically correct response the structure's adaptive value to the human body. Acceptable responses include:

- SWEAT GLAND-This structure regulates body temperature by releasing moisture from the blood to the skin surface where it can evaporate.

- PANCREAS-This organ produces digestive enzymes used in the digestive function. • LIVER-This organ filters the blood of dead blood cells and toxic materials.

- EPIGLOTTIS-This structure prevents swallowed food from entering the trachea.

- CAPILLARY-This structure enables the blood to reach all body tissues.

- VILLUS-This structure permits the absorption of digested food from the intestine into the bloodstream.

- KIDNEY-This organ filters certain toxic materials from the blood and excretes them from the body.

- PLATELET-This structure promotes blood clotting by releasing enzymes into the blood.

10. 4 Acid rain has a pH closest to that of vinegar. The second paragraph of the selection states that acid rain has a pH value between 3.0 and 5.0. The scale presents data on the pH of several common substances, one of which is vinegar with a pH value of approximately 3.0.

Wrong Choices Explained

(1) Ammonia does not have a pH closest to that of acid rain. According to the scale, ammonia has a pH value of approximately 13.0.

(2) Tap water does not have a pH closest to that of acid rain. According to the scale, tap water has a pH value of approximately 6.5.

(3) Baking soda does not have a pH closest to that of acid rain. According to the scale, baking soda has a pH value of approximately 8.2.

11. 2 The most likely source of acid rain in New York State is the midwestern United States. The first paragraph of the selection states that this acid rain's principal sources are smokestack gases released by coal-burning facilities located in the midwestern states.

Wrong Choices Explained

(1), (3), (4) The areas of the far western United States, far eastern Canada, and far western Europe are not the most likely sources of acid rain in New York State. Although smokestack gases are produced in these regions to a greater or lesser extent than in the midwestern United States, the prevailing westerly winds would be unlikely to carry them from these regions to the atmosphere over New York State.

12. 2 The food chain algae - aquatic insect - trout - otter would most immediately be affected by acid rain. These organisms all live in or near water and depend on clean, unpolluted water for survival.

Wrong Choices Explained

(1), (3), (4) The food chains grass -- rabbit - fox --) decay bacteria, shrub - mouse - snake - hawk, and tree --> caterpillar -- > bird - lynx are all terrestrial food chains. Although all would eventually be affected by acid rain, they would not be the most immediately affected.

13. 3 Acid rain can most appropriately be characterized as a type of technological oversight. The technologies of steam and electrical power generation have had a positive effect on our economy and the growth of our nation but have had an unintended negative impact on the natural environment. The gases produced by coal and oil-fueled power plants and factories have become a problem in that the acid precipitation that results has killed fish and aquatic insects that form an important part of the aquatic ecosystem. The destruction of these ecosystems in turn has profound negative implications for human health and survival.

Wrong Choices Explained

(1) Acid rain is not most appropriately characterized as a type of biological control. A biological control is an environmentally sound method for controlling unwanted insects and other pests by using their natural biological enemies to exert this control.

(2) Acid rain is not most appropriately characterized as conservation of resources. Conservation of resources involves using the minimum amount of our scarce natural resources, as well as recycling materials to reclaim these resources for reuse.

(4) Acid rain is not most appropriately characterized as a type of land-use management. Land-use management involves using the minimum amount of our dwindling land resources, preserving open space and arable land for enjoyment by future generations.

14. 3 A strain of fish that could survive under conditions of increased acidity could best be obtained by selective breeding. Fish of all species are organisms that reproduce by means of sexual reproduction, the foundation of selective breeding techniques. These techniques allow breeders to mate pairs of organisms that display the traits desired for breeding (in this case, fish with a tolerance for elevated levels of acidity). The offspring of these breeding pairs have an increased likelihood of displaying the desired trait and forming a self-reproducing variety of the species over time.

Wrong Choices Explained

(1), (2), (4) Binary fission, vegetative propagation, and budding are not reproductive processes that would be likely to produce a strain of fish that could survive under conditions of increased acidity. These reproductive processes are all examples of asexual reproduction that are not used by any species of fish as its primary method of reproduction. In addition, as a reproductive process, asexual reproduction does not normally result in a wide variety of traits. Rather, it tends to maintain genetic traits intact and unchanging over many generations.

Question Set 2.1 (p. 78)

1. 1 The human digestive system is characterized by A, B, and C. Peristalsis (A) is a wave of muscular contractions that moves food through the food tube. In humans, this occurs in the esophagus, stomach, and intestines. In humans, smooth (involuntary) muscle tissues (B) are responsible for peristaltic movement. Accessory organs (C) present in humans include the liver, gallbladder, and

pancreas, which are not part of the food tube but that produce or store substances important to the digestive process.

Wrong Choices Explained

(2), (3), (4) The combinations of characteristics A only, B only, and B and C only do not occur in humans or in other commonly studied animals.

2. 4 It has two atria and two ventricles, and it pumps blood directly into arteries is a correct statement about the human heart. The human heart, like that of other mammal species, is a four-chambered vessel whose design helps to separate oxygenated and deoxygenated blood. These chambers include two thin-walled atria, which receive blood from veins, and two muscular ventricles, which pump blood out to the body through arteries.

Wrong Choices Explained

(1) It has two atria and one ventricle, and it pumps blood directly into veins is not a correct statement about the human heart. A three-chambered heart is characteristic of amphibians such as frogs but not humans. Blood is not pumped into veins from the heart.

(2) It has one atrium and one ventricle, and it is composed of cardiac muscle is not a correct statement about the human heart. Cardiac muscle is the muscle type found in human blood vessels, but the heart in humans is not two-chambered.

(3) It has one atrium and two ventricles, and it is composed of visceral muscle is not a correct statement about the human heart. This is a nonsense distracter since no known organism has this combination of heart chambers. Visceral muscle is not found in the human heart.

3. 4 Filtering of bacteria from the lymph is a process that would be affected by a malfunction of the lymph nodes. This process is one of the essential functions of the lymphatic system.

Wrong Choices Explained

(1), (2), (3) These are all nonsense distracters, since none of these processes is carried out in the lymph. Release of carbon dioxide and oxygen are associated with the respiratory system. Filtering of glucose may be carried out by the excretory system under certain circumstances.

4. 4 Of the choices given, decreased consumption of complex carbohydrates (for example, starches) is least likely to have the effect of promoting heart attack. By decreasing the consumption of starchy foods, there may even be a positive effect on the body's ability to ward off heart disease.

Wrong Choices Explained

(1), (2), (3) An increase in arterial blood pressure, oxygen deprivation of cardiac muscle, and narrowing of the arteries transporting blood to the heart muscle are all potential contributors to heart disease and may help to set up the conditions for heart attack in certain people. All place additional strain onto the heart muscle, making failure under stress more likely.

5. 1 Structure A (mouth) is the site in which the initial hydrolysis of carbohydrates occurs. Saliva secreted into the mouth contains digestive enzymes that hydrolyze starch into disaccharides.

Wrong Choices Explained

(2) Structure E (small intestine) is the organ where the digestion of all food types is completed and the end products of digestion are absorbed into the blood.

(3) Structure C (stomach) is the site in which the chemical digestion of protein begins.

(4) Structure D (pancreas) is an accessory organ that produces a variety of digestive juices important for the complete hydrolysis of carbohydrates, proteins, and lipids.

6. 4 Structure E (small intestine) is the organ where the digestion of all food types is completed and the end products of digestion are absorbed into the blood.

Wrong Choices Explained

(1) Structure F (large intestine) is where solid wastes accumulate and water is reabsorbed.

(2) Structure H (liver) is an accessory organ that manufactures bile and stores glycogen.

(3) Structure C (stomach) is the site in which the chemical digestion of protein begins.

7. 3 Structure C (stomach) is the site in which the chemical digestion of proteins begins.

Wrong Choices Explained

(1) Structure G (gallbladder) is the site where bile is stored after it is manufactured by the liver.

(2) Structure B (esophagus) is the structure that moves food from the mouth to the stomach.

(4) Structure E (small intestine) is the organ where the digestion of all food types is completed and the end products of digestion are absorbed into the blood.

8. 1 An artery, with its muscular walls, is the blood vessel most likely to produce a detectable pulse. The pulse is a wave of muscular contractions that help blood to move through the circulatory system.

Wrong Choices Explained

(1) A vein, by lacking muscular walls, is not likely to produce a detectable pulse. Veins serve as a return system for blood to the heart.

(2) A capillary is only one-cell thick and contains blood under very low pressure. Pulses would not be detected in the capillary.

(3) A lacteal is a microscopic extension of the lymphatic system found within a villus in the small intestine. There is no blood pressure in a lacteal.

9. 2 Structures B, F, and I are those most likely to contain deoxygenated blood in the human heart. Deoxygenated blood enters the heart from the body in structure I (left atrium) and then passes to structure F (left ventricle), where it is pumped through structure B (pulmonary artery) to the lungs.

Wrong Choices Explained

(1) Structures A, B, and C is not the correct choice. Structure A is the aorta, which carries oxygenated blood to the body. Structures C are the pulmonary veins, which carry oxygenated blood from the lungs to the heart.

(3) Structures C, D, and E is not the correct choice. Structures C are the pulmonary veins, which carry oxygenated blood from the lungs to the heart. Structure D is the right atrium, which receives oxygenated blood from the pulmonary veins. Structure E is the right ventricle, which pumps oxygenated blood into the aorta.

(4) Structures D, H, and I is not the correct choice. Structure D is the right atrium, which receives oxygenated blood from the pulmonary veins. Structure H is the vena cava, which carries deoxygenated blood from the body to the heart.

10. 1 Structure G is the left atrioventricular (A-V) valve that opens when blood passes from structure Ito structure F, but then closes to prevent the blood from flowing back into structure I (left atrium).

Wrong Choices Explained

(2) Structure B, the aorta, is the major artery leading from the heart to all parts of the body. It does not control the backflow of blood into an atrium.

(3) Structures C are the pulmonary veins. These blood vessels carry oxygenated blood from the lungs to the heart and do not control the backflow of blood into an atrium.

(4) Structure H is the vena cava, which carries deoxygenated blood from the body to the heart. It is not involved in the control of backflow of blood.

11. 4 Lymph vessels have specialized regions, known as nodes, where bacteria are attacked by phagocytic white blood cells and removed from the bloodstream.

Wrong Choices Explained

(1) Arteries are muscular blood vessels specialized for moving blood from the heart to the body extremities and internal organs.

(2) Capillaries are microscopic blood vessels that connect arteries to veins. Most molecular exchange occurs in the capillaries.

(3) Veins are valved blood vessels that carry blood back to the heart from all around the body.

Question Set 2.2 (p. 84)

1. 4 This question requires a knowledge of the structural design of the human respiratory system. Air passing out of the body during exhalation would start in the alveoli of the lungs and then proceed in order through the bronchioles, bronchi, trachea, pharynx, and oral/nasal cavity to the environment.

Wrong Choices Explained

(1), (2), (3) These distracters all reference parts of the human respiratory system. However, during exhalation, air passes through the alveoli, bronchioles, and bronchi before reaching the trachea.

2. 1 In humans, blood is cooled as it passes through capillaries surrounding sweat glands in the skin. Heat (along with excess salt and water) is absorbed from the blood and transferred to the glands as sweat. As sweat droplets evaporate from the skin surface, heat dissipates with it and the body cools.

Wrong Choices Explained

(2) The nephron is the functional unit of the human kidney. Although it is associated with removal of materials (urea, water, and salts) from the blood, it is not directly involved in temperature regulation.

(3) The liver is involved with filtering the blood; it is responsible for removing worn-out red blood cells and recycling their components in the body. The liver also removes a variety of toxic substances, including alcohol, from the blood. The liver is not directly involved in temperature regulation.

(4) The urinary bladder is responsible for collecting and storing urine passing from the kidneys. It is not directly involved in temperature regulation.

3. 2 This question requires a knowledge of the structural and functional design of the human excretory system. In humans, the urethra (X) is responsible for the transport of urine out of the body to the environment.

Wrong Choices Explained

(1) The filtration of cellular wastes from the blood is performed by the paired kidneys, shown at

the top of the diagram.

(3) The storage of urine is a function performed by the urinary bladder, shown immediately above the urethra in the diagram.

(4) The secretion of hormones is not a function performed by the human excretory system. However, the adrenal glands, which are a part of the human regulatory system, are located near the kidneys (not shown in the diagram).

4. 2 The region labeled X is most likely an alveolus within the human lung. The diagram shows oxygen (02) diffusing into the blood from the alveolus and carbon dioxide (CO2) diffusing out of the blood and passing into the alveolus.

Wrong Choices Explained

(1) A glomerulus is a portion of the nephron within the human kidney. Glomeruli are not associated with gas exchange in humans.

(3) A villus is a microscopic projection of the inner lining of the human small intestine. Villi are not associated with gas exchange in humans.

(4) The liver is an organ in humans specialized for the removal and storage of toxic materials from the blood. The liver is not associated with gas exchange in humans.

5. 1 Anaerobic respiration in muscle cells, forming lactic acid is a condition arising from the continual use of muscles during prolonged physical exercise such as that encountered in a marathon. In the absence of sufficient oxygen, the muscle cells carry on lactic acid fermentation to produce energy. The resulting lactic acid buildup produces a sensation of pain in the muscle, commonly called muscle fatigue.

Wrong Choices Explained

(2), (3), (4) Aerobic respiration in muscle cells, generating glycogen; anaerobic respiration in liver cells, producing glucose; and aerobic respiration in liver cells, synthesizing alcohol are nonsense distracters. No type of respiration in humans produces glycogen, glucose, or alcohol.

6. 4 The nasal cavity in humans is lined with a ciliated mucous membrane that warms, moistens, and filters air. The cilia move dust-laden mucus to the outside, while tissues warm and moisten the air before it enters the lung interior.

Wrong Choices Explained

(1) The pharynx is a cavity at the back of the throat, where the mouth cavity and the nasal cavity join. No ciliated tissues are in the pharynx.

(2) The alveolus is the respiratory sac in the lung where gas exchange occurs between the environment and the blood. The air reaching the alveolus must already be warmed and moistened to prevent drying of the lung tissues.

(3) The epiglottis is a small flap of tissue that closes the trachea while food is being swallowed. The epiglottis helps to prevent choking.

7. 3 The ureter transports urine from the kidney to the urinary bladder. From the urinary bladder, the urine passes through the urethra to the environment.

Wrong Choices Explained

(1) From the blood to the kidney is incorrect. This is accomplished in the nephron within the kidney.

(2) From the liver to the kidney is incorrect. This is accomplished only by the interaction of the bloodstream, as the waste products of protein deamination are removed for filtering in the kidney.

(4) From the urinary bladder to outside the body is incorrect. This is accomplished by way of the urethra.

8. 2 Constriction of the bronchial tubes and wheezing are symptoms commonly associated with asthma. In its acute state, asthma can be life threatening, as the victim's breathing tubes narrow and close.

Wrong Choices Explained

(1) Enlargement and degeneration of the alveoli may be a symptom of the human disorder known as emphysema.

(3) Inflammation and swelling of the epiglottis is not associated with any known human disorder.

(4) Constriction of the nasal cavity and watery eyes may be a symptom of an allergic reaction in humans.

9. 4 Structure D, the diaphragm, is a sheet of muscle tissue that contracts, causing a pressure change in the chest cavity during breathing. When the diaphragm presses downward, pressure in the chest cavity is reduced and air is forced into the lungs by atmospheric pressure. When the diaphragm presses upward, pressure in the chest cavity is increased and air is expelled to the atmosphere.

Wrong Choices Explained

(1) Structure A is the trachea, which is a rigid tube that conducts air from the mouth and nasal cavities downward toward the lung.

(2) Structure B is the bronchus, one of two extensions of the trachea leading deep into the lung tissues.

(3) Structure C is the lung, which contains thousands of small air sacs (alveoli) that facilitate the absorption of oxygen from the atmosphere.

10. 2 The statement it regulates the chemical composition of the blood is true of the main function of the nephron. Blood passes through capillary networks where materials diffuse out of the blood fluid and into the nephron interior. Metabolic wastes, such as urea, salts, and water, are removed from the blood. However, beneficial materials, such as dissolved food molecules, are returned to the blood. With this mechanism, the chemical composition of the blood is maintained.

Wrong Choices Explained

(1), (3) The statements it breaks down red blood cells to form nitrogenous wastes and it forms urea from the waste products of protein metabolism are true of the liver but not of the nephron.

(4) The statement it absorbs digested food from the contents of the small intestine is true of the villus but not of the nephron.

Question Set 2.3 (p. 93)

1. 1 This process is an example of maintenance of homeostasis. As the runner exercises, an increase in metabolism produces heat. This heat is absorbed by the blood and is carried to sweat glands in the skin, where it is transferred to droplets of perspiration. As these droplets evaporate from the skin surface, the blood is cooled, helping to maintain a stable body temperature.

Wrong Choices Explained

(2) Antigen-antibody reactions involve the body's defense mechanism against disease. By itself, it is an example of maintenance of homeostasis. However, the description given does not match this particular process.

(3) Acquired characteristics is a concept contained in the evolutionary theories of Jean Lamarck. These theories have been largely discredited by modern science.

(4) Environmental factors affecting phenotype is a concept discussed in modem genetic theory. It states that the expression of certain genetic traits can be altered by particular environmental conditions.

2. 3 Neurotransmitters, such as acetylcholine, are secreted by the terminal branches of neurons. These chemical neurotransmitters diffuse across the synapse and cause subsequent neurons to fire nerve impulses. In this manner, nerve impulses are transferred from neuron to neuron until the impulse reaches the central nervous system.

Wrong Choices Explained

(1) Antibodies are produced by the blood in response to the detection of foreign proteins (antigens) in the blood.

(2) Antigens are foreign proteins that may enter the blood and stimulate the production of antibodies.

(4) Lipids are biochemicals that take on a wide variety of particular shapes and characteristics. Lipids are composed of a glycerol molecule bonded chemically to three fatty acid molecules.

3. 3 C represents the most logical choice of those given. The statement should read as follows: "The endocrine glands produce hormones, which are transported by the circulatory system." Endocrine glands lack ducts and so depend on the bloodstream to carry hormones throughout the body.

Wrong Choices Explained

(1), (2), (4) These nonsense distracters indicate combinations of glands, products, and transport systems that do not exist in nature.

4. Definitions (acceptable sample responses):

- Coordination-regulates the body's activities through the use of nerve impulses and hormones

- Excretion-gets rid of cellular wastes from the body

- Digestion-breaks complex foods down into soluble subunits that can be absorbed by the cell

- Circulation-moves materials through the body from one place to another

- Synthesis-manufacture of complex molecules from simpler subunits

Explanations of interaction (acceptable sample responses):

- Circulation/excretion-The circulatory system moves cell wastes to places where they can be removed from the body.

- Coordination/digestion-The nervous system coordinates the peristaltic movement of food through the food tube so that digestion and absorption of the food can occur.

5. 1 In humans, muscle is anchored to bones by connective tissues known as tendons. Cartilage does not perform this function in humans. (HINT: Always pay close attention to exam questions that use the italicized word not.)

Wrong Choices Explained

(2), (3), (4) These distracters all reference functions characteristic of human cartilage.

6. 3 This question requires a knowledge of the structural and functional design of the human nervous system. An interneuron is shown at X lying within the spinal cord and linking a sensory neuron (below) with a motor neuron (above). The motor neuron in turn enervates a muscle effector. A reflex arc typically involves this structural pattern, designed to provide rapid responses (reflexes) to potentially dangerous situations in nature.

Wrong Choices Explained

(1) The effector in this diagram is the muscle, which enables a movement response.

(2) The motor neuron is shown linking the interneuron (X) with the muscle.

(4) The receptor (not shown) could be any of the body's sense organs or internal receptors.

7. 2 Production of blood cells is a function of the human skeletal system. Both red and white blood cells are produced in bone marrow.

Wrong Choices Explained

(1) Transmit impulses is a function of the regulatory system in humans.

(3) Produce lactic acid occurs in human muscle under anaerobic conditions.

(4) Store nitrogenous wastes is a function of the excretory system in humans.

8. 3 The pituitary gland is responsible for the elongation of structures A and B in the photograph. Structures A and B are long bones of the arm and leg. Pituitary growth hormone produced by the pituitary gland is responsible for the elongation of these bones.

Wrong Choices Explained

(1) The islets of Langerhans in the pancreas are responsible for producing the hormone insulin; insulin regulates the concentration of sugar in the blood.

(2) The liver acts as a reservoir for glycogen produced when the body stores excess sugar. The liver produces no hormones and does not directly influence the growth of bone tissue.

(4) Striated muscles produce no hormones and do not directly affect the elongation of these bones.

9. 3 Both the central and peripheral nervous systems are brought into play in the example given. When the child hears the clap of thunder, both the central and peripheral nervous systems are involved in the initial startle reflex (reflex arc). The central nervous system is involved in the child's decision to find his/her mother for comfort (cerebrum). The peripheral nervous system in involved in the child's feelings of fear (endocrine response) and the movement of muscles needed to allow the

child to run to his/her mother (locomotion). Coordination of those muscles is a central nervous system function (cerebellum).

Wrong Choices Explained

(1) The central nervous system only is not correct. The peripheral nervous system is needed to relay central commands to the muscles and glands.

(2) The peripheral nervous system only is not correct. Central control of a complex response is necessary for survival.

(4) Neither the central nor the peripheral nervous system is not correct. Both systems are needed to effect a coordinated response.

10. 4 Ligaments, strong elastic connective tissues, are responsible for attaching bone to bone at joints in the skeleton, including the shoulder and elbow joints.

Wrong Choices Explained

(1) Cartilage is a type of connective tissue found in many flexible parts of the human body. Cartilage acts as a cushion, not a connector, between bones.

(2) Tendons are another form of elastic connective tissue in the body. Tendons are specialized for connecting muscle to bone, not bone to bone.

(3) Extensors are muscles that extend joints. They are not associated with linkages between bones.

11. 2 The adrenal gland secretes the hormone adrenaline in times of emergency. Adrenaline speeds up metabolic rate, enabling the body to respond to the emergency.

Wrong Choices Explained

(1) The thyroid gland secretes the hormone thyroxin, which regulates the body's general metabolic rate.

(3) The islets of Langerhans, embedded within the pancreas, secrete the hormone insulin, which regulates the concentration of sugar in the blood.

(4) The parathyroid gland secretes the hormone parathormone, which regulates the metabolism of calcium in the body.

12. 1 The thyroid gland secretes the hormone thyroxin, which regulates the body's general metabolic rate. Dietary iodine is necessary for the proper synthesis of thyroxin.

Wrong Choices Explained

(2), (3), (4) The adrenal gland, islets of Langerhans, and parathyroid gland do not require dietary iodine to produce their respective hormones.

Question Set 2.4 (p. 110)

1. 1 The compound light microscope typically has a low-power magnification of 100x and relatively limited resolution. At this level of magnifica tion and resolution, viewing cells and some of the larger cell organelles (such as cell walls, chloroplasts, and nuclei) is posssible, especially if stains are added to enhance the color or contrast of these features.

Wrong Choices Explained

(2), (3), (4) The items mentioned in these distracters are generally too small or too difficult to stain to be viewed under a compound light microscope on low power. Under conditions of higher magnification and specialized specimen preparation (such as those used in electron microscopy), viewing ribosomes, endoplasmic reticula, lysosomes, and mitochondria would be possible. Genes and nucleotides, being molecular in size, would be difficult or impossible to view using known methodologies.

2. 2 Ina living cell, ribosomes provide the site for the manufacture of new polypeptide molecules (such as enzymes and structural proteins) from free amino acid molecules in the cytoplasm. While the precise role of the ribosomes in protein synthesis is not completely understood, they are known to be necessary for its successful completion. If ribosomes were to become disabled in the cell, the synthesis of essential enzymes would theoretically cease.

Wrong Choices Explained

(1) Uncontrolled mitotic cell division is a characteristic of many cancers. It is associated with changes that are thought to occur within the cell's nucleus. Ribosomes are not directly involved in this process.

(3) Antibodies are substances produced by specialized cells in response to the antigens of a foreign invading cell or virus. Antibodies are thought to combine to specific antigens in the body, rendering them harmless. Ribosomes are essential to the production of antibodies, which are proteins. If the ribosomes were not functioning, antibody production would cease, not increase. - -- - - - - - - -- - - - -- - -

(4) The transport of glucose and other small molecules in a cell depends on the cell membrane and cytoplasm of the cell. Ribosomes are not directly involved in this process.

3. 3 The diagram most likely represents a protozoan ingesting food during heterotrophic nutrition. The protozoan illustrated is most likely an ameba carrying out the process of phagocytosis to ingest a food particle found in its water environment. The food particle is first detected (illustration 1), then engulfed by cytoplasmic extensions known as pseudopods (illustration 2), and finally enclosed in a

food vacuole for digestion (illustration 3).

Wrong Choices Explained

(1) The diagram does not represent a virus destroying a cell by extracellular digestion. An illustration of this process would show a crystalline virus particle attaching to the exterior of a cell, injecting its genetic material into the cell interior, producing a number of new viruses from the cell's genetic material, and bursting the cell in order to release the new virus particles.

(2) The diagram does not represent a member of the bryophyte phylum performing intercellular digestion. Members of the bryophyte phylum include mosses, which are autotrophic and whose cells are surrounded by cell walls. The cell illustrated is clearly not a plant cell carrying on photosynthesis.

(4) The diagram does not represent a lysosome egesting a food particle into the cytoplasm. Lysosomes are specialized vacuoles in the cell that contain digestive enzymes. During the nutritional process, lysosomes combine with food vacuoles to facilitate chemical digestion. They are not directly involved with the process of egestion.

4. 4 The arrows in this diagram represent the movement of the indicated substances from the interior of a unicellular protist (a paramecium) to the environment. The substances indicated are carbon dioxide (CO2) and ammonia (NH 3)' which are both metabolic wastes produced in the cell. These substances are being excreted from the cell in this illustration.

Wrong Choices Explained

(1) Certain types of anaerobic respiration may result in the production of carbon dioxide, but this process is not carried on in paramecia. Ammonia is never a product of anaerobic respiration.

(2) Certain types of autotrophic nutrition may use (but not release) carbon dioxide. Ammonia is never a product of autotrophic nutrition. Paramecia do not carry on autotrophic nutrition.

(3) Deamination of amino acids may occur in a paramecia and may result in the production of ammonia as a metabolic waste. However, carbon dioxide is never a product of deamination.

5. 3 In this diagram, structure A illustrates a flagellum of an alga cell. Like the flagella of protists, these structures are primarily used to allow the organism to move about in its watery environment. This movement is classified as a type of locomotion.

Wrong Choices Explained

(1), (2) The structure most closely associated with the life functions of excretion and transport in this organism is the cell membrane, which is not labeled.

(4) The structure most closely associated with the life function of reproduction in this organism is

the nucleus, which is not labeled.

6. 3 C12H220,, illustrates the organic compound maltose. The presence of the key elements carbon (C), hydrogen (H), and oxygen (0) clearly indicate that this compound is organic.

Wrong Choices Explained

(1) Mg(OH)2 is the chemical formula for magnesium hydroxide, an inorganic base. No carbon is present in the formula of this compound; therefore it cannot be organic.

(2) NaCl is the chemical formula for sodium chloride, common table salt, which is an inorganic salt. No carbon is present in the formula of this compound, therefore it cannot be organic.

(4) NH3 is the chemical formula for ammonia, an inorganic material resulting from protein metabolism in certain bacteria. No carbon is present in the formula of this compound, therefore it cannot be organic.

7. 3 Diffusion is the process that results in the movement of molecules from a region of higher concentration (area A) to a region of lower concentration (area B). This net movement will occur until the concentrations of molecules have reached equilibrium between area A and area B.

Wrong Choices Explained

(1), (2) Phagocytosis and pinocytosis are processes by which certain protists engulf their food and enclose it within a vacuole for digestion.

(4) Cyclosis refers to the streaming of cytoplasm in the cell, a simple form of intracellular transport.

8. 3 This diagram illustrates a molecule of lipid. Lipids have a high energy content. The many carbon-hydrogen bonds present in this molecule indicate that a large amount of energy will be derived from its complete breakdown.

Wrong Choices Explained

(1) The statement it has the ability to control heredity is false. A molecule that controls heredity is the nucleic acid DNA.

(2) The statement it has the ability to control reactions is false. Molecules capable of controlling cell reactions are known as catalysts and enzymes.

(4) The statement it is involved in photosynthesis is false. Photosynthesis is a chemical process involving principally carbon dioxide, water, ATP, PGAL, glucose, and oxygen, as well as a number of enzymes.

9. 2 The molecule shown, which may also be represented by the empirical formula C3H5(OH)31 is a molecule of glycerol. Glycerol is one of two products that result from the chemical digestion of a triglyceride lipid, the other being fatty acid.

Wrong Choices Explained

(1) The molecule shown, which may also be represented by the empirical formula CO 2' is a molecule of carbon dioxide. Carbon dioxide is not an end product of any known chemical digestion but is an end product of aerobic respiration.

(3) The molecule shown, which may also be represented by the empirical formula H2O, is a molecule of water. Water is a reactant, not an end product, of chemical digestion.

(4) The molecule shown, which may also be represented by the empirical formula CH4, is a molecule of methane. Methane is not an end product of any known chemical digestion but is an end product of decomposition.

10. 3 A carboxyl group is illustrated in box Y. This group is common to organic acids, including amino acids, and is often written as -COOH.

Wrong Choices Explained

(1) An amino group, also common to amino acids, is written -NHS.

(2) A variable group, more commonly known as a radical group, refers to the chemical composition of individual amino acid molecules. Each type of amino acid contains a unique chemical composition in the radical group position.

(4) A peptide group is a nonsense distracter. No known chemical group carries this name.

11. 2 There are two peptide bonds illustrated in this diagram. These bonds are the C-N bonds that link one amino acid to the next prior to hydrolysis.

Wrong Choices Explained

(1), (3), (4) These bond counts are not correct for the molecule illustrated.

12. 1 Diagram A illustrates a group of plant cells whose cell membranes are pressed tightly against the cell wall by cytoplasm containing a relatively high concentration of water. Diagram B illustrates the same cells after the addition of salt water. Note that the cytoplasm has shrunk in volume as water has moved out of the cell by osmosis (diffusion of water) from a region of high concentration of water (the cell interior) toward a region of lower concentration of water (the cell exterior).

Wrong Choices Explained

(2) The addition of distilled water to this system would have the opposite effect from that illustrated; the cytoplasm would swell with the rapid inward movement of water, perhaps to the point of bursting.

(3), (4) Most common sources of pond water or tap water contain dissolved mineral concentrations similar to that found in the natural habitats of most terrestrial or aquatic species. The addition of water from these sources would probably have little or no effect on the cells' appearance.

Question Set 2.5 (p. 132)

1. 1 The Cell Theory is one of the central principles of modern biology. The "units of structure and function" are the cells that make up the bodies of all known living organisms, from amebas to humans. The "functions" referenced are the chemical reactions that constitute the cell's metabolic activities. These, in turn, enable the life functions of living organisms. A unique feature of living cells is their ability to produce new living cells like themselves (cells "arising from preexisting units").

Wrong Choices Explained

(2) The lock-and-key model of enzyme activity is a theoretical concept used to explain the specificity of enzymes involved in the cell's metabolism. This concept is much more limited in scope than cell theory. Enzymes are important in the functioning of a cell but are not structural units and cannot arise from preexisting enzymes.

(3) Natural selection is a term used to describe the mechanism by which favorable variations within a species are thought to be selected by natural forces to increase in frequency (and by which unfavorable traits are gradually reduced in frequency) in a species population. Natural selection deals with forces outside the organism and therefore cannot be described as making up the structure of living things.

(4) The heterotroph hypothesis is a theory proposed by scientists to explain the origin of life on Earth from primitive organic molecules floating in the oceans of the early Earth. Because the heterotroph hypothesis deals with events that theoretically took place before true cells existed, it is not used to describe the structure and function of modem life-forms.

2. 4 The statement "in both plants and animals, the daughter cells are genetically identical to the original cell" is true. Mitotic cell division ensures this continuity by replicating the genetic material prior to its separation into the two new daughter cells. This process occurs in all organisms employing mitotic cell division as a mechanism of growth and repair of body tissues.

Wrong Choices Explained

(1) The statement "it is exactly the same in plant and animal cells" is not correct since minor differences in the mechanics of cell division are evident when comparing plant and animal cells.

(2) The statement "the walls of plant cells pinch in, but the membranes of animal cells do not" is not correct. In plant cells, cell division is associated with the formation of the cell plate, which divides the cytoplasm and separates the daughter nuclei. In animal cells, the cell membrane pinches in to perform the same function.

(3) The statement "most plant cells use centrioles, but most animal cells do not" is not correct. Centrioles are commonly found in animal cells undergoing mitotic cell division. This process occurs in plant cells without the presence of centrioles.

3. 4 Sperm cells and egg cells are monoploid (n) gametes formed during the process of meiotic cell division. A zygote results from the fusion of two monoploid nuclei in fertilization, so it must be diploid (2n) in chromosome number.

Wrong Choices Explained

(1), (2), (3) Each of these distracters contains an incorrect combination of choices (see above).

4. 1 Gregor Mendel performed his experiments in the 1800s, prior to modern scientific research findings concerning chromosome structure or function. He described observed characteristics of and performed controlled breeding experiments with garden peas that led to the development of theories concerning the inheritance of characteristics. He postulated the existence of physical structures, which he referred to as factors (today's genes) that are passed from generation to generation in the reproductive process.

Wrong Choices Explained

(2) Mendel developed the principle of dominance, but he did so without reliance on or knowledge of the gene-chromosome theory.

(3) The modern compound light microscope was developed over time through the contributions of many scientists; Mendel is not known for his contributions in this area. He would not have studied genes with a microscope since he was unaware of the genes' existence except as theoretical factors.

(4) Mendel had no direct knowledge of the existence of gene mutations and so would not have been able to use such mutations as an explanation for variation.

5. 2 The principle of independent assortment is used to describe the ratio of phenotypic combinations that result from a typical dihybrid cross (in this case, a cross between guinea pigs heterozygous for fur color and fur texture). The term refers to the tendency of genes on nonhomologous chromosomes to combine (assort) in predictable ratios independently of each other.

Wrong Choices Explained

(1) The term intermediate inheritance describes a pattern of genetic inheritance in which the contrasting traits controlled by an allele pair blend to produce an intermediate phenotype (for

example, black fur x white fur - silver fur).

(3) The term multiple alleles describes a pattern of genetic inheritance in which more than a single allele pair controls expression of a trait (for example, tallness in humans).

(4) The term codominance describes a pattern of genetic inheritance similar to intermediate inheritance but in which the traits controlled by the allele pair are both expressed fully in the offspring, resulting in a mottled appearance. (for example, red x white -4 roan).

6. 3 Of the 200 seeds produced, approximately half, or 100, seeds can be expected to be homozygous dominant (TT). The other half will be heterozygous (Tt) for this trait. A Punnett square in which TT is crossed with Tt will illustrate (see below).

(HINT: Be careful to read this question as number of seeds rather than percentage of seeds.)

P_1: $TT \times Tt$

	T	t
T	TT	Tt
T	TT	Tt

F_1: 50% TT, 50% Tt

Wrong Choices Explained

(1), (2), (4) Each of these distracters contains an incorrect number of seeds. Be careful to read distracter (2) "50," as 50 seeds, and not as 50 percent.

7. 4 The X and Y chromosomes carry genes that determine maleness and femaleness in humans. Genes located on either of these two chromosomes are said to be sex-linked.

Wrong Choices Explained

(1) The term hybrid refers to the heterozygous condition of an allele pair.

(2) The term codominant refers to a type of intermediate inheritance.

(3) The term autosomal refers to chromosomes other than the X and Y chromosomes.

8. 3 Mutations can be passed on to offspring only if they occur in cells (primary sex cells) that give rise to gametes. Mutations in other (somatic) cells may cause cancerous conditions in their recipients, but these conditions cannot be passed on to succeeding generations.

Wrong Choices Explained

(1), (2), (4) Skin cells, lung cells, and uterine cells are all examples of somatic cells. Mutations in somatic cells cannot be passed on to offspring.

9. 3 Fur color in the Himalayan hare depends on the temperature of the skin during fur growth. The

diagram illustrates an experiment that shows that artificial cooling stimulates the skin to produce dark fur. Since temperature is an environmental condition, this experiment shows that certain genetic traits can he influenced by environmental conditions.

Wrong Choices Explained

(1) Heredity always influences gene expression. The experiment is not focused on this area.

(2) Genes are arranged on homologous chromosomes in essentially the same order. The experiment is not focused on this area.

(4) It is unlikely that this experiment would have resulted in gene mutations so extensive as to be immediately observable as a change in hair color.

10. 2 Molecule 1 represents a DNA molecule. The presence of units labeled T (for thymine) confirms this fact. In the living cell, DNA is found in the nucleus, associated with the chromatin.

Wrong Choices Explained

(1) The centriole is an organelle found in animal cells that serves as a point of attachment for the spindle fibers during mitotic cell division.

(3) The cell wall is an organelle that bounds and gives mechanical support to animal cells.

(4) The lysosome is an organelle that houses hydrolytic enzymes used in the digestion of complex food molecules in the cell.

11. 1 Molecule 3 represents a polypeptide (protein) molecule composed of four units of amino acid. Each of the amino acids is coded by a unique combination of three nitrogenous bases in DNA, as translated by mRNA molecules (molecule 2).

Wrong Choices Explained

(2) DNA is a very large polymer composed of repeating units of nucleic acid. DNA does not serve as a building block for other molecules.

(3) Fatty acids serve as components of lipid molecules, not of protein molecules.

(4) RNA, like DNA, is a very large polymer composed of repeating units of nucleic acid. RNA does not serve as a building block for other molecules.

12. 4 Molecule 2 represents a molecule of messenger RNA (mRNA). This molecule is manufactured from free nucleic acids, using DNA as a template. mRNA then migrates to the ribosome to perform the task of protein synthesis.

Wrong Choices Explained

(1) Cell vacuoles are specialized for storing various materials, including ingested foods, water, and toxic wastes.

(2) The plasma membrane provides the outer covering of the cell. It is specialized to regulate the entry and exit of materials into and out of the cell.

(3) The lysosome is an organelle that houses hydrolytic enzymes used in the digestion of complex food molecules in the cell.

13. 2 Dehydration synthesis (joining by removing water) is a process by which complex molecules are formed by the chemical combination of two or more simpler subunits. By using this reaction, two amino acid molecules might be joined to synthesize one molecule of a dipeptide. Water is a byproduct of this reaction.

Wrong Choices Explained

(1) Deamination is a process by which amino acids are broken down into their component parts for conversion into urea.

(3) Enzymatic hydrolysis is sometimes referred to as splitting with water. A complex molecule is split into two simpler molecules by adding the elements making up a water molecule to the bond that used to join the molecules. It is the chemical opposite of dehydration synthesis.

(4) Oxidation is a general biochemical term that relates to chemical reactions in which oxygen is chemically added to an element or compound.

14. 3 In the first paragraph, reference is made to the fact that all embryos develop female sex organs during the first 35-40 days (5-6 weeks) after fertilization.

Wrong Choices Explained

(1) Although these structures are formed during this period, they are not the only structures to be formed.

(2), (4) According to the passage (second paragraph), sex differentiation occurs after 35-40 days, not within the first 5 weeks.

15. 1 The passage identifies the SRY gene as the determiner of maleness.

Wrong Choices Explained

(2) The SRY gene is a single locus on the Y chromosome; the remainder of the chromosome is evidently not critical to this process.

(3) The X chromosome does not carry the SRY gene, and therefore cannot determine maleness.

(4) The MIS gene is activated by the SRY gene therefore the MIS gene cannot activate the process.

16. 2 The MIS gene is activated by a chemical produced by the SRY gene, which stimulates it to cause the female organs to disappear.

Wrong Choices Explained

(1) The X chromosome is not involved in the production of maleness in humans.

(3), (4) The presence of reproductive structures, male or female, is not cited in this passage as having anything to do with the stimulation of the MIS gene.

17. 4 Both the SRY and the MIS genes are involved in this process, the SRY gene acting as a trigger factor and the MIS gene performing the task of tissue resorption.

Wrong Choices Explained

(1) The X chromosome is not involved in the production of maleness in humans.

(2) The SRY gene is a single locus on the Y chromosome; the remainder of the chromosome is evidently not critical to this process.

(3) The MIS gene is activated by the SRY gene, therefore the MIS gene cannot activate the process.

18. 3 Messenger RNA (mRNA) is manufactured from free nucleic acids, using DNA as a template to produce a specific coded message concerning the design of an enzyme molecule. mRNA then migrates to the enzyme-producing region (ribosome) to perform protein synthesis.

Wrong Choices Explained

(1) Hormones are chemical substances produced by endocrine glands that are responsible for the chemical regulation of the body. They are not directly involved in protein synthesis.

(2) Nerve impulses are carried along neurons as electrochemical changes on the cell membrane. They are not directly involved in protein synthesis.

(4) DNA molecules provide the code for protein synthesis. They do not directly participate in protein synthesis.

19. 3 Genetic engineering refers to a set of laboratory techniques that involve the artificial translocation of genes from one cell to the chromosomes of other host cells. The host cells may then be used to produce specific enzymes or other materials unique to the translocated gene. The examples given are two of the economic benefits that might be derived from such activities.

Wrong Choices Explained

(1) Natural selection is a process occurring in nature by which favorable varieties of a species may be selected by natural forces for survival and then pass their favorable traits on to their offspring. It is unlikely that natural selection would lead to the kinds of traits referenced in the question.

(2) Sporulation is a reproductive process carried out by certain molds and fungi. As an asexual reproductive process, it is unlikely to result in unique new varieties such as those referenced.

(4) Chromatography is a laboratory technique used to separate and study complex organic compounds found in cells. It does not relate directly to the production of new genetic varieties.

20. 3 One cell with two identical nuclei would result from this situation. Mitosis is a process by which a cell nucleus first replicates its genetic material and then undergoes a nuclear division that results in two identical daughter nuclei. Cytoplasmic division normally accompanies mitosis, separating the daughter nuclei into two separate daughter cells.

Wrong Choices Explained

(1) Two cells, each with one nucleus would be the result of normal mitotic cell division.

(2) Two cells, each without a nucleus could not result since mitosis normally results in the formation of identical daughter nuclei. Also, two cells could not result in the absence of cytoplasmic division.

(4) One cell without a nucleus could not result since mitosis normally results in the formation of identical daughter nuclei.

21. 4 The cross IAi x lei may result in a child with blood phenotype O. The homozygous recessive condition (ii) produces the 0 phenotype. Statistically, the offspring of this cross has a 25% chance of having blood type O. The Punnett square below will illustrate this cross.

P_1: $I^Ai \times I^Bi$

	I^A	i
I^B	I^AI^B	I^Bi
i	I^Ai	ii

F_1: 25% AB, 25% A, 25% B, 25% O

Wrong Choices Explained

(1) The cross IN x IBIS will not result in type 0 blood in the offspring. There is a 50% chance of type AB and a 50% chance of type B in the offspring of this cross.

(2) The cross IAIA x Pi will not result in type 0 blood in the offspring. There is a 50% chance of type AB and a 50% chance of type A in the offspring of this cross.

(3) The cross I"IB x ii will not result in type 0 blood in the offspring. There is a 50% chance of type A and a 50% chance of type B in the offspring of this cross.

22. 1 Artificial selection and inbreeding are techniques that may be used to develop animals with certain desirable characteristics. The breeder selects individuals with evidence of desirable traits to be used as breeding stock. Once a favorable line has been established, it is maintained in future generations by inbreeding related individuals within the breeding population.

Wrong Choices Explained

(2) Grafting and hybridization are techniques normally associated with plant reproduction. Grafting refers to a process by which a plant slip (scion) is forced to grow into a stem (stock) of a different plant of the same species.

(3) Regeneration and incubation are processes associated with repair of damaged or lost tissues (regeneration) or the care by parents of eggs in a nest (incubation).

(4) Vegetative propagation and binary fission are methods of asexual reproduction carried out by plants and ameba, respectively.

23. 2 The environment influences wing phenotype in these fruit flies. For this particular mutation, the expression of the curly wing phenotype depends not only on the homozygous recessive genotype but also on the presence of high environmental temperatures (25°C) during development. Since the same genotype expresses a different phenotype (straight wing) at lower temperatures (16°C), we say that the trait is influenced by environmental conditions.

Wrong Choices Explained

(1) The statement fruit flies with curly wings cannot survive at high temperatures is not supported by the information given. If anything, the question leads us to believe that high temperatures support the curly wing condition.

(3) The statement high temperatures increase the rate of mutations is not supported by the information given. There is no evidence derived from the question that this mutant condition was caused by the environmental condition of temperature but instead, only influenced by it.

(4) The statement wing length in these fruit flies is directly proportional to temperature is not supported by the information given. The question implies an all-or-none condition with respect to the expression of this trait. No gradations in wing length are referenced, so wing length cannot be described as being proportional.

24. 1 A genetic code is contained within structure A, which represents a chromosome inside the nucleus of an animal cell. This genetic code is specific for the production of one or more proteins in the cell.

Wrong Choices Explained

(2) A single nucleotide only is not found in structure A. A chromosome is made up of hundreds, it

not thousands, of nucleotides for each strand of DNA contained within it.

(3) A messenger RNA molecule is not found in structure A. Messenger RNA molecules are formed next to DNA molecules but then migrate from the nucleus to the ribosome.

(4) A small polysaccharide is not found in structure A. Polysaccharides, such as starch, are not normally associated with chromosome structure.

25. 3 Recombinant DNA is represented by structure B. Genes from an animal chromosome (structure A) have- been spliced into the genome of a bacterial cell, forming a new genetic combination. The bacterial cell will now be capable of producing the protein or proteins coded for by the animal DNA.

Wrong Choices Explained

(1) A ribosome is not represented by structure B. Ribosomes are small organelles containing RNA and are located on the endoplasmic reticulum of most cells.

(2) Transfer RNA is not represented by structure B. The diagram indicates that structure A is composed of DNA, not RNA.

(4) A male gamete is not represented by structure B. Male gametes are sperm cells. Although sperm cells contain DNA, they are not found in the nuclei of animal cells.

26. 2 The technique illustrated is genetic engineering. Genetic engineering involves using various laboratory procedures to move genes from one cell to another.

Wrong Choices Explained

(1) Cloning is a technique in which the undifferentiated cells of an organism are used to produce a new organism with the same set of characteristics.

(3) Protein synthesis is a natural cellular process involving DNA and RNA molecules where amino acids are joined in particular sequences to produce specific proteins for use by the cell.

(4) In vitro fertilization is a laboratory technique in which mature eggs are fertilized outside the mother's body and the resulting zygote is reintroduced into the mother's uterus for development.

27. A. Charles Darwin - He developed the theory of Natural Selection, which explains evolution.

B. Stanley Miller - He proved that the chemical precursors of life could be formed in the laboratory.

C. Francis Crick - He developed the first workable model of DNA molecular structure.

C. Gregor Mendel - He described the fundamental concepts of genetic inheritance through work with pea plants.

(NOTE: Any correct, complete-sentence answer is acceptable.)

Question Set 2.6 (p. 151)

1. 4 Organism A was probably more primitive than organism B and organism C is a correct statement about the relationship among these organisms. By assuming that the fossils illustrated in the diagram are of sequentially evolved species, it can be inferred from evolutionary theory that the most primitive fossil is in the lowest (oldest) rock layer (A), and that the most advanced fossil is in the upper (youngest) rock layer (C).

Wrong Choices Explained

(1) Organism A was probably more structurally advanced than organism B and organism C is incorrect because it is unlikely that an older form of organism is more structurally advanced than a more recent form of that organism.

(2) Organism C probably gave rise to organism A and organism B is not a correct statement about the relationship among these organisms. Since the rock layers are "undisturbed," the top layer must have been the last one laid down. For this reason, it would be impossible for an organism whose fossils are found in layer C to have lived before, and given rise to, organisms whose fossils are found in deeper strata (A or B).

(3) All of these organisms probably evolved at the same time is not a correct statement about the relationship among these organisms. Given the long time frame required for the deposition of sedimentary rock, it is unlikely that all three of these organisms could have lived at the same time.

2. 3 Comparative embryology is often used to assess the degree of similarity between two species. The more similar two organisms are in terms of their embryological development, the more closely related they are assumed to be. This assessment can, and often does, point to the likelihood that they share a common ancestry.

Wrong Choices Explained

(1) Birds and reptiles are assigned to different genera. Therefore, they cannot belong to the same species.

(2) Species do not have to be closely related to be adapted for life in the same habitat. An example of this phenomenon is cacti and snakes that live successfully in the desert.

(4) The embryos of birds and reptiles show marked similarities. Neither is an animal-like protist. Rather, they are members of closely related vertebrate genera.

3. 1 Modern evolutionary theory borrows a great deal from the work of Charles Darwin. In

addition, it uses the discoveries of geneticists of the 20th century in the areas of genetic inheritance and gene mutation to shed light on the mechanisms of the evolutionary process. As a result of this work, we now know that variations are the result of mutations and gene recombination.

Wrong Choices Explained

(2) Overproduction of organisms leads to extinction is not a concept included in modern theories of evolution. Overpopulation can be a serious problem for species. However, by itself, it rarely results in the extinction of a species since natural checks and balances tend to keep species population growth under control.

(3) Variations exist only in large populations is not a correct statement. Variations are not limited to large populations but exist in all populations, small and large.

(4) Competition occurs only between members of the same species is not a correct statement. Competition for environmental resources is not limited to members of the same species but occurs both between different species and within a single species.

4. 1 The concept of organic evolution is illustrated by these diagrams. Organic evolution refers to the mechanism thought to govern the changes in living things over geologic time. The diagram illustrates the physical changes that have occurred within the horse family over 60 million years, based on the fossil record.

Wrong Choices Explained

(2) Ecological succession refers to the changes that occur in ecological communities over long periods of time. It is not used to describe evolutionary change within a species and is not referenced in this diagram.

(3) Intermediate inheritance is used to describe a pattern of genetic inheritance in which the contrasting traits controlled by an allele pair blend to produce an intermediate phenotype. No reference is made to this pattern of inheritance in the diagram.

(4) Geographical isolation is used to describe situations in which species populations are separated by physical barriers (such as oceans, mountains, or canyons). This separation tends to promote variation leading to speciation. No geographical isolation can be inferred from this diagram.

5. 4 When long periods of evolutionary stability (equilibrium) are interrupted by relatively short periods of rapid evolutionary change (punctuation), the pattern of evolution is referred to as punctuated equilibrium.

Wrong Choices Explained

(1) The term use and disuse refers to the evolutionary theory of Jean Lamarck, which has been largely discredited as a viable theory of evolutionary change.

(2) Reproductive isolation refers to behavioral mechanisms that can isolate two varieties of a species from interbreeding even though they may inhabit the same geographical area.

(3) The term homologous structures refers to the study of comparative anatomy that postulates that similarities in structure, regardless of function, signal common ancestry between two or more different species.

6. 2 The phenomenon illustrated in the diagram is an increase in the adaptive value of gene a. We are led to- believe that selective pressures have been brought to bear on the test species over 10 generations such that the lighter phenotype is negatively selected. This selection pressure gradually eliminates organisms displaying the light phenotype, eliminating with them a large proportion of the dominant allele A. As the frequency of allele A diminishes, the frequency of allele a increases proportionately, resulting in more organisms displaying the darker phenotype controlled by genotype aa.

Wrong Choices Explained

(1) A decrease in the adaptive value of gene a would result in an increase in the proportion of light phenotypes in this population rather than a decrease.

(3) A quick comparison of the branch at generations 1 and 10 reveals the same relative density of this population. No evidence indicates an increase in the population of this insect in this diagram.

(4) No information is given in the diagram that would lead us to believe that a decrease in the mutation rate of gene A has occurred. This situation might be caused by an increased mutation rate of A but not a decreased rate.

7. 3 Natural selection is the centerpiece of Darwin's theory of evolution. Darwin theorized that natural conditions (selection pressures) favor some varieties of a species over other varieties of the same species. As the favorable variety survives these pressures at a higher rate, its members are more readily available to produce offspring expressing the same favorable variety. In this way, Darwin thought, new and favorable varieties of a species are selected by nature to become common in the species. When carried to an extreme, these varieties can become different species surviving under different sets of environmental conditions.

Wrong Choices Explained

(1), (2) Evolution by means of the use and disuse of body structures and the transmission of acquired characteristics were central ideas expressed in the evolutionary theory of Jean Lamarck. Lamarck's theories have been largely disproved by modern science.

(4) Mutagenic agents and gene mutation as a means of creating new varieties in species were concepts unknown at the time that Darwin developed his evolutionary theory. These concepts have been developed in the context of modem science.

8. 1 The increasing need for new antibiotics to kill new, antibiotic-resistant strains of bacteria is often used as a clear example of evolution at work in the present day. Bacteria, like other living species, express many genetic variations, including resistance to the effects of antibiotics. In an environment where the presence of antibiotics is common (such as a hospital), the antibiotics act as a selection pressure that eliminates most (but not all) members of the bacterial species. A single bacterium that contains a mutation for .resistance to a particular antibiotic can reproduce millions of bacterial cells like itself in a very short time. New types of antibiotics must constantly be produced to combat these resistant strains.

Wrong Choices Explained

(2) An increasing number of individuals in the human population is an environmental problem not directly supporting the concept that evolution is occurring in the present.

(3) A decreasing number of new fossils discovered in undisturbed rock layers is not directly related to evolution occurring in living species. The discovery and study of fossils provides evidence that evolution occurred in the past.

(4) Decreasing activity of photosynthetic organisms due to warming of the atmosphere references an environmental problem not directly supporting the concept that evolution is occurring in the present.

9. 3 Similar nucleotide sequences in the genetic material of separate species provide evidence that these species may have similar evolutionary histories. Genetic material, and particularly gene sequences, are passed from generation to generation by reproduction. The more similar these sequences are, and the more sequences there are that are similar, the more closely related the species are considered to be.

Wrong Choices Explained

(1) It is extremely unlikely that these two species are evolving into the same species. The process of evolution tends to lead to greater, not less, diversity among living things.

(2) No information is presented in the question that would point to the possibility that these two species contain identical DNA. If this were the case, then they would be the same, not different, species.

(4) No information is presented in the question that would indicate that these two species have the same number of mutations. Mutations are thought to occur randomly in nature, so the likelihood that two separate species have the same number of mutations is small.

10. 4 Gradualism is a theory of evolutionary change that assumes that mutations occur at a predicable pace and the environmental pressures stay relatively constant over time. These two factors, then, result in a relatively constant rate of change of the gene pool of most species, leading to slow, gradual evolution.

Wrong Choices Explained

(1) The term punctuated equilibrium refers to a theory of evolutionary ,change in which long periods of relatively slow change are interrupted by relatively short periods of rapid evolution.

(2) Geographic isolation is a term relating to a condition (physical separation) that can promote the development of new species varieties as well as new species.

(3) Speciation is a term that relates to the change of separate varieties of a single species into two separate and distinct species.

11. 2 The relationship between the bird and moth is predator-prey. The bird is the predator of the moth and other insects that constitute its prey.

Wrong Choices Explained

(1) A producer-consumer relationship would have to involve a plant (the producer) and a herbivore (the consumer). No such relationship is indicated in the passage.

(3) A parasite-host relationship is a symbiosis between an organism (the parasite) that lives in or on another (the host) and harms it in the process. The bird and moth live separate existences in this case.

(4) An autotroph-heterotroph relationship would have to involve a plant (the autotroph) and a herbivore (the heterotroph). No such relationship is indicated in the passage.

12. They introduced industry to the at-ea. OR They built factories that produced pollution.

(NOTE: Other correct, complete-sentence responses are acceptable.)

13. Mutations change DNA, resulting in new traits. OR Crossing-over during meiosis may produce new gene combinations. OR Fertilization involves the union of sex cells from each of two parents, resulting in offspring different from either parent.

(NOTE: Other correct, complete-sentence responses are acceptable.)

Question Set 2.7 (p. 165)

1. 1 Of those shown, diagram I most clearly illustrates the process of binary fission. The diagram shows an ameba-like organism undergoing the cytoplasmic division stage of mitotic cell division. Clearly visible in each of the two forming daughter cells is a newly formed nucleus.

Wrong Choices Explained

(2) Diagram 2 illustrates a yeast cell undergoing budding. Budding is a form of asexual

reproduction characterized by mitosis followed by unequal cytoplasmic division.

(3) Diagram 3 illustrates a strawberry plant reproducing by runners. While mitotic cell division is involved in this form of reproduction, it is not binary fission.

(4) Diagram 4 illustrates a bread mold in the process of spreading spores. Spore formation is a form of asexual reproduction, but does not involve binary fission.

2. 4 Four monoploid cells normally form in a male when a primary sperm cell undergoes meiotic cell division. Meiotic cell division involves two distinct phases, the first of which reduces the number of chromosomes from diploid (2n) to monoploid (n). The second division separates homologous chromosomes into gamete cells known as sperm cells.

Wrong Choices Explained

(1), (2), (3) Each of these is a nonsense distracter. Normal cell division does not result in the combinations indicated.

3. 1 The sequence that represents the correct order of events in the development of sexually reproducing animals is fertilization -4 cleavage --> differentiation - growth. Fertilization refers to the fusion of gametes to form a zygote. Cleavage is the rapid mitotic cell division of the zygote to form a cell mass. Differentiation is a process by which the new cells begin to specialize into embryonic tissues. Growth is the increase in cell number and organism size that leads to the formation of an adult organism.

Wrong Choices Explained

(2), (3), (4) These sequences are each out of order.

4. 4 Structures E and G secrete hormones that regulate the development of secondary sex characteristics. Structure E is the male testis; structure G is the female ovary. These structures produce hormones that regulate the development of secondary sex characteristics such as production of body hair, breast enlargement, and voice and muscle tone changes in the adult human.

Wrong Choices Explained

(1) Structures A and J represent the male urinary bladder and the female urinary bladder, respectively. These structures serve to store urine prior to its controlled elimination.

(2) Structures D and H represent the male vas deferens and the female oviduct, respectively. The primary role of these structures is to transport gametes to the site of fertilization.

(3) Structures F and I represent the male scrotum and the female uterus, respectively. The scrotum surrounds the testes and provides conditions conducive to the formation and storage of sperm cells. The uterus functions to receive a fertilized egg and provide a stable environment for its development.

5. 3 The pathway followed by sperm cells implanted inside the female is K to I to H. K represents the vagina, which serves as the site for the implantation of sperm during intercourse. I represents the uterus, through which the sperm must travel to reach the egg. H represents the oviduct, within which the sperm meet the mature egg and where fertilization normally occurs.

Wrong Choices Explained

(1), (2), (4) These sequences are each out of order.

6. 2 Gametogenesis occurs within structures E and G. Structure E is the male testis; structure G is the female ovary. These structures produce sperm cells and egg cells, respectively, which are the male and female gametes involved in the process of sexual reproduction.

Wrong Choices Explained

(1) Structures A and J represent the male urinary bladder and the female urinary bladder, respectively. These structures serve to store urine prior to its controlled elimination.

(3) Structures B and I represent the male urethra and female uterus, respectively. In males, the urethra serves to guide the release of sperm cells into the female reproductive tract. The urethra also conducts urine from the urinary bladder to the environment. The uterus functions to receive a fertilized egg and provide a stable environment for its development.

(4) Structures D and H represent the male vas deferens and the female oviduct, respectively. The primary role of these structures is to transport gametes to the site of fertilization.

7. 3 Structures G and I are directly affected by hormones involved in the menstrual cycle. Structure G is the female ovary, which produces eggs throughout the period of sexual maturity in females. Structure I is the uterus, which functions to receive a fertilized egg and provide a stable environment for its development.

Wrong Choices Explained

(1) Structures C and E represent the male penis and the male testis, respectively. These structures are not affected by hormones produced in the female menstrual cycle.

(2) Structures A and D represent the male urinary bladder and the male vas deferens, respectively. These structures are not affected by hormones produced in the female menstrual cycle.

(4) Structures I and J represent the female uterus and the female urinary bladder, respectively. While the uterus is affected by the production of hormones, the urinary bladder is not similarly affected.

8. 4 When a human egg is released from the ovary, it passes directly into the oviduct for transport to the uterus.

Wrong Choices Explained

(1) The cervix is a muscular structure at the base of the uterus that keeps the developing embryo and its associated membranes within the uterus during gestation.

(2) The vagina serves as the site for the implantation of sperm during intercourse as well as the birth canal following gestation.

(3) The uterus is the organ in which the embryo implants and the placenta forms during gestation.

9. 2 The uterus periodically readies itself for implantation of a fertilized egg. The duration of the menstrual cycle is approximately 28 days. If no fertilized egg is received by the 28th day of the cycle, the uterine lining is shed in a process known as menstruation.

Wrong Choices Explained

(1) Ovulation is the process by which a mature egg cell is released from the ovarian follicle once every 28 days in the menstrual cycle.

(3) The follicle stage of the menstrual cycle is the 14-day period, immediately prior to ovulation, in which the egg undergoes maturation inside the ovarian follicle.

(4) The corpus luteum stage of the menstrual cycle is the 8- to 10-day period, immediately following ovulation, in which the cells of the follicle transform into the corpus luteum for the production of progesterone.

10. 1 The sequence D --> B -4 C - A provides for follicle stage (D), followed by ovulation (B), followed by corpus luteum stage (C), followed by menstruation (A).

Wrong Choices Explained

(2), (3), (4) These are nonsense distracters whose sequences do not coincide with any known reproductive cycle.

11. 3 The fluid acts as a transport medium for sperm. This fluid is known as semen. Its primary function is to provide a protective watery medium for the sperm cells as they enter the female reproductive tract.

Wrong Choices Explained

(1) Removes polar bodies from the surface of the sperm is a nonsense distracter. Polar bodies are not associated with sperm production.

(2) Activates the egg nucleus so that it begins to divide is not an advantage of this fluid medium. The egg is stimulated to divide by the act of fertilization. Semen is not directly involved in this

process.

(4) Provides currents that propel the egg down the oviduct is not an advantage of this fluid medium. Cilia that line the oviduct are responsible for establishing fluid currents that both carry the egg downward toward the uterus and carry sperm upward toward the ovary. Semen is not directly involved in this process.

12. 4 The placenta is the structure through which substances can diffuse from the mother's blood into the fetal blood. This structure forms in the uterus and establishes a physical link between the maternal and fetal tissues.

Wrong Choices Explained

(1) The amnion is a membrane that immediately surrounds the developing embryo and provides a watery environment during development.

(2) The fallopian tube, also known as the oviduct, is the site of fertilization and early development (cleavage).

(3) The yolk sac provides nutrition for the human embryo during the very early stages of development, before the placenta is formed. It deteriorates as soon as the placental connection is established.

13. 1 Stage 11 shows the first appearance of the mesoderm layer, which can be seen as a group of cells lying between the outer ectoderm layer and inner endoderm layer. The mesoderm will eventually give rise to many of the body's internal organs, including muscle, bone, and circulatory structures.

Wrong Choices Explained

(2) Stage 8 represents the blastula stage of embryonic development, characterized by a hollowing of the cell mass created by the cleavage divisions. No cell specialization is present at this stage.

(3) Stage 6 represents the cell mass resulting from five consecutive cleavage divisions. No cell specialization is present at this stage.

(4) Stage 4 represents the cell mass resulting from three consecutive cleavage divisions. No cell specialization is present at this stage.

14. 3 The oviduct is normally the site of the first several cleavage divisions. Cleavage follows fertilization and precedes implantation of the embryo in the uterus.

Wrong Choices Explained

(1) The ovary is the site of egg formation and the process of ovulation. The released egg is carried

along the oviduct toward the uterus.

(2) The vagina is the site of sperm implantation during intercourse. Sperm cells must swim through the female tract until they contact the egg within the oviduct.

(4) The uterus is the site of embryo implantation and fetal development.

15. 1 Gametogenesis and fertilization most immediately precede the sequence of developmental stages represented in the diagram. Gametogenesis is the process by which sperm cells and egg cells are produced in the testes and ovaries, respectively. Fertilization is the fusion of egg cell and sperm cell nuclei within the female tract.

Wrong Choices Explained

(2) Menstruation and menopause do not most directly precede this sequence of developmental stages. Menstruation is the shedding of the uterine lining that occurs when an egg is not fertilized. Menopause is the cessation of the menstrual cycle that occurs in most females at about age 50.

(3) Prenatal development and gestation do not most directly precede this sequence of developmental stages. Prenatal development refers to the entire developmental process, encompassing this sequence of stages up to birth. Gestation refers to the 9-month period during which prenatal development occurs in humans.

(4) Placental formation and metamorphosis do not most directly precede this sequence of developmental stages. Placental formation is an event that follows, rather than precedes, this sequence of stages. The placenta forms a connection between mother and fetus during gestation. Metamorphosis is a term relating to development in insects, not humans.

16. The data in the tables do support the scientists' claim. The measurements of newborns of drinkers are uniformly lower than those of nondrinkers, including shorter gestation periods (4.7% shorter), lower birth weight (17.4% lower), less length (6.6% shorter), and smaller head size (7.0% smaller).

(NOTE: Any correct, complete-sentence response is acceptable.)

17. The data are based on a relatively small sample size of 40 drinkers, so additional data is needed.

(NOTE: Any correct, complete-sentence response is acceptable.)

18. Embryological tissues are very sensitive to chemical changes in the uterus. The younger and more highly undifferentiated fetal tissues are, the more they can be affected by chemicals in their environment.

(NOTE: Any correct, complete-sentence response is acceptable.)

19. Sample essay: "Sexual and asexual reproduction are alike in that they both result in the production of new organisms from a parent or parents. They are unlike in that asexual reproduction results in offspring that have no genetic variation from the parent, while sexual reproduction allows a mixing of new traits each time an offspring is produced. This is due to the fact that in sexual reproduction, two monoploid sex cells fuse, each carrying half of each parent's genetic information. The resulting zygote contains a unique combination of traits.

"Examples of organisms that reproduce asexually include the ameba, hydra, yeast, and planaria worm. Organisms that reproduce sexually include earthworms, humans, and flowering plants."

(NOTE: Any essay that correctly addresses the points required in the question is acceptable.)

Question Set 2.8 (p. 184)

1. 2 Living matter is able to control chemical activities with organic catalysts. The controlled chemical activity in living matter is one of the distinguishing characteristics of life. Enzymes (organic catalysts) are principally responsible for controlling this chemical activity, enabling reactions to occur under conditions found in the cell.

Wrong Choices Explained

(1) Living matter is unable to diffuse materials is not a true statement. Diffusion is a process by which molecules of a substance move from a region of higher concentration to a region of lower concentration of that substance. It occurs naturally in many living and nonliving systems and does not depend on living things for its operation.

(3) Living matter is able to create energy is not a true statement. Scientists theorize that the amount of energy in the universe is fixed and is neither created nor destroyed but only transferred from one form to another. Energy, although essential to the survival of living things, cannot be created by them.

(4) Living matter is unable to use energy for metabolic activities is not a true statement. The life function of respiration is involved with the transfer of chemical bond energy in foods (such as glucose) to molecules of ATP. The energy in ATP is subsequently used by the cell as a controlled source of energy to run cellular reactions (metabolism). Respiration is common to all known life-forms.

2. 2 The nutritional process illustrated by the equation A + C -4 A + B + D is photosynthesis. The carbon-fixation reactions combine the atoms of hydrogen, oxygen, and carbon found in water (A) and carbon dioxide (C) into molecules of glucose (B); Water (A) and oxygen (D) are by-products of this autotrophic nutritional process. Water (A) is both a reactant in and a product of this process.

Wrong Choices Explained

(1) The equation B + D -> A + C illustrates the process of aerobic respiration, which involves the

same substances as does photosynthesis but is its chemical opposite.

(3), (4) These equations, B + C ---> A + D and A + B + D -~ B + C, are nonsense equations that cannot occur either in nature or in the laboratory.

3. 4 B and D represent chemicals needed for cellular respiration. Glucose (B) is combined with oxygen (D) to release energy for use in the cell. This is a process carried on by both animals and plants.

Wrong Choices Explained

(1) The substances water (A) and carbon dioxide (C) are reactants in the process of photosynthesis, the chemical opposite of aerobic respiration.

(2), (3) The combinations of substances in these distracters are nonsense combinations that would rarely, if ever, occur in nature.

4. 2 Respiration involves chemical reactions in which food molecules (such as glucose) are broken down and molecular energy is released to form molecules of adenosine triphosphate (ATP). This process is carried on by all known living organisms as a means of making energy available for cellular processes.

Wrong Choices Explained

(1) C6HL206 is the chemical formula for glucose, which is synthesized in the process of photosynthesis, not respiration.

(3) Alcohol is a by-product of fermentation, a type of anaerobic respiration. While it is a product of the respiratory process, it is not produced by all organisms but rather by a few specialized yeasts.

(4) Molecular oxygen is a by-product of photosynthesis, not respiration.

5. 2 When an organism reacts to a change in environmental conditions, its reaction is known as a response. The brine shrimp discussed in this paragraph respond to a change in light conditions by moving toward the light, a nervous response. Response to environmental stimuli is a characteristic of regulation.

Wrong Choices Explained

(1) Negative feedback is a concept normally associated with hormonal regulation in animals. Hormonal negative feedback is not normally associated with simple nervous responses such as the one discussed in the paragraph.

(3) A stimulus is defined as an environmental change that results in a response by an organism. In this paragraph, the stimulus is the change in light conditions.

(4) Active transport is a process by which materials may be actively moved into or out of a cell through the expenditure of energy. The life function associated with active transport is that of transport.

6. 1 An examination of graph A shows that, from a temperature of 0°C to a temperature of 38°C, enzyme action tends to increase at a fairly steady pace. Once the temperature of 40°C is reached, however, the rate of enzyme action begins to decrease rapidly, indicating that the enzyme molecules in the system are being destroyed through the irreversible process of denaturation.

Wrong Choices Explained

(2) Graph A shows that the rate of enzyme action is approximately 50% of optimum at 23°C.

(3), (4) Graph B shows that, at least for the human stomach enzyme pepsin, the rate of enzyme action is near optimum at pH 2 and pH 3.

7. 2 The measure of acidity or basicity used in the biology laboratory is pH (concentration of hydrogen ion). Graph B is clearly labeled as a representation of the effect of pH on enzyme action.

Wrong Choices Explained

(1) Graph A represents the effect of temperature on the rate of enzyme action.

(3) Graph C represents the effect of enzyme concentration on the rate of enzyme action.

(4) Graph D represents the effect of substrate concentration on the rate of enzyme action.

8. 2 The equation represents those steps in photosynthesis known as the carbon-fixation reactions. Prior to these reactions, water (H2O) is split into hydrogen and oxygen in the reaction known as photolysis, making water the most likely source of hydrogen for this equation.

Wrong Choices Explained

(1), (3) PGAL (phosphoglyceraldehyde) is the intermediate and glucose (C6H12O6) the final molecular product resulting from this process. These molecules are the recipients, not the sources, of the hydrogen represented in the equation.

(4) ATP (adenosine triphosphate) is a specialized molecule that provides energy for many cellular reactions, including this one. However, it does not serve as a source of hydrogen for these reactions.

9. 4 The cell organelle indicated as structure D is a chloroplast. The chloroplast is the site of the photosynthetic reactions, including photolysis and carbon-fixation reactions.

Wrong Choices Explained

(1) Structure A represents a plant cell nucleus, which is involved in cell regulation.

(2) Structure B represents the cytoplasm, which provides a watery medium for cell activities.

(3) Structure C represents a food vacuole, which is involved in storage of manufactured starch.

10. In active immunity, the body is stimulated to mount its own defenses against foreign antigens in the blood. These foreign antigens can be acquired naturally, by contracting a disease, or introduced artificially by inoculation with a vaccine. Active immunity is usually long lasting.

Wrong Choices Explained

Passive immunity is acquired when antibodies produced in another organism are introduced into the blood via injection. Passive immunity is usually short-lived.

Allergies arise in response to specific foreign antigens. The body responds to these antigens by releasing chemicals known as histamines, which in turn affect the body by causing headaches, runny nose, watery eyes, and a variety of other symptoms.

Tissue rejection is used to describe the reaction of a host organism to a transplanted tissue or organ from a donor organism. If the antigens of the host and those of the donor do not closely match, the host may reject the transplanted tissues in a process similar to that associated with natural active immunity.

11. Allergies arise in response to specific foreign antigens. The body responds to these antigens by releasing chemicals known as histamines, which in turn affect the body by causing headaches, runny nose, watery eyes, and a variety of other symptoms.

Wrong Choices Explained

See question 10.

12. 2 The human disorder known as anemia is associated with insufficient amounts of hemoglobin, the oxygen-carrying compound in red blood cells. Anemia sufferers usually tire quickly due to insufficient amounts of oxygen reaching body tissues.

Wrong Choices Explained

(1) Angina pectoris refers to chronic chest pain caused by insufficient oxygen reaching the heart muscle. Angina is usually associated with narrowing of the coronary arteries due to cholesterol buildup on the artery walls.

(3) Coronary thrombosis, commonly known as heart attack, is an acute disorder of the circulatory system resulting from complete blockage of the coronary artery.

(4) High blood pressure is a chronic disorder of the circulatory system, which may result from the gradual narrowing of arterial vessels throughout the body.

13. 4 A lack of iodine in the diet, which has caused the development of a goiter is the correct response. Goiter is often associated with diets insuffi cient in iodine, an element essential to the operation of the thyroid gland located in the throat. Without iodine, the thyroid enlarges, producing the swelling described in the question.

Wrong Choices Explained

(1), (2), (3) An excess of calcium in the diet, which has caused a muscle deformity, deposits of fat under the skin caused by a vegetable diet, and inherited neck deformities caused by elevated environmental temperatures are all nonsense distracters that relate to no known human disorders.

14. 4 Glucose is the principal product of photosynthesis. Glucose may be metabolized into more complex carbohydrates by dehydration synthesis, a chemical process occurring in plant cells that produces starch, cellulose, and other complex carbohydrates.

Wrong Choices Explained

(1), (2) Starch and protein can result from dehydration synthesis of smaller molecular units. Dehydration synthesis results in more complex, not less complex, molecular by-products.

(3) Glycerol, a component of certain fat molecules, cannot be synthesized into complex carbohydrates.

15. 1 The graphs indicate that this enzyme works best at a temperature of 35°C and a pH of 8. The temperature graph clearly shows the high point of the graph directly at the midpoint between 30°C and 40°C, while the pH graph shows the optimum pH at 8.

Wrong Choices Explained

(2), (4) The statements this enzyme works best at a temperature of 50°C and a pH of 12 and this enzyme works best at a temperature above 50°C and a pH above 12 are not supported by the information in the graphs. The graphs show that the rate of enzyme activity drops off drastically above 40°C and above pH 9.

(3) The statement temperature and pH have no effect on the action of this enzyme is incorrect. The graphs clearly show that the rate of enzyme activity varies greatly when these two variables are manipulated.

16. 4 Of those given, the statement it reduces the amount of raw material reaching the active site of the enzyme that produces prostaglandins most correctly describes how aspirin acts to reduce flu symptoms. In the second paragraph, the article describes how aspirin blocks a critical area of the enzyme that manufactures prostaglandins, preventing the raw materials used in its manufacture from reaching the active site of the enzyme.

Wrong Choices Explained

(1), (2), (3) These statements are not supported by the information given in the article. Close reading of the article is necessary to eliminate these distracters.

17. 1 Of those given, the statement it interferes with the activity of an enzyme that helps to protect the stomach most accurately describes how aspirin can irritate the stomach of some people. In the third paragraph, aspirin's effect on the stomach-protecting enzyme PGHS-1 is discussed. By completely blocking this enzyme, stomach-protecting substances cannot be manufactured, and stomach irritation can result.

Wrong Choices Explained

(2), (3, (4) These statements are not supported by the information given in the article. Close reading of the article is necessary to eliminate these distracters.

18. 2 The molecule is a crystal with a tube running up the middle of it. (Other correct, complete-sentence responses are acceptable.)

Wrong Choices Explained

Students should take care to give their responses in biologically accurate, complete-sentence format, including a subject, predicate, and appropriate punctuation. Responses that do not meet these basic criteria cannot be considered for credit.

19. The willow tree bark contains salicylic acid, which is similar to acetylsalicylic acid, the active ingredient in aspirin.

(Other correct, complete-sentence responses are acceptable.)

Wrong Choices Explained

Students should take care to give their responses in biologically accurate, complete-sentence format, including a subject, predicate, and appropriate punctuation. Responses that do not meet these basic criteria cannot be considered for credit.

20. 2 Cancer is characterized by abnormal cells that suddenly begin to undergo cell division at a very rapid rate. A cancerous cell can produce a mass of abnormal cells in a relatively short time, crowding out normal tissues.

Wrong Choices Explained

(1) Albinism is a genetic condition, controlled by a single mutant somatic gene, in which the skin lacks the ability to produce pigments.

(3) Hemophilia is a genetic condition, controlled by a single mutant sexlinked gene, in which the blood lacks the ability to produce clotting factors.

(4) Color blindness is a genetic condition, controlled by a single mutant sex-linked gene, in which the eyes lacks the ability to produce proteins necessary for recognizing certain colors.

21. 3 Asthma is a disorder in humans characterized by constricted airways due to the presence of an irritant. Asthma can be life-threatening if not properly treated.

Wrong Choices Explained

(1) Coronary thrombosis is a human disorder in which the heart muscle becomes damaged due to blockage of the coronary artery.

(2) Arthritis is a human disorder in which skeletal joints become inflamed, swollen, and painful.

(4) Emphysema is a human disorder in which lung tissue deteriorates, leaving the lung inefficient at absorbing oxygen.

22. 4 A lack of essential amino acids in the diet is the most likely cause of the condition described in the passage. Because breast milk contains proteins produced by the mother's own body, it will contain the correct balance of amino acids needed by the infant for proper growth. When the diet is changed to cereal, mainly carbohydrates, these proteins are no longer available to the child. As a result, the child is not able to obtain essential amino acids for its own cells to synthesize proteins.

Wrong Choices Explained

(1) Too many nucleic acids in the diet is not the likely cause of these symptoms. Nucleic acids are manufactured in the cell nucleus from free nucleotides. They are not found in large quantities in cereal grains.

(2) An overconsumption of complete protein foods is not the likely cause of these symptoms. The disorder is described as a protein deficiency in the passage. Overconsumption of complete protein foods would lead to an abundance, not a deficiency, of protein in the body.

(3) Not enough carbohydrates in the diet is not the likely cause of these symptoms. Cereal grains contain large concentrations of carbohydrates, which provide an energy source but relatively small quantities of protein.

23. 2 Cell type B would be fewer in number and lighter in appearance is the statement that best describes the changes observed in the blood of a person with anemia, assuming all other variables are kept constant. The cells labeled B are red blood cells, which contain the red oxygen-carrying pigment hemoglobin. A person with anemia cannot produce hemoglobin efficiently, so red blood cell production drops. The red blood cells that are produced may contain less hemoglobin than those of a person without this condition.

Wrong Choices Explained

(1), (4) Cell type A would be fewer in number and larger in size and cell type A would he larger in size and darker in appearance are not correct responses. The cell labeled A is a white blood cell. White blood cells lack hemoglobin and so would be unaffected by the anemic condition.

(3) Cell type B would be larger in size and greater in number is not the correct response. Cell size would be unaffected by anemia. The cells' appearance would be lighter, not darker, due to the lack of sufficient hemoglobin.

24. The experimental group and control group should be set up identically, except that the control group should receive a placebo rather than a dose of Lowervil. OR All parts of the experiment have to be the same except that the control group does not receive the drug.

(NOTE: Any correct, complete-sentence answer is acceptable.)

25. Using a large number in the experiment in order to eliminate bias is important. OR If the experiment is run with a small number of subjects, then statistical significance will be difficult to measure.

(NOTE: Any correct, complete-sentence answer is acceptable.)

26. The researcher should carefully measure the blood pressure of both experimental and control subjects before and after the administration of the drug. OR The researcher should establish a baseline blood pressure for each participant in the study then monitor blood pressure changes after administration of the drug or placebo.

(NOTE: Any correct, complete-sentence answer is acceptable.)

27. Veins and arteries may be blocked and tissue damage may result. OR The body may reject the new organ.

(NOTE: Any correct, complete-sentence answer is acceptable.)

28. A transplant patient might take an immunosuppressant drug in order to prevent the rejection of the new organ or tissue.

(NOTE: Any correct, complete-sentence answer is acceptable.)

29. The drug may weaken the patient's ability to fight diseases. OR The drug may leave the patient less able to fight infection.

(NOTE: Any correct, complete-sentence answer is acceptable.)

30. Tissues or organs grown from stem cells of the patient would not be rejected by the patient's immune system. OR Organs produced by this process would not be foreign material and would not be attacked by the patient's immune system.

(NOTE: Any correct, complete-sentence answer is acceptable.)

Question Set 2.9 (p. 214)

1. 4 From the information given in the diagram, the statement that best describes some organisms in the food web illustrated is raccoons, fish, and ducks are secondary consumers. Each of these organisms is shown consuming another organism that is either itself a primary or secondary consumer.

Wrong Choices Explained

(1) The statement minnows and fish are primary consumers is not supported by the information in the diagram. Fish are shown consuming aquatic crustaceans, which are primary consumers.

(2) The statement algae and floating plants are decomposers is not supported by information given in the diagram. Algae and floating plants are producers.

(3) The statement aquatic crustaceans are omnivores is unsupported by the information in the diagram. Aquatic crustaceans are shown consuming only plant matter.

2. 2 Of the statements given, population B competed more successfully for food than population A did best describes the data shown in the graph. We are led to believe that populations A and B inhabit the same environmental niche and compete for the same food supply in their range. Over time, these two stable populations undergo a significant change, perhaps in the face of a sudden reduction in available food supply. As a result of this change, population A is virtually eliminated, while population B increases in number.

Wrong Choices Explained

(1) The statement all of the plant populations in this habitat decreased is not supported by the data. While some of the plant populations likely decreased, assuming that all plant populations decreased is unreasonable.

(3) The statement population A produced more offspring than population B did is false. The data shows population B increasing in number, indicating that many offspring are being produced. At the same time, we see population A decreasing in number, indicating a reduced rate of reproductive activity.

(4) The statement population A consumed the members of population B is false. The question states that these populations are herbivores, so A would not consume members of B. Also, if A had consumed B, then we would expect that B would decrease in relation to A, but this is not the case.

3. 1 The tundra is a biome characterized by very cold average temperatures such that the subsoil is permanently frozen. Because of the lack of soil moisture, only surface plants such as lichens and mosses have a chance for survival.

Wrong Choices Explained

(2) The taiga is a biome characterized by cool average temperatures. Coniferous forests are common, as are caribou and moose.

(3) The temperate deciduous forest biome is characterized by moderate average temperatures, good rainfall, broadleaf (deciduous) forests, and index animals such as deer and squirrels.

(4) The grassland biome is characterized by moderate average temperatures, low rainfall, grassy prairies, and index animals including bison and prairie dogs.

(5) The desert biome is characterized by wide variations in daily temperature, little rainfall, sagebrush and cactus, and index animals such as roadrunners, coyotes, and rattlesnakes.

(6) The tropical forest biome is characterized by high average temperature, abundant rainfall, dense tropical forests, and index animals such as the parrot and monkey.

4. 6 The tropical forest biome is characterized by high average temperature, abundant rainfall, dense tropical forests, and index animals such as the parrot and monkey.

Wrong Choices Explained

(1), (2), (3), (4), (5) See question 3.

5. 5 The desert biome is characterized by wide variations in daily temperature, little rainfall, sagebrush and cactus, and index animals such as roadrunners, coyotes, and rattlesnakes.

Wrong Choices Explained

(1), (2), (3), (4), (6) See question 3.

6. 2 Because a number of different types of organisms are present, both plant and animal species, this diagram illustrates the level of ecological organization known as a community.

Wrong Choices Explained

(1) The term biosphere refers to the entire inhabited portion of the planet, a much broader level of organization than that illustrated in the diagram.

(3) The habitat is the natural environment for a species, including both biotic and abiotic factors. This diagram illustrates only biotic factors.

(4) The biome level of ecological organization is a major grouping of large, but similar ecosystems, a much broader level of organization than is illustrated in the diagram.

7. 1 As the owl population increases, interspecies and intraspecies competition for what is

presumably a fixed food supply will increase dramatically. This food supply may be taxed beyond its ability to support the owl and hawk populations, and eventually many members of these populations would die of starvation.

Wrong Choices Explained

(2) An increase in the mouse population will benefit the hawks and owls since additional food resources will be made available. This should allow a slight increase in the owl and hawk populations over time.

(3) A decrease in the hawk population will also benefit the food supply since hawks compete with owls for a limited food supply.

(4) A decrease in the owl population will benefit the food supply since owls compete with hawks for a limited food supply.

8. 2 All the Homo sapiens living in New York State represent a population. The term "population" is used to refer to all the members of a single species inhabiting a given geographic area at a given time. The species Homo sapiens (humans) inhabiting the geographic area of New York State constitutes such a population.

Wrong Choices Explained

(1), (3), (4) All the vertebrates, plant and animal species, or flowering plants inhabiting New York State are much too broad groupings to represent a population since each of these represents multiple species.

9. 4 Temperature and oxygen content are examples of abiotic factors in the environment.

Wrong Choices Explained

(1), (2), (3) Each of these distracters references the measurement of living things, representing biotic factors. These biotic factors include scavengers, green plants and snails, and fish.

10. 3 When green plants are eaten by primary consumers that are in turn eaten by secondary consumers, energy is passed from level to level in the food chain.

Wrong Choices Explained

(1) The process of photosynthesis is involved in the food chain only to the extent that the process is responsible for capturing light energy and using it to manufacture the substances used as food by the consumers.

(2) Natural selection describes the mechanism by which favorable variations within a species are thought to be selected by natural forces to increase in frequency (and by which unfavorable traits are

gradually reduced in frequency) in a species population. The term does not relate to this question.

(4) Ecological succession refers to the changes that occur in ecological communities over long periods of time. The term does not relate to this question.

11. 2 The nitrogen cycle depends primarily on various chemical and biological processes associated with the metabolism of nitrogen compounds. Plant and animal nitrogenous wastes are processed by a variety of soil bacteria specialized for this task. None of the processes mentioned deal primarily with the metabolism of nitrogen compounds.

Wrong Choices Explained

(1), (4) The carbon-hydrogen-oxygen cycle is very much associated with the processes of photosynthesis and respiration, which function to recycle these elements through the environment as complementary biological processes.

(3) The water cycle depends on the physical processes of transpiration, evaporation, and condensation to operate in nature.

12. **3** The tapeworm's association with the human is harmful to the human because nutrients are removed by the tapeworm before they can be absorbed by the intestine. Therefore the relationship is one of *parasitism* (+, –).

Wrong Choices Explained

(1) Commensalism is a symbiotic relationship in which the host organism is not harmed but the other organism is benefited (0, +).

(2) Mutualism is a symbiotic relationship in which both organisms in the relationship are benefited (+, +).

13. 2 The bacteria use the legume as a site from which to carry on their metabolic activities; the legume utilizes nutrients from the bacteria's activities. This relationship can be characterized as mutualism since both organisms in the relationship are benefited (+, +).

Wrong Choices Explained

(1), (3) See question 12.

14. 3 The flea's association with the dog is harmful to the dog because blood is removed from the dog by the flea, making it unavailable for the dog to use. Therefore, the relationship is one of parasitism (+, -).

Wrong Choices Explained

(1), (2) See question 12.

15. 4 Lichens - grasses -4 shrubs -4 trees represents a typical ecological succession from bare rock. Bare rock succession requires a special ized type of pioneer organism. Lichens are known for their ability to survive on bare rock and to begin the conversion of rock into soil. Lichens are succeeded by grasses that help soil building by adding organic matter to the soil. Shrubs with shallow root structures are next, followed by trees with deeper root structures.

Wrong Choices Explained

(1), (2), (3) These distracters all contain incorrect sequences of succession communities.

16. 4 This ecosystem will be self-sustaining if materials cycle between the organisms labeled A and the organisms labeled B. Organisms labeled A include the animals illustrated in the diagram; organisms labeled B include the plants. In any balanced ecosystem, materials such as carbon, hydrogen, and oxygen cycle between these two types of organisms.

Wrong Choices Explained

(1), (2) If the organisms labeled A outnumber the organisms labeled B or the organisms labeled A are equal in number to the organisms labeled B the entire ecosystem would be disrupted. In any stable ecosystem, the number and biomass of producer organisms must be greater than that of consumers.

(3) If the type of organisms represented by B are eliminated, this would represent an extreme condition that would lead to the total collapse of the ecosystem.

17. 2 Abiotic factors (nonliving factors) in the environment are necessary for the survival of living things. The abiotic materials and energy sources mentioned in the question are all essential to the survival of the plant as it carries out its life functions.

Wrong Choices Explained

(1) Biotic factors important to plants might include other living plant and animal species in the plant's environment. No biotic factors are mentioned in the statement.

(3), (4) Symbiotic relationships and carnivore-herbivore relationships always involve other living things and, as such, are biotic relationships.

18. 3 The statement decomposers release a material that is acted upon by other organisms is best represented in the diagram. The diagram shows various types of bacteria taking in nitrogen-containing compounds and releasing others after having acted upon them internally. Some of these nitrogen-containing materials are in turn acted upon by other types of organisms, such as plants and animals.

Wrong Choices Explained

(1) The statement respiration and photosynthesis are interrelated is not supported by information given in the diagram. No reference to these life processes is made in the diagram nor are their chemical reactants or products shown.

(2) The statement transpiration and condensation are related to the water cycle is not supported by information given in the diagram. No reference to these abiotic processes is made in the diagram.

(4) The statement predators and their prey are involved in many interactions is not supported by information given in the diagram. No reference to these nutritional relationships is made in the diagram.

19. 2 The statement stored energy decreases from consumer 2 to consumer 3 is correct. In any environment, the total available energy decreases with each successive step of the food chain, energy being lost as heat and motion at each exchange of food matter between levels. The biomass pyramid represents this phenomenon.

Wrong Choices Explained

(1) The statement the producer organisms contain the least amount of stored energy is not correct. In fact, the producer level of the biomass pyramid contains the most energy of any level.

(3) The statement consumer 3 contains the greatest amount of stored energy is not correct. In fact, the top consumer level of the biomass pyramid contains the least energy of any level.

(4) The statement stored energy increases from the producer to consumer 1 is not correct. In fact, the total amount of stored energy decreases in the biomass pyramid from producer to any consumer level.

20. 2 The statement it persists until the environment changes is correct. The climax stage is the the final stage of succession. It is characterized by a self-perpetuating community of plant and animal species. When the environment changes drastically and the climax community is disturbed, the process of succession may begin again.

Wrong Choices Explained

(1) The statement it changes rapidly is incorrect. In fact, the climax community displays a marked stability over long periods of time.

(3) The statement it is the first community to inhabit an area is incorrect. The first community to inhabit an area is known as the pioneer community.

(4) The statement it consists entirely of plants is not correct. Stable climax communities are characterized by the diversity of plant and animal life that inhabit them.

21. 4 Of the choices given, an increase in sediment, fallen leaves, and tree limbs accumulating in

the bottom of the pond would most likely lead to terrestrial succession. As these materials build up on the pond bottom, pond water is displaced and becomes gradually shallower. Eventually, terrestrial plants will gain a foothold on this moist organic mat and terrestrial succession will begin.

Wrong Choices Explained

(1) A decrease in the number of suspended particles in the pond water would not tend to speed the rate of terrestrial succession of a pond. The sedimentation rate would decrease and water displacement would slow.

(2) An increase in current velocity of the pond water would not tend to speed the rate of sediment buildup in the pond. Suspended particles and accumulated sediment could be more readily washed away.

(3) A decrease in the number of diverse organisms in the shallow water of the pond would signal a decline in biological activity in the pond. This might lead to a decrease in the rate of organic matter deposition in the pond, thereby slowing the rate of filling and the rate of terrestrial succession.

22. 2 Competition between the squirrels is the most likely result when resources are limited. This may result in a reduction in the squirrel population over time to bring the natural community back into proper balance.

Wrong Choices Explained

(1) An increase in the number of squirrels is not a likely result of this situation. In fact, a decrease in the population is likely to occur.

(3) Increased habitats for the squirrels is not a likely result of this situation. The habitat is limited to the areas capable of supporting the population. These areas will be unlikely to increase in the short term.

(4) A greater diversity of food for the squirrels is not a likely result of this situation. The squirrels' food requirements are most likely limited to relatively few choices. It is unlikely that the squirrels would be capable of changing them at will.

23. 4 The mouse, deer, and cricket are the primary consumers shown in the diagram. Each of these organisms is shown drawing its nutrition from plant matter, which is the main characteristic defining a primary consumer.

Wrong Choices Explained

(1), (2), (3) The mouse, snake, and hawk, the snake, hawk, and frog, and the cricket, frog,and deer are all combinations that contain organisms that are not primary consumers. The diagram shows that snakes consume mice, hawks consume mice and frogs, and frogs consume crickets.

24. 1 X--biotic factors; Y-abiotic factors is the information that belongs in areas X and Y. Biotic factors are those relating to the presence and activities of living things in the environment. Abiotic factors are those relating to the nonliving portion of the environment.

Wrong Choices Explained

(2) X-ecological relationships; Y-biotic relationships is not a correct response. The subcategories of area Y are clearly abiotic, not biotic, factors.

(3) X-abiotic factors; Y-interacting populations is not a correct response. The subcategories of area X are clearly biotic, not abiotic, factors.

(4) X-energy flow; Y-biotic factors is not a correct response. The subcategories of area Y are clearly abiotic, not biotic, factors.

25. 3 Parasitism best describes the relationship between the dogwood and the fungus. In this relationship, the parasite (fungus) is benefited (+) and the host organism (dogwood) is harmed (-).

Wrong Choices Explained

(1) Commensalism is a type of symbiosis in which one organism is helped (+) and the host organism is neither helped nor harmed (0).

(2) Mutualism is a type of symbiosis in which one organism is helped (+) and the host organism is helped as well (+).

(4) Saprophytism refers to plants and fungi that depend on decaying organic matter for their food supply.

26. Sample essay: "The organisms in this food web interact on many different nutritional levels. Producers absorb the Sun's energy and convert it to food energy. The plants are consumed by herbivores, which are then consumed by carnivores, including the wolf (or worms or fish). The energy is absorbed by the grass, is passed to the deer when the deer eats grass, and eventually reaches the wolf when the wolf consumes the deer. Decomposers are important in the food web because they recycle the materials that make up the bodies of dead organisms so that new organisms can use them."

"If the wolf population decreases, then the deer population will increase because no predator is present to limit it. As the deer population increases, its members will consume the grass at a much faster rate. After a year, the grass population will decrease as a result."

"When the farmer sprays pesticides near the pond, the pesticides will wash into the pond. Their presence there will pollute the water, killing beneficial insect and other species. The pesticide-contaminated insects will he consumed by the fish. As this occurs, the pesticide will build up in the bodies of the fish until they die or become inedible to humans."

(NOTE: Any essay that correctly addresses the points required in the question is acceptable.)

Question Set 2.10 (p. 233)

1. 1 The use of biological controls of insect pests is one of the positive effects humans have had on the environment in the past several years. In this example, the ladybugs and praying mantises represent nonharmful insects (biological controls) that prey on harmful ones.

Wrong Choices Explained

(2) This choice is a nonsense distracter since scientists do not refer to insect pests as being exploited.

(3) The term abiotic control has no explicit meaning in the context of controlling insect pests.

(4) Biocides are chemical substances toxic to living things. Their use in the environment to control insect pests can have unintended, severe negative consequences.

2. 2 Preservation of species is a major positive outcome of the measures listed in this question. Wildlife refuges enable wild animals to live in natural surroundings and to thrive without interference by humans. Game laws help to ensure that now common species will not be overhunted in the future.

Wrong Choices Explained

(1), (4) The use of biocides and exploitation of species are considered major negative aspects of human involvement in the environment. They would not result from wildlife refuges and game laws.

(3) The use of biological controls is a positive aspect of human involvement in the environment. However, it would not result from wildlife refuges and game laws.

3. 1 Protection of natural habitat is a positive effect that humans have had on their environment in the past several years. This practice has brought several species, including the American bald eagle, back from the brink of extinction.

Wrong Choices Explained

(2) Importation of food into their nesting sites is an activity that would have little positive value for the preservation of a wild species. In fact, the less interference by humans in the lives of wild species, the better for the species' ultimate survival.

(3) Preservation of other eagle species that occupy the same niche would have a negative impact on the survival of this species since interspecies competition would be made much more significant by this change.

(4) Increased use of pesticides would have a negative impact since many pesticides can interfere

with the reproductive cycles of eagles and other bird species.

4. 2 Using insecticides to kill insects that compete with humans for food is a human activity that would be more likely to have a negative impact on the environment than the other three. Insecticides contain chemicals that may be toxic to beneficial insects, amphibians, fish, and birds, among other animal species. If these chemicals enter the food chain, they may build up in concentration and eventually pose a threat to top-level feeders, including humans.

Wrong Choices Explained

(1) Using reforestation and cover cropping to control soil erosion is generally considered a positive human activity since its goal is the stabilization of soils that might otherwise erode into streams and be lost as a resource.

(3) Developing research aimed toward the preservation of endangered species is generally considered a positive human activity since its goal is the maintenance of biodiversity in the environment. Biodiversity is thought to be of vital importance in maintaining the overall health of the environment.

(4) Investigating the use of biological controls for pests is generally considered a positive human activity since its goal is using the natural enemies of these pests instead of a chemical biocide to control the pests' numbers.

5. 4 Habitat destruction is most likely to endanger species. Some organisms depend on the conditions available in relatively limited habitat zones. When these zones are disturbed or destroyed, the organisms cannot find suitable conditions elsewhere, cannot breed, and may be eliminated altogether in a very short time.

Wrong Choices Explained

(1) Cover cropping is a positive human effect on the environment. It involves planting crops on cultivated land in order to control soil erosion.

(2) Use of pollution controls is a positive human effect on the environment. It involves using techniques to limit the amount of pollution that enters our air, water, and soil resources.

(3) Use of erosion controls is a positive human effect on the environment. It involves using a variety of techniques to limit the amount of soil lost to erosion.

6. 1 Retinoid by-products may cause fetal deformities is the reason pregnant women are advised not to use medicines containing retinoids. This information is found in the third paragraph of the passage.

Wrong Choices Explained

(2) Retinoid by-products cause parasites to invade developing frogs is not supported by the passage. Parasites are mentioned in the fourth paragraph of the passage as being a possible alternate cause for the frog deformities referenced in the first and second paragraphs of the passage. The passages makes no reference to retinoids causing parasites to invade developing frogs.

(3) Retinoid by-products mimic the effects of pesticides on fetal tissue is not supported by the passage. The key word "mimic" is found in the second and third paragraphs of the passage. In the third paragraph, the passage notes that certain pesticides can mimic retinoids, but no direct reference to the effects of pesticides on fetal tissue is made.

(4) Retinoid by-products reduce abnormalities in maternal tissue is not supported by the passage. Nowhere in the passage is this statement made. In fact, the third paragraph states that pregnant women are warned not to use retinoids because of their possible deforming effect on fetal tissues.

7. 3 Other animals in the ponds containing deformed frogs did not have abnormalities is the reason some scientists argue that pesticides may not be the cause of the frog deformities. Instead, some scientists believe that the deformities may be caused by parasites of the frogs. This information is found in the fourth paragraph of the passage.

Wrong Choices Explained

(1) Pesticide use has decreased over the last four years is not supported by the passage. No statement to this effect is made in the passage.

(2) New pesticides are used in skin-care products is not supported by the passage. No statement to this effect is made in the passage.

(4) Laboratory experiments have determined that a pesticide can mimic retinoids is supported by the passage in the third paragraph. However, this fact is not used in the passage as supporting evidence that pesticides may not be the cause of the frog deformities.

8. 2 Parasites that affect frogs usually do not affect fish is a possible reason for the absence of deformed fish in the ponds that contained deformed frogs. While this is not stated explicitly in the passage, an inference to this effect may be made from the information supplied in the fourth paragraph of the passage.

Wrong Choices Explained

(1) Fish can swim away from chemicals introduced into the pond is not a possible reason for the absence of deformed fish in the ponds that contained deformed frogs. Any water-soluble chemical introduced into an aquatic environment will diffuse through the water until it reaches equal concentration everywhere in the system. Therefore, fish cannot swim away from it.

(3) Fish cannot develop deformities is not a possible reason for the absence of deformed fish in the ponds that contained deformed frogs. Any organism whose embryonic cells are assaulted by a

mutagenic chemical or parasite can develop deformities.

(4) Frogs and fish are not found in the same habitat is not a possible reason for the absence of deformed fish in the ponds that contained deformed frogs. In fact, fish and frogs are frequently found inhabiting the same aquatic habitats such as ponds, streams, and marshes.

9. 4 Factors that affect frogs may also affect other organisms is an inference that can be made from the information in the passage. The fact that pregnant women are warned against using retinoids is evidence that scientists understand that chemical substances can be harmful to all living things, especially in their developmental stages.

Wrong Choices Explained

(1) Only a few isolated incidents of frog deformities have been observed is not an inference that should be made from the information in this passage. In fact, the passage leaves the impression that many such deformities have been noted and studied over the past 4 years.

(2) If frog parasites are controlled, all frog deformities will stop is not an inference that should be made from the information in this passage. Parasites as a possible cause of frog deformities has not been firmly established by scientific research. Several possible causes for these deformities are being studied.

(3) Deformities in frogs are of little significance is not an inference that should be made from the information in this passage. In fact, scientists are sufficiently concerned about this phenomenon that significant resources are being put into researching the possible causes of the frog deformities and their relationship to human birth defects. This research has led scientists to warn pregnant women not to use substances containing retinoids or their byproducts.

10. Some pesticides mimic retinoids, which can cause deformities inside growing animals such as frogs.

(NOTE: Any correct, complete-sentence response is acceptable.)

11. Sample essay: "The Brazilian Amazon River rain forest is being destroyed by logging and agriculture. Loggers come in and strip the forest of trees, which are sold for timber. Farmers then follow and plant crops in the cleared land, selling the crops they produce. The soil in these areas is too thin and unproductive to serve as farmland for long, so new areas are continually being cleared."

"When this happens to an area of the rain forest, the environment is changed drastically. Trees are removed, which exposes the soil to drying. Understory plants cannot survive the changed conditions and die out rapidly. Animals that depend on the deep forest habitat for food and shelter are forced to migrate to other forest habitats or die from exposure or lack of food. Humans are affected because the soils in these areas quickly erode and cause silting of the rivers."

"Steps can be taken to preserve these areas from further destruction. Laws can be passed to limit the amount of forest that can be destroyed in this way in any one year. Parks and preserves can be established to ensure that sizable tracts of this habitat are never destroyed."

(NOTE: Any essay that correctly addresses the points required in the question is acceptable.)

12. Chemical herbicides may cause air or water pollution that could kill species other than the loosestrife. OR The beetle is a natural enemy of the loosestrife and so less likely to cause habitat disruption than herbicides.

(NOTE: Any correct, complete-sentence response is acceptable.)

13. The beetles might multiply and compete with native insect species. OR It is possible that the beetles could also consume native species of plants such as the cattail.

(NOTE: Any correct, complete-sentence response is acceptable.)

14. The spray may reach other areas and harm people, pets, or other animals in that area. OR The spray could kill beneficial insects.

(NOTE: Any correct, complete-sentence response is acceptable.)

15. Predators or parasites of the mosquitoes could be released into the area to control them. OR Swamp areas could be drained to reduce the breeding areas. OR Sterilized male mosquitoes could he released to mate with females to reduce the rate of reproduction.

(NOTE: Any correct, complete-sentence response is acceptable.)

16. Positive: Biological control (or draining or sterilization) means that no pesticide is released that could harm other species.

Negative: Habitat modifications could be detrimental to other species. OR Predators or parasites released could harm other species or spread disease.

(NOTE: Any correct, complete-sentence response is acceptable.)

Glossary of Prominent Scientists

Crick, Francis A 20th-century British scientist who, with James Watson, developed the first workable model of DNA structure and function.

Darwin, Charles A 19th-century British naturalist whose theory of organic evolution by natural selection forms the basis for the modem scientific theory of evolution.

Fox, Sidney A 20th-century American scientist whose experiments showed that Stanley Miller's simple chemical precursors could be joined to form more complex biochemicals.

Hardy, G. H. A 20th-century British mathematician who, with W. Weinberg, developed the Hardy-Weinberg principle of gene frequencies.

Lamarck, Jean An 18th-century French scientist who devised an early theory of organic evolution based on the concept of use and disuse.

Linnaeus, Carl An 18th-century Dutch scientist who developed the first scientific system of classification, based on similarity of structure.

Mendel, Gregor A 19th-century Austrian

monk and teacher who was the first to describe many of the fundamental concepts of genetic inheritance through his work with garden peas.

Miller, Stanley A 20th-century American scientist whose experiments showed that the simple chemical precursors of life could be produced in the laboratory.

Morgan, Thomas Hunt A 20th-century American geneticist whose pioneering work with Drosophila led to the discovery of several genetic principles, including sex linkage.

Watson, James A 20th-century American scientist who, with Francis Crick, developed the first workable model of DNA structure and function.

Weinberg, W. A 20th-century German physician who, with G. H. Hardy, developed the Hardy-Weinberg principle of gene frequencies.

Weismann, August A 19th-century German biologist who tested Lamarck's theory of use and disuse and found it to be unsupportable by scientific methods.

Glossary of Biological Terms

abiotic factor Any of several nonliving, physical conditions that affect the survival of an organism in its environment.

absorption The process by which water and dissolved solids, liquids, and gases are taken in by the cell through the cell membrane.

accessory organ In human beings, any organ that has a digestive function but is not part of the food tube. (See liver; gallbladder; pancreas.)

acid A chemical that releases hydrogen ion ($H+$) in solution with water.

acid precipitation A phenomenon in which there is thought to be an interaction between atmospheric moisture and the oxides of sulfur and nitrogen that results in rainfall with low pH values.

active immunity The immunity that develops when the body's immune system is stimulated by a disease organism or a vaccination.

active site The specific area of an enzyme molecule that links to the substrate molecule and catalyzes its metabolism.

active transport A process by which materials are absorbed or released by cells against the concentration gradient (from low to high concentration) with the expenditure of cell energy.

adaptation Any structural, biochemical, or behavioral characteristic of an organism that helps it to survive potentially harsh environmental conditions.

addition A type of chromosome mutation in which a section of a chromosome is transferred to a homologous chromosome.

adenine A nitrogenous base found in DNA and RNA molecules.

adenosine triphosphate (ATP) An organic compound that stores respiratory energy in the form of chemicalbond energy for transport from one part of the cell to another.

adrenal cortex A portion of the adrenal gland that secretes steroid hormones that regulate various aspects of blood composition.

adrenal gland An endocrine gland that produces several hormones, including adrenaline. (See adrenal cortex; adrenal medulla.)

adrenal medulla A portion of the adrenal gland that secretes the hormone adrenaline, which regulates various aspects of the body's metabolic rate.

adrenaline A hormone of the adrenal medulla that regulates general metabolic rate, the rates of heartbeat and breathing, and the conversion of glycogen to glucose.

aerobic phase of respiration The reactions of aerobic respiration in which two pyruvic acid molecules are converted to six molecules of water and six molecules of carbon dioxide.

aerobic respiration A type of respiration in which energy is released from organic molecules with the aid of oxygen.

aging A stage of postnatal development that involves differentiation, maturation, and eventual deterioration of the body's tissues.

air pollution The addition, due to technological oversight, of some unwanted factor (for example, chemical oxides, hydrocarbons, particulates) to our air resources.

albinism A condition, controlled by a single mutant gene, in which the skin lacks the ability to produce skin pigments.

alcoholic fermentation A type of anaerobic respiration in which glucose is converted to ethyl alcohol and carbon dioxide.

allantois A membrane that serves as a reservoir for wastes and as a respiratory surface for the embryos of many animal species.

allele One of a pair of genes that exist at the same location on a pair of homologous chromosomes and exert parallel control over the same genetic trait.

allergy A reaction of the body's immune system to the chemical composition of various substances.

alveolus One of many air sacs within the lung that function to absorb atmospheric gases and pass them on to the bloodstream.

amino acid An organic compound that is the component unit of proteins.

amino group A chemical group having the formula $-NH_2$ that is found as a part of all amino acid molecules.

ammonia A type of nitrogenous waste with high solubility and high toxicity.

amniocentesis A technique for detecting genetic disorders in unborn human beings in which a small amount of amniotic fluid is removed and the chromosome content of its cells analyzed. (See karyotyping.)

amnion A membrane that surrounds the embryo in many animal species and contains a fluid to protect the developing embryo from mechanical shock.

amniotic fluid The fluid within the amnion membrane that bathes the developing embryo.

amylase An enzyme specific for the hydrolysis of starch.

anaerobic phase of respiration The reactions of aerobic respiration in which glucose is converted to two pyruvic acid molecules.

anaerobic respiration A type of respiration in which energy is released from organic molecules without the aid of oxygen.

anal pore The egestive organ of the paramecium.

anemia A disorder of the human transport system in which the ability of the blood to carry oxygen is impaired usually because of reduced numbers of red blood cells.

angina pectoris A disorder of the human transport system in which chest pain

signals potential damage to the heart muscle due to narrowing of the opening of the coronary artery.

animal One of the five biological kingdoms; it includes multicellular organisms whose cells are not bounded by cell walls and that are incapable of photosynthesis (for example, human being).

Annelida A phylum of the animal kingdom whose members (annelids) include the segmented worms (for example, earthworm).

antenna A receptor organ found in many arthropods (for example, grasshopper), which is specialized for detecting chemical stimuli.

anther The portion of the stamen that produces pollen.

antibody A chemical substance produced in response to the presence of a specific antigen that neutralizes that antigen in the immune response.

antigen A chemical substance, usually a protein, recognized by the immune system as a foreign invader and that is neutralized by a specific antibody.

anus The organ of egestion of the digestive tract.

aorta The principal artery carrying blood from the heart to the body tissues.

aortic arches A specialized part of the earthworm's transport system that serves as a pumping mechanism for the blood fluid.

apical meristem A plant growth region located at the tip of the root or tip of the stem.

appendicitis A disorder of the human digestive tract in which the appendix becomes inflamed as a result of bacterial infection.

aquatic biome An ecological biome composed of many different water environments.

artery A thick-walled blood vessel that carries blood away from the heart under pressure.

arthritis A disorder of the human locomotor system in which skeletal joints become inflamed, swollen, and painful.

Arthropoda A phylum of the animal kingdom whose members (arthropods) have bodies with chitinous exoskeletons and jointed appendages (for example, grasshopper).

artificial selection A technique of plant/animal breeding in which individual organisms displaying desirable characteristics are chosen for breeding purposes.

asexual reproduction A type of reproduction in which new organisms are formed from a single parent organism.

asthma A disorder of the human respiratory system in which the respiratory tube becomes constricted by swelling brought on by some irritant.

atrium In human beings, one of the two thin-walled upper chambers of the heart that receive blood.

autonomic nervous system A subdivision of the peripheral nervous system consisting of nerves associated with automatic functions (for example, heartbeat, breathing).

autosome One of several chromosomes present in the cell that carry genes controlling "body" traits not associated with primary and secondary sex characteristics.

autotroph An organism capable of carrying on autotrophic nutrition. Selffeeder.

autotrophic nutrition A type of nutrition in which organisms manufacture their own organic foods from inorganic raw materials.

auxin A biochemical substance, a plant hormone, produced by plants that regulates growth patterns.

axon An elongated portion of a neuron that conducts nerve impulses, usually away from the cell body of the neuron.

base A chemical that releases hydroxyl ion (OH-) in solution with water.

bicarbonate ion The chemical formed in the blood plasma when carbon dioxide is absorbed from body tissues.

bile In human beings, a secretion of the liver that is stored in the gallbladder and that emulsifies fats.

binary fission A type of cell division in which mitosis is followed by equal cytoplasmic division.

binomial nomenclature A system of naming used in biological classification that consists of the genus and species names (for example, Homo sapiens).

biocide use The use of pesticides that eliminate one undesirable organism but that have, due to technological oversight, unanticipated effects on beneficial species as well.

biological controls The use of natural enemies of various agricultural pests for pest control, thereby eliminating the need for biocide use-a positive aspect of human involvement with the environment.

biomass The total mass of living material present at the various trophic levels in a food chain.

biome A major geographical grouping of similar ecosystems, usually named for the climax flora in the region (for example, Northeast Deciduous Forest).

biosphere The portion of the earth in which living things exist, including all land and water environments.

biotic factor Any of several conditions associated with life and living things that affect the survival of living things in the environment.

birth In placental mammals, a stage of embryonic development in which the baby passes through the vaginal canal to outside of the mother's body.

blastula In certain animals, a stage of embryonic development in which the embryo resembles a hollow ball of undifferentiated cells.

blood The complex fluid tissue that functions to transport nutrients and respiratory gases to all parts of the body.

blood typing An application of the study of immunity in which the blood of a person is characterized by its antigen composition.

bone A tissue that provides mechanical support and protection for bodily organs and levers for the body's locomotive activities.

Bowman's capsule A cup-shaped portion of the nephron responsible for filtering of soluble blood components.

brain An organ of the central nervous system responsible for regulating conscious and much unconscious activity in the body.

breathing A mechanical process by which air is forced into the lung by means of muscular contraction of the diaphragm and rib muscles.

bronchiole One of several subdivisions of the bronchi that penetrate the lung interior and terminate in alveoli.

bronchitis A disorder of the human respiratory system in which the bronchi become inflamed.

bronchus One of the two major subdivisions of the breathing tube; the bronchi are ringed with cartilage and conduct air from the trachea to the lung interior.

Bryophyta A phylum of the plant kingdom that consists of organisms lacking vascular tissues (for example, moss).

budding A type of asexual reproduction in which mitosis is followed by unequal cytoplasmic division.

bulb A type of vegetative propagation in which a plant bulb produces new bulbs that may be established as independent organisms with identical characteristics.

cambium The lateral meristem tissue in woody plants responsible for annual growth in stem diameter.

cancer Any of a number of conditions characterized by rapid, abnormal, and uncontrolled division of affected cells.

capillary A very small, thin-walled blood vessel that connects an artery to a vein and through which all absorption into the blood fluid occurs.

carbohydrate An organic compound composed of carbon, hydrogen, and oxygen in a 1:2:1 ratio (for example, C6H1 206).

carbon-fixation reactions A set of biochemical reactions in photosynthesis in which hydrogen atoms are combined with carbon and oxygen atoms to form PGAL and glucose.

carbon 14 A radioactive isotope of carbon used to trace the movement of carbon in various biochemical reactions, and also used in the carbon dating of fossils.

carbon-hydrogen-oxygen cycle A process by which these three elements are made available for use by other organisms through the chemical reactions of respiration and photosynthesis.

carboxyl group A chemical group having the formula -000H and found as part of all amino acid and fatty acid molecules.

cardiac muscle A type of muscle tissue in the heart and arteries associated with the rhythmic nature of the pulse and heartbeat.

cardiovascular disease In human beings, any disease of the circulatory organs.

carnivore A heterotrophic organism that consumes animal tissue as its primary source of nutrition.

(See secondary consumer.)

carrier An individual who, though not expressing a particular recessive trait, carries this gene as part of his/her heterozygous genotype.

carrier protein A specialized molecule embedded in the cell membrane that aids the movement of materials across the membrane.

cartilage A flexible connective tissue found in many flexible parts of the body (for example, knee); common in the embryonic stages of development.

catalyst Any substance that speeds up or slows down the rate of a chemical reaction. (See enzyme.)

cell plate A structure that forms during cytoplasmic division in plant cells and serves to separate the cytoplasm into two roughly equal parts.

cell theory A scientific theory that states, "All cells arise from previously existing cells" and "Cells are the unit of structure and function of living things."

cell wall A cell organelle that surrounds and gives structural support to plant cells; cell walls are composed of cellulose.

central nervous system The portion of the vertebrate nervous system that consists of the brain and the spinal cord.

centriole A cell organelle found in animal cells that functions in the process of cell division.

centromere The area of attachment of two chromatids in a double-stranded chromosome.

cerebellum The portion of the human brain responsible for the coordination of muscular activity.

cerebral hemorrhage A disorder of the human regulatory system in which a broken blood vessel in the brain may result in severe dysfunction or death.

cerebral palsy A disorder of the human regulatory system in which the motor and speech centers of the brain are impaired.

cerebrum The portion of the human brain responsible for thought, reasoning, sense interpretation, learning, and other conscious activities.

cervix A structure that bounds the lower end of the uterus and through which sperm must pass in order to fertilize the egg.

chemical digestion The process by which nutrient molecules are converted by chemical means into a form usable by the cells.

chemosynthesis A type of autotrophic nutrition in which certain bacteria use the energy of chemical oxidation to convert inorganic raw materials to organic food molecules.

chitin A polysaccharide substance that forms the exoskeleton of the grasshopper and other arthropods.

chlorophyll A green pigment in plant cells that absorbs sunlight and makes possible certain aspects of the photosynthetic process.

chloroplast A cell organelle found in plant cells that contains chlorophyll and functions in photosynthesis.

Chordata A phylum of the animal kingdom whose members (chordates) have internal skeletons made of cartilage and/or bone (for example, human being).

chorion A membrane that surrounds all other embryonic membranes in many animal species, protecting them from mechanical damage.

chromatid One strand of a doublestranded chromosome.

chromosome mutation An alteration in the structure of a chromosome involving many genes. (See nondisjunction; translocation; addition; deletion.)

Cilia Small, hairlike structures in paramecia and other unicellular organisms that aid in nutrition and locomotion.

classification A technique by which scientists sort, group, and name organisms for easier study.

cleavage A series of rapid mitotic divisions that increase cell number in a developing embryo without a corresponding increase in cell size.

climax community A stable, self-perpetuating community that results from an ecological succession.

cloning A technique of genetic investigation in which undifferentiated cells of an organism are used to produce new organisms with the same set of traits as the original cells.

closed-transport system A type of circulatory system in which the transport fluid is always enclosed within blood vessels (for example, earthworm, human).

Clot A structure that forms as a result of enzyme-controlled reactions following the rupturing of a blood vessel and serves as a plug to prevent blood loss.

codominance A type of intermediate inheritance that results from the simultaneous expression of two dominant alleles with contrasting effects.

codon See triplet codon.

Coelenterata A phylum of the animal kingdom whose members (coelenterates) have bodies that resemble a sack (for example, hydra, jellyfish).

coenzyme A chemical substance or chemical subunit that functions to aid the action of a particular enzyme. (See vitamin.)

cohesion A force binding water molecules together that aids in the upward conduction of materials in the xylem.

commensalism A type of symbiosis in which one organism in the relationship benefits and the other is neither helped nor harmed.

common ancestry A concept central to the theory of evolution that postulates that all organisms share a common ancestry whose closeness varies with the degree of shared similarity.

community A level of biological organization that includes all of the species populations inhabiting a particular geographic area.

comparative anatomy The study of similarities in the anatomic structures of organisms, and their use as an indicator of common ancestry and as evidence of organic evolution.

comparative biochemistry The study of similarities in the biochemical makeups of organisms, and their use as an indicator of common ancestry and as evidence of organic evolution.

comparative cytology The study of similarities in the cell structures of organisms, and their use as an indicator of common ancestry and as evidence of organic evolution.

comparative embryology The study of similarities in the patterns of embryological development of organisms, and their use as an indicator of common ancestry and as evidence of organic evolution.

competition A condition that arises

when different species in the same habitat attempt to use the same limited resources.

complete protein A protein that contains all eight essential amino acids.

compound A substance composed of two or more different kinds of atom (for example, water: H20).

compound light microscope A tool of biological study capable of producing a magnified image of a biological specimen by using a focused beam of light.

conditioned behavior A type of response that is learned but that becomes automatic with repetition.

conservation of resources The development and application of practices to protect valuable and irreplaceable soil and mineral resources-a positive aspect of human involvement with the environment.

constipation A disorder of the human digestive tract in which fecal matter solidifies and becomes difficult to egest.

consumer Any heterotrophic animal organism (for example, human being).

coronary artery An artery that branches off the aorta to feed the heart muscle.

coronary thrombosis A disorder of the human transport system in which the heart muscle becomes damaged as a result of blockage of the coronary artery.

corpus luteum A structure resulting from the hormone-controlled transformation of the ovarian follicle that produces the hormone progesterone.

corpus luteum stage A stage of the menstrual cycle in which the cells of the follicle are transformed into the corpus luteum under the influence of luteinizing hormone (LH).

cotyledon A portion of the plant embryo that serves as a source of nutrition for the young plant before photosynthesis begins.

cover cropping A proper agricultural practice in which a temporary planting (cover crop) is used to limit soil erosion between seasonal plantings of main crops.

crop A portion of the digestive tract of certain animals that stores food temporarily before digestion.

cross-pollination A type of pollination in which pollen from one flower pollinates flowers of a different plant of the same species.

crossing-over A pattern of inheritance in which linked genes may be separated during synapsis in the first meiotic division, when sections of homologous chromosomes may be exchanged.

cuticle A waxy coating that covers the upper epidermis of most leaves and acts to help the leaf retain water.

cutting A technique of plant propagation in which vegetative parts of the parent plant are cut and rooted to establish new plant organisms with identical characteristics.

Cyclosis The circulation of the cell fluid (cytoplasm) within the cell interior.

CytOn The cell body of the neuron, which generates the nerve impulse.

cytoplasm The watery fluid that provides a medium for the suspension of organelles within the cell.

cytoplasmic division The separation of daughter nuclei into two new daughter cells.

cytosine A nitrogenous base found in both DNA and RNA molecules.

daughter cell A cell that results from mitotic cell division.

daughter nucleus One of two nuclei that form as a result of mitosis.

deamination A process by which amino acids are broken down into their component parts for conversion into urea.

death The irreversible cessation of bodily functions and cellular activities.

deciduous A term relating to broadleaved trees that shed their leaves in the fall.

decomposer Any saprophytic organism that derives its energy from the decay

of plant and animal tissues (for example, bacteria of decay, fungus); the final stage of -a food chain.

decomposition bacteria In the nitrogen cycle, bacteria that break down plant and animal protein and produce ammonia as a by-product.

dehydration synthesis A chemical process in which two organic molecules may be joined after removing the atoms needed to form a molecule of water as a by-product.

deletion A type of chromosome mutation in which a section of a chromosome is separated and lost.

dendrite A cytoplasmic extension of a neuron that serves to detect an environmental stimulus and carry an impulse to the cell body of the neuron.

denitrifying bacteria In the nitrogen cycle, bacteria that convert excess nitrate salts into gaseous nitrogen.

deoxygenated blood Blood that has released its transported oxygen to the body tissues.

deoxyribonucleic acid (DNA) A nucleic acid molecule known to be the chemically active agent of the gene; the fundamental hereditary material of living organisms.

deoxyribose A five-carbon sugar that is a component part of the nucleotide unit in DNA only.

desert A terrestrial biome characterized by sparse rainfall, extreme temperature variation, and a climax flora that includes cactus.

diabetes A disorder of the human regulatory system in which insufficient insulin production leads to elevated blood sugar concentrations.

diarrhea A disorder of the human digestive tract in which the large intestine fails to absorb water from the waste matter, resulting in watery feces.

diastole The lower pressure registered during blood pressure testing. (See systole.)

differentiation The process by which embryonic cells become specialized to perform the various tasks of particular tissues throughout the body.

diffusion A form of passive transport in which soluble substances are absorbed or released by cells.

digestion The process in which complex foods are broken down by mechanical or chemical means for use by the body.

dipeptide A chemical unit composed of two amino acid units linked by a peptide bond.

diploid chromosome number The number of chromosomes found characteristically in the cells (except gametes) of sexually reproducing species.

disaccharidase Any disaccharidehydrolyzing enzyme.

disaccharide A type of carbohydrate known also as a double sugar; all disaccharides have the molecular formula C12H-011.

disjunction The separation of homologous chromosome pairs at the end of the first meiotic division.

disposal problems Problems, due to technological oversight, that result when commercial and technological activities produce solid and/or chemical wastes that must be disposed of.

dissecting microscope A tool of biological study that magnifies the image of a biological specimen up to 20 times normal size for purposes of gross dissection.

dominance A pattern of genetic inheritance in which the effects of a dominant allele mask those of a recessive allele.

dominant allele (gene) An allele (gene) whose effect masks that of its recessive allele.

double-stranded chromosome The two-stranded structure that results from chromosomal replication.

Down's syndrome In human beings, a condition characterized by mental and physical retardation that may be caused by the nondisjunction of chromosome number 21.

Drosophila The common fruit fly, an

organism that has served as an object of genetic research in the development of the gene-chromosome theory.

ductless gland See endocrine gland.

ecology The science that studies the interactions of living things with each other and with the nonliving environment.

ecosystem The basic unit of study in ecology, including the plant and animal community in interaction with the nonliving environment.

ectoderm An embryonic tissue that differentiates into skin and nerve tissue in the adult animal.

effector An organ specialized to produce a response to an environmental stimulus; effectors may be muscles or glands.

egestion The process by which undigested food materials are eliminated from the body.

electron microscope A tool of biological study that uses a focused beam of electrons to produce an image of a biological specimen magnified up to 25,000 times its normal size.

element The simplest form of matter; an element is a substance (for example, nitrogen) made up of a single type of atom.

embryo An organism in the early stages of development following fertilization.

embryonic development A series of complex processes by which animal and plant embryos develop into adult organisms.

emphysema A disorder of the human respiratory system in which lung tissue deteriorates, leaving the lung with diminished capacity and efficiency.

emulsification A process by which fat globules are surrounded by bile to form fat droplets.

endocrine (ductless) gland A gland (for example, thyroid, pituitary) specialized for producing and secreting hormones directly into the bloodstream; such glands lack ducts.

endoderm An embryonic tissue that differentiates into the digestive and respiratory tract lining in the adult animal.

endoplasmic reticulum (ER) A cell organelle known to function in the transport of cell products from place to place within the cell.

environmental laws Federal, state, and local legislation enacted in an attempt to protect environmental resources-a positive aspect of human involvement with the environment.

enzymatic hydrolysis An enzyme-controlled reaction by which complex food molecules are broken down chemically into simpler subunits.

enzyme An organic catalyst that controls the rate of metabolism of a single type of substrate; enzymes are protein in nature.

enzyme-substrate complex A physical association between an enzyme molecule and its substrate within which the substrate is metabolized.

epiCotyl A portion of the plant embryo that specializes to become the upper stem, leaves, and flowers of the adult plant.

epidermis The outermost cell layer in a plant or animal.

epiglottis In a human being, a flap of tissue that covers the upper end of the trachea during swallowing and prevents inhalation of food.

esophagus A structure in the upper portion of the digestive tract that conducts the food from the pharynx to the midgut.

essential amino acid An amino acid that cannot be synthesized by the human body but must be obtained by means of the diet.

estrogen A hormone, secreted by the ovary that regulates the production of female secondary sex characteristics.

evolution Any process of gradual change through time.

excretion The life function by which living things eliminate metabolic wastes from their cells.

exoskeleton A chitinous material that covers the outside of the bodies of most arthropods and provides protection for internal organs and anchorage for muscles.

exploitation of organisms Systematic removal of animals and plants with commercial value from their environments to sell them-a negative aspect of human involvement with the environment.

extensor A skeletal muscle that extends (opens) a joint.

external development Embryonic development that occurs outside the body of the female parent (for example, birds).

external fertilization Fertilization that occurs outside the body of the female parent (for example, fish).

extracellular digestion Digestion that occurs outside the cell.

fallopian tube See oviduct.

fatty acid An organic molecule that is a component of certain lipids.

fauna The animal species comprising an ecological community.

feces The semisolid material that results from the solidification of undigested foods in the large intestine.

fertilization The fusion of gametic nuclei in the process of sexual reproduction.

filament The portion of the stamen that supports the anther.

flagella Microscopic, whiplike structures found on certain cells that aid in locomotion and circulation.

flexor A skeletal muscle that flexes (closes) a joint.

flora The plant species comprising an ecological community.

flower The portion of a flowering plant specialized for sexual reproduction.

fluid-mosaic model A model of the structure of the cell membrane in which large protein molecules are thought to be embedded in a bilipid layer.

follicle One of many areas within the ovary that serve as sites for the periodic maturation of ova.

follicle stage The stage of the menstrual cycle in which an ovum reaches its final maturity under the influence of the hormone FSH.

follicle-stimulating hormone (FSH) A pituitary hormone that regulates the maturation of and the secretion of estrogen by the ovarian follicle.

food chain A series of nutritional relationships in which food energy is passed from producer to herbivore to carnivore to decomposer; a segment of a food web.

food web A construct showing a series of interrelated food chains and illustrating the complex nutritional interrelationships that exist in an ecosystem.

fossil The preserved direct or indirect remains of an organism that lived in the past, as found in the geologic record.

fraternal twins In human beings, twin offspring that result from the simultaneous fertilization of two ova by two sperm; such twins are not genetically identical.

freshwater biome An aquatic biome made up of many separate freshwater systems that vary in size and stability and may be closely associated with terrestrial biomes.

fruit Any plant structure that contains seeds; a mechanism of seed dispersal.

Fungi One of the five biological kingdoms; it includes organisms unable to manufacture their own organic foods (for example, mushroom).

gallbladder An accessory organ that stores bile.

gallstones A disorder of the human digestive tract in which deposits of hardened cholesterol lodge in the gallbladder.

gamete A specialized reproductive cell produced by organisms of sexually reproducing species. (See sperm; ovum; pollen; ovule.)

gametogenesis The process of cell divi

sion by which gametes are produced. (See meiosis; spermatogenesis; oogenesis.)

ganglion An area of bunched nerve cells that acts as a switching point for nerve impulses traveling from receptors and to effectors.

garden pea The research organism used by Mendel in his early scientific work in genetic inheritance.

gastric cecum A gland in the grasshopper that secretes digestive enzymes.

gastrula A stage of embryonic development in animals in which the embryo assumes a tube-within-a-tube structure and distinct embryonic tissues (ectoderm, mesoderm, endoderm) begin to differentiate.

gastrulation The process by which a blastula becomes progressively more indented, forming a gastrula.

gene A unit of heredity; a discrete portion of a chromosome thought to be responsible for the production of a single type of polypeptide; the factor responsible for the inheritance of a genetic trait.

gene frequency The proportion (percentage) of each allele for a particular trait that is present in the gene pool of a population.

gene linkage A pattern of inheritance in which genes located along the same chromosome are prevented from assorting independently but are linked together in their inheritance.

gene mutation An alteration of the chemical nature of a gene that changes its ability to control the production of a polypeptide chain.

gene pool The sum total of all the inheritable genes for the traits in a given sexually reproducing population.

gene-chromosome theory A theory of genetic inheritance that is based on current understanding of the relationships between the biochemical control of traits and the process of cell division.

genetic counseling Clinical discussions concerning inheritance patterns that are designed to inform prospective parents of the potential for expression of a genetic disorder in their offspring.

genetic engineering The use of various techniques to move genes from one organism to another.

genetic screening A technique for the detection of human genetic disorders in which bodily fluids are analyzed for the presence of certain marker chemicals.

genome The total genetic makeup (DNA) of an organism.

genotype The particular combination of genes in an allele pair.

genus A level of biological classification that represents a subdivision of the phylum level; having fewer organisms with great similarity (for example, Drosophila, Paramecium).

geographic isolation The separation of species populations by geographic barriers, facilitating the evolutionary process.

geologic record A supporting item of evidence of organic evolution, supplied within the earth's rock and other geologic deposits.

germination The growth of the pollen tube from a pollen grain; the growth of the embryonic root and stem from a seed.

gestation The period of prenatal development of a placental mammal; human gestation requires approximately nine months.

gizzard A portion of the digestive tract of certain organisms, including the earthworm and the grasshopper in which food is ground into smaller fragments.

glomerulus A capillary network lying within Bowman's capsule of the nephron.

glucagon A hormone, secreted by the islets of Langerhans, that regulates the release of blood sugar from stored glycogen.

glucose A monosaccharide produced commonly in photosynthesis and used by both plants and animals as a fuel in the process of respiration.

glycerol An organic compound that is a component of certain lipids.

glycogen A polysaccharide synthesized in animals as a means of storing glucose; glycogen is stored in the liver and in the muscles.

goiter A disorder of the human regulatory system in which the thyroid gland enlarges because of a deficiency of dietary iodine.

Golgi complex Cell organelles that package cell products and move them to the plasma membrane for secretion.

gonad An endocrine gland that produces the hormones responsible for the production of various secondary sex characteristics. (See ovary; testis.)

gout A disorder of the human excretory system in which uric acid accumulates in the joints, causing severe pain.

gradualism A theory of the time frame required for organic evolution that assumes that evolutionary change is slow, gradual, and continuous.

grafting A technique of plant propagation in which the stems of desirable plants are attached (grafted) to rootstocks of related varieties to produce new plants for commercial purposes.

grana The portion of the chloroplast within which chlorophyll molecules are concentrated.

grassland A terrestrial biome characterized by wide variation in temperature and a climax flora that includes grasses.

growth A process by which cells increase in number and size, resulting in an increase in size of the organism.

growth-stimulating hormone (GSH) A pituitary hormone regulating the elongation of the long bones of the body.

guanine A nitrogenous base found in both DNA and RNA molecules.

guard cell One of a pair of cells that surround the leaf stomate and regulate its size.

habitat The environment or set of ecological conditions within which an organism lives.

Hardy-Weinberg principle A hypothesis, advanced by G. H. Hardy and W. Weinberg that states that the gene pool of a population should remain stable as long as a set of ideal conditions is met.

heart In human beings, a four-chambered muscular pump that facilitates the movement of blood throughout the body.

helix Literally a spiral; a term used to describe the twisted ladder shape of the DNA molecule.

hemoglobin A type of protein specialized for the transport of respiratory oxygen in certain organisms, including earthworms and human beings.

herbivore A heterotrophic organism that consumes plant matter as its primary source of nutrition. (See primary consumer.)

hermaphrodite An animal organism that produces both male and female gametes.

heterotroph An organism that typically carries on heterotrophic nutrition.

heterotroph hypothesis A scientific hypothesis devised to explain the probable origin and early evolution of life on earth.

heterotrophic nutrition A type of nutrition in which organisms must obtain their foods from outside sources of organic nutrients.

heterozygous A term used to refer to an allele pair in which the alleles have different, contrasting effects (for example, Aa, RW).

high blood pressure A disorder of the human transport system in which systolic and diastolic pressures register higher than normal because of narrowing of the artery opening.

histamine A chemical product of the body that causes irritation and swelling of the mucous membranes.

homeostasis The condition of balance and dynamic stability that characterizes living systems under normal conditions.

homologous chromosomes A pair of

chromosomes that carry corresponding genes for the same traits.

homologous structures Structures present within different species that can be shown to have had a common origin but that may or may not share a common function.

homozygous A term used to refer to an allele pair in which the alleles are identical in terms of effect (for example, AA, aa).

hormone A chemical product of an endocrine gland that has a regulatory effect on the cell's metabolism.

hoSt The organism harmed in a parasitic relationship.

hybrid A term used to describe a heterozygous genotype. (See heterozygous.)

hybridization A technique of plant/animal breeding in which two varieties of the same species are crossbred in the hope of producing offspring with the favorable traits of both varieties.

hydrogen bond A weak electrostatic bond that holds together the twisted strands of DNA and RNA molecules.

hydrolysis The chemical process by which a complex food molecule is split into simpler components through the addition of a molecule of water to the bonds holding it together.

hypocotyl A portion of the plant embryo that specializes to become the root and lower stem of the adult plant.

hypothalamus An endocrine gland whose secretions affect the pituitary gland.

identical twins In human beings, twin offspring resulting from the separation of the embryonic cell mass of a single fertilization into two separate masses; such twins are genetically identical.

importation of organisms The introduction of nonactive plants and animals into new areas where they compete strongly with native species-a negative aspect of human involvement with the environment.

in vitro fertilization A laboratory technique in which fertilization is accomplished outside the mother's body using mature ova and sperm extracted from the parents' bodies.

inbreeding A technique of plant/animal breeding in which a purebred variety is bred only with its own members so as to maintain a set of desired characteristics.

independent assortment A pattern of inheritance in which genes on different, nonhomologous chromosomes are free to be inherited randomly and regardless of the inheritance of the others.

ingestion The mechanism by which an organism takes in food from its environment.

inorganic compound A chemical compound that lacks the element carbon or hydrogen (for example, table salt: NaCl).

insulin A hormone, secreted by the islets of Langerhans, that regulates the storage of blood sugar as glycogen.

intercellular fluid (ICF) The fluid that bathes cells and fills intercellular spaces.

interferon A substance, important in the fight against human cancer, that may now be produced in large quantities with techniques of genetic engineering.

intermediate inheritance Any pattern of inheritance in which the offspring expresses a phenotype different from the phenotypes of its parents and usually representing a form intermediate between them.

internal development Embryonic development that occurs within the body of the female parent.

internal fertilization Fertilization that occurs inside the body of the female parent.

interneuron A type of neuron, located in the central nervous system, responsible for the interpretation of impulses received from sensory neurons.

intestine A portion of the digestive tract

in which chemical digestion and absorption of digestive end products occur.

intracellular digestion A type of chemical digestion carried out within the cell.

iodine A chemical stain used in cell study; an indicator used to detect the presence of starch. (See staining.)

islets of Langerhans An endocrine gland, located within the pancreas, that produces the hormones insulin and glucagon.

karyotype An enlarged photograph of the paired homologous chromosomes of an individual cell that is used in the detection of certain genetic disorders involving chromosome mutation.

karyotyping A technique for the detection of human genetic disorders in which a karyotype is analyzed for abnormalities in chromosome structure or number.

kidney The excretory organ responsible for maintaining the chemical composition of the blood. (See nephron.)

kidney failure A disorder of the human excretory system in which there is a general breakdown of the kidney's ability to filter blood components.

kingdom A level of biological classification that includes a broad grouping of organisms displaying general structural similarity; five kingdoms have been named by scientists.

lacteal A small extension of the lymphatic system, found inside the villus, that absorbs fatty acids and glycerol resulting from lipid hydrolysis.

lactic acid fermentation A type of anaerobic respiration in which glucose is converted to two lactic acid molecules.

large intestine A portion of the digestive tract in which undigested foods are solidified by means of water absorption to form feces.

lateral meristem A plant growth region located under the epidermis or bark of a stem. (See cambium.)

Latin The language used in biological classification for naming organisms by means of binomial nomenclature.

lentiCel A small pore in the stem surface that permits the absorption and release of respiratory gases within stem tissues.

leukemia A disorder of the human transport system in which the bone marrow produces large numbers of abnormal white blood cells. (See cancer.)

lichen A symbiosis of alga and fungus that frequently acts as a pioneer species on bare rock.

limiting factor Any abiotic or biotic condition that places limits on the survival of organisms and on the growth of species populations in the environment.

lipase Any lipid-hydrolyzing enzyme.

lipid An organic compound composed of carbon, hydrogen, and oxygen in which hydrogen and oxygen are not in a 2:1 ratio (for example, a wax, plant oil); many lipids are constructed of a glycerol and three fatty acids.

liver An accessory organ that stores glycogen, produces bile, destroys old red blood cells, deaminates amino acids, and produces urea.

lock-and-key model A theoretical model of enzyme action that attempts to explain the concept of enzyme specificity.

lung The major organ of respiratory gas exchange.

luteinizing hormone (LH) A pituitary hormone that regulates the conversion of the ovarian follicle into the corpus luteum.

lymph Intercellular fluid (ICF) that has passed into the lymph vessels.

lymph node one of a series of structures in the body that act as reservoirs of lymph and also contain white blood cells as part of the body's immune system.

lymph vessel One of a branching series

of tubes that collect ICF from the tissues and redistribute it as lymph.

lymphatic circulation The movement of lymph throughout the body.

lymphocyte A type of white blood cell that produces antibodies.

lysosome A cell organelle that houses hydrolytic enzymes used by the cell in the process of chemical digestion.

Malpighian tubules In arthropods (for example, grasshopper), an organ specialized for the removal of metabolic wastes.

maltase A specific enzyme that catalyzes the hydrolysis (and dehydration synthesis) of maltose.

maltose A type of disaccharide; a maltose molecule is composed of two units of glucose joined together by dehydration synthesis.

marine biome An aquatic biome characterized by relatively stable conditions of moisture, salinity, and temperature.

marsupial mammal See nonplacental mammal.

mechanical digestion Any of the processes by which foods are broken apart physically into smaller particles.

medulla The portion of the human brain responsible for regulating the automatic processes of the body.

meiosis The process by which four monoploid nuclei are formed from a single diploid nucleus.

meningitis A disorder of the human regulatory system in which the membranes of the brain or spinal cord become inflamed.

menstrual cycle A hormone-controlled process responsible for the monthly release of mature ova.

menstruation The stage of the menstrual cycle in which the lining of the uterus breaks down and is expelled from the body via the vaginal canal.

meristem A plant tissue specialized for embryonic development. (See apical meristem; lateral meristem: cambium.)

mesoderm An embryonic tissue that differentiates into muscle, bone, the excretory system, and most of the reproductive system in the adult animal.

messenger RNA (mRNA) A type of RNA that carries the genetic code from the nuclear DNA to the ribosome for transcription.

metabolism All of the chemical processes of life considered together; the sum total of all the cell's chemical activity.

methylene blue A chemical stain used in cell study. (See staining.)

microdissection instruments Tools of biological study used to remove certain cell organelles from within cells for examination.

micrometer (pm) A unit of linear measurement equal in length to 0.001 millimeter (0.000001 meter), used for expressing the dimensions of cells and cell organelles.

mitochondrion A cell organelle that contains the enzymes necessary for aerobic respiration.

mitosis A precise duplication of the contents of a parent cell nucleus followed by an orderly separation of these contents into two new, identical daughter nuclei.

mitotic cell division A type of cell division that results in the production of two daughter cells identical to each other and to the parent cell.

Monera One of the five biological kingdoms; it includes simple unicellular forms lacking nuclear membranes (for example, bacteria).

monohybrid cross A genetic cross between two organisms both heterozygous for a trait controlled by a single allele pair. The phenotypic ratio resulting is 3: 1; the genotypic ratio is 1:2:1.

monoploid chromosome number The number of chromosomes commonly found in the gametes of sexually reproducing species.

monosaccharide A type of carbohydrate known also as a simple sugar; all

monosaccharides have the molecular formula $C_6H_{12}O_6$.

motor neuron A type of neuron that carries command impulses from the central nervous system to an effector organ.

mucus A protein-rich mixture that bathes and moistens the respiratory surfaces.

multicellular Having a body that consists of large groupings of specialized cells (for example, human being).

multiple alleles A pattern of inheritance in which the existence of more than two alleles is hypothesized, only two of which are present in the genotype of any one individual.

muscle A type of tissue specialized to produce movement of body parts.

mutagenic agent Any environmental condition that initiates or accelerates genetic mutation.

mutation Any alteration of the genetic material, either a chromosome or a gene, in an organism.

mutualism A type of symbiosis beneficial to both organisms in the relationship.

nasal cavity A series of channels through which outside air is admitted to the body interior and is warmed and moistened before entering the lung.

natural selection A concept, central to Darwin's theory of evolution, to the effect that the individuals best adapted to their environment tend to survive and to pass their favorable traits on to the next generation

negative feedback A type of endocrine regulation in which the effects of one gland may inhibit its own secretory activity while stimulating the secretory activity of another gland.

nephridium An organ found in certain organisms, including the earthworm, specialized for the removal of metabolic wastes.

nephron The functional unit of the kidney. (See glomerulus; Bowman's capsule.)

nerve A structure formed from the bundling of neurons carrying sensory or motor impulses.

nerve impulse An electrochemical change in the surface of the nerve cell.

nerve net A network of nervelike cells in coelenterates such as the hydra.

neuron A cell specialized for the transmission of nerve impulses.

neurotransmitter A chemical substance secreted by a neuron that aids in the transmission of the nerve impulse to an adjacent neuron.

niche The role that an organism plays in its environment.

nitrifying bacteria In the nitrogen cycle, bacteria that absorb ammonia and convert it into nitrate salts.

nitrogen cycle The process by which nitrogen is recycled and made available for use by other organisms.

nitrogen-fixing bacteria A type of bacteria responsible for absorbing atmospheric nitrogen and converting it to nitrate salts in the soil.

nitrogenous base A chemical unit composed of carbon, hydrogen, and nitrogen that is a component part of the nucleotide unit.

nitrogenous waste Any of a number of nitrogen-rich compounds that result from the metabolism of proteins and amino acids in the cell. (See ammonia; urea; uric acid.)

nondisjunction A type of chromosome mutation in which the members of one or more pairs of homologous chromosomes fail to separate during the disjunction phase of the first meiotic division.

nonplacental mammal A type of mammal (marsupial) in which internal development is accomplished without the aid of a placental connection.

nucleic acid An organic compound composed of repeating units of nucleotide.

nucleolus A cell organelle located within the nucleus that functions in protein synthesis.

nucleotide The repeating unit making up the nucleic acid polymer (for example, DNA, RNA).

nucleus A cell organelle that contains the cell's genetic information in the form of chromosomes.

nutrition The life function by which living things obtain food and process it for their use.

omnivore A heterotrophic organism that consumes both plant and animal matter as sources of nutrition.

one gene-one polypeptide A scientific hypothesis concerning the role of the individual gene in protein synthesis.

oogenesis A type of meiotic cell division in which one ovum and three polar bodies are produced from each primary sex cell.

open transport system A type of circulatory system in which the transport fluid is not always enclosed within blood vessels (for example, grasshopper).

oral cavity In human beings, the organ used for the ingestion of foods.

oral groove The ingestive organ of the paramecium.

organ transplant An application of the study of immunity in which an organ or tissue of a donor is transplanted into a compatible recipient.

organelle A small, functional part of a cell specialized to perform a specific life function (for example, nucleus, mitochondrion).

organic compound a chemical compound that contains the elements carbon and hydrogen (for example, carbohydrate, protein).

organic evolution The mechanism thought to govern the changes in living species over geologic time.

Osmosis A form of passive transport by which water is absorbed or released by cells.

ovary A female gonad that secretes the hormone estrogen, which regulates female secondary sex characteristics; the ovary also produces ova, which are used in reproduction.

overcropping A negative aspect of human involvement with the environment in which soil is overused for the production of crops, leading to exhaustion of soil nutrients.

overgrazing The exposure of soil to erosion due to the loss of stabilizing grasses when it is overused by domestic animals-a negative aspect of human involvement with the environment.

overhunting A negative aspect of human involvement with the environment in which certain species have been greatly reduced or made extinct by uncontrolled hunting practices.

oviduct A tube that serves as a channel for conducting mature ova from the ovary to the uterus; the site of fertilization and the earliest stages of embryonic development.

ovulation The stage of the menstrual cycle in which the mature ovum is released from the follicle into the oviduct.

ovule A structure located within the flower ovary that contains a monoploid egg nucleus and serves as the site of fertilization.

Ovum A type of gamete produced as a result of oogenesis in female animals; the egg, the female sex cell.

oxygen 18 A radioactive isotope of oxygen that is used to trace the movement of this element in biochemical reaction sequences.

oxygenated blood Blood that contains a high percentage of oxyhemoglobin.

oxyhemoglobin Hemoglobin that is loosely bound to oxygen for purposes of oxygen transport.

pH A chemical unit used to express the concentration of hydrogen ion ($H+$), or the acidity, of a solution.

palisade layer A cell layer found in most leaves that contains high concentrations of chloroplasts.

pancreas An accessory organ that produces enzymes that complete the

hydrolysis of foods to soluble end products; also the site of insulin and glucagon production.

parasitism A type of symbiosis from which one organism in the relationship benefits, while the other (the host) is harmed, but not ordinarily killed.

parathormone A hormone of the parathyroid gland that regulates the metabolism of calcium in the body.

parathyroid gland An endocrine gland whose secretion, parathormone, regulates the metabolism of calcium in the body.

passive immunity A temporary immunity produced as a result of the injection of preformed antibodies.

passive transport Any process by which materials are absorbed into the cell interior from an area of high concentration to an area of low concentration without the expenditure of cell energy (for example, osmosis, diffusion).

penis A structure that permits internal fertilization through direct implantation of sperm into the female reproductive tract.

peptide bond A type of chemical bond that links the nitrogen atom of one amino acid with the terminal carbon atom of a second amino acid in the formation of a dipeptide.

peripheral nerves Nerves in the earthworm and grasshopper that branch from the ventral nerve cord to other parts of the body.

peripheral nervous system A major subdivision of the nervous system that consists of all the nerves of all types branching through the body. (See autonomic nervous system; somatic nervous system.)

peristalsis A wave of contractions of the smooth muscle lining; the digestive tract that causes ingested food to pass along the food tube.

petal An accessory part of the flower that is thought to attract pollinating insects.

phagocyte A type of white blood cell that engulfs and destroys bacteria.

phagocytosis The process by which an ameba surrounds and ingests large food particles for intracellular digestion.

pharynx The upper part of the digestive tube that temporarily stores food before digestion.

phenotype The observable trait that results from the action of an allele pair.

phenylketonuria (PKU) A genetically related human disorder in which the homozygous combination of a particular mutant gene prevents the normal metabolism of the amino acid phenylalanine.

phloem A type of vascular tissue through which water and dissolved sugars are transported in plants from the leaf downward to the roots for storage.

phosphate group A chemical group made up of phosphorus and oxygen and that is a component part of the nucleotide unit.

phosphoglyceraldehyde (PGAL) An intermediate product formed during photosynthesis that acts as the precursor of glucose formation.

photochemical reactions A set of biochemical reactions in photosynthesis in which light is absorbed and water molecules are split. (See photolysis.)

photolysis The portion of the photochemical reactions in which water molecules are split into hydrogen atoms and made available to the carbon-fixation reactions.

photosynthesis A type of autotrophic nutrition in which green plants use the energy of sunlight to convert carbon dioxide and water into glucose.

phylum A level of biological classification that is a major subdivision of the kingdom level, containing fewer organisms with greater similarity (for example, Chordata).

pinOCytOSis A special type of absorption by which liquids and particles too large to diffuse through the cell membrane may be taken in by vacuoles formed at the cell surface.

pioneer autotrophs The organisms supposed by the heterotroph hypothesis to have been the first to evolve the ability to carry on autotrophic nutrition.

pioneer species in an ecological succession, the first organisms to inhabit a barren environment.

pistil The female sex organ of the flower. (See stigma; style; ovary.)

pituitary gland An endocrine gland that produces hormones regulating the secretions of other endocrine glands; the master gland.

placenta in placental mammals, a structure composed of both embryonic and maternal tissues that permits the diffusion of soluble substances to and from the fetus for nourishment and the elimination of fetal waste.

placental mammal A mammal species in which embryonic development occurs internally with the aid of a placental connection to the female parent's body.

plant One of the five biological kingdoms; it includes multicellular organisms whose cells are bounded by cell walls and that are capable of photosynthesis (for example, maple tree).

plasma The liquid fraction of blood, containing water and dissolved proteins.

plasma membrane A cell organelle that encloses the cytoplasm and other cell organelles and regulates the passage of materials into and out of the cell.

platelet A cell-like component of the blood that is important in clot formation.

polar body One of three nonfunctional cells produced during oogenesis that contain monoploid nuclei and disintegrate soon after completion of the process.

polio A disorder of the human regulatory system in which viral infection of the central nervous system may result in severe paralysis.

pollen The male gamete of the flowering plant.

pollen tube A structure produced by the germinating pollen grain that grows through the style to the ovary and carries the sperm nucleus to the ovule for fertilization.

pollination The transfer of pollen grains from anther to stigma.

pollution control The development of new procedures to reduce the incidence of air, water, and soil pollution-a positive aspect of human involvement with the environment.

polyploidy A type of chromosome mutation in which an entire set of homologous chromosomes fail to separate during the disjunction phase of the first meiotic division.

polysaccharide A type of carbohydrate composed of repeating units of monosaccharides that form a polymeric chain.

polyunsaturated fat A type of fat in which many bonding sites are unavailable for the addition of hydrogen atoms.

population All the members of a particular species in a given geographical location at a given time.

population control The use of various practices to slow the rapid growth in the human population-a positive aspect of human interaction with the environment.

population genetics A science that studies the genetic characteristics of a sexually reproducing species and the factors that affect its gene frequencies.

postnatal development The growth and maturation of an individual from birth, through aging, to death.

prenatal development The embryonic development that occurs before birth within the uterus. (See gestation.)

primary consumer Any herbivorous organism that receives food energy from the producer level (for example, mouse); the second stage of a food chain.

primary sex cell The diploid cell that undergoes meiotic cell division to produce monoploid gametes.

producer Any autotrophic organism

capable of trapping light energy and converting it to the chemical bond energy of food (for example, green plants); the organisms forming the basis of the food chain.

progesterone A hormone produced by the corpus luteum and/or placenta that has the effect of maintaining the uterine lining and suppressing ovulation during gestation.

protease Any protein-hydrolyzing enzyme.

protein A complex organic compound composed of repeating units of amino acid.

Protista One of the five biological kingdoms; it includes simple unicellular forms whose nuclei are surrounded by nuclear membranes (for example, ameba, paramecium).

pseudopod A temporary, flowing extension of the cytoplasm of an ameba that is used in nutrition and locomotion.

pulmonary artery One of two arteries that carry blood from the heart to the lungs for reoxygenation.

pulmonary circulation Circulation of blood from the heart through the lungs and back to the heart.

pulmonary vein One of four veins that carry oxygenated blood from the lungs to the heart.

pulse Rhythmic contractions of the artery walls that help to push the blood fluid through the capillary networks of the body.

punctuated equilibrium A theory of the time frame required for evolution that assumes that evolutionary change occurs in bursts with long periods of relative stability intervening.

pyramid of biomass A construct used to illustrate the fact that the total biomass available in each stage of a food chain diminishes from producer level to consumer level.

pyramid of energy A construct used to illustrate the fact that energy is lost at each trophic level in a food chain and is most abundant at the producer level. pyruvic acid An intermediate product in the aerobic or anaerobic respiration of glucose.

receptor An organ specialized to receive a particular type of environmental stimulus.

recessive allele (gene) An allele (gene) whose effect is masked by that of its dominant allele.

recombinant DNA DNA molecules that have been moved from one cell to another in order to give the recipient cell a genetic characteristic of the donor cell.

recombination The process by which the members of segregated allele pairs are randomly recombined in the zygote as a result of fertilization.

rectum The portion of the digestive tract in which digestive wastes are stored until they can be released to the environment.

red blood cell Small, nonnucleated cells in the blood that contain hemoglobin and carry oxygen to body tissues.

reduction division See meiosis.

reflex A simple, inborn, involuntary response to an environmental stimulus.

reflex arc The complete path involving a series of three neurons (sensory, interneuron, and motor) working together in a reflex action.

regeneration A type of asexual reproduction in which new organisms are produced from the severed parts of a single parent organism; the replacement of loss or damaged tissues.

regulation The life process by which living things respond to changes within and around them, and by which all life processes are coordinated.

replication An exact self-duplication of the chromosome during the early stages of cell division; the exact self-duplication of a molecule of DNA.

reproduction The life process by which new cells arise from preexisting cells by cell division.

reproductive isolation The inability of

species varieties to interbreed and produce fertile offspring because of variations in behavior or chromosome structure.

respiration The life function by which living things convert the energy of organic foods into a form more easily used by the cell.

response The reaction of an organism to an environmental stimulus.

rhizoid A rootlike fiber produced by fungi that secrete hydrolytic enzymes and absorb digested nutrients.

ribonucleic acid (RNA) A type of nucleic acid that operates in various ways to facilitate protein synthesis.

ribose A five-carbon sugar found as a component part of the nucleotides of RNA molecules only.

ribosomal RNA (rRNA) The type of RNA that makes up the ribosome.

ribosome A cell organelle that serves as the site of protein synthesis in the cell.

root A plant organ specialized to absorb water and dissolved substances from the soil as well as to anchor the plant to the soil.

root hair A small projection of the growing root that serves to increase the surface area of the root for absorption.

roughage A variety of undigestible carbohydrates that add bulk to the diet and facilitate the movement of foods through the intestine.

runner A type of vegetative propagation in which an above-ground stem (runner) produces roots and leaves and establishes new organisms with identical characteristics.

saliva A fluid secreted by salivary glands that contains hydrolytic enzymes specific to the digestion of starches.

salivary gland The gland that secretes saliva, which is important in the chemical digestion of certain foods.

Salt A chemical composed of a metal and a nonmetal joined by means of an ionic bond (for example, sodium chloride).

saprophyte A heterotrophic organism that obtains its nutrition from the decomposing remains of dead plant and animal tissues (for example, fungi, bacteria).

saturated fat A type of fat molecule in which all available bonding sites on the hydrocarbon chains are taken up with hydrogen atoms.

scrotum A pouch extending from the wall of the lower abdomen that houses the testes at a temperature optimum for sperm production.

secondary consumer Any carnivorous animal that derives its food energy from the primary consumer level (for example, a snake); the third level of a food chain.

secondary sex characteristics The physical features, different in males and females, that appear with the onset of sexual maturity.

seed A structure that develops from the fertilized ovule of the flower and germinates to produce a new plant.

seed dispersal Any mechanism by which seeds are distributed in the environment so as to widen the range of a plant species. (See fruit.)

segregation The random separation of the members of allele pairs that occurs during meiotic cell division.

self-pollination A type of pollination in which the pollen of a flower pollinates another flower located on the same plant organism.

sensory neuron A type of neuron specialized for receiving environmental stimuli, which are detected by receptor organs.

sepal An accessory part of the flower that functions to protect the bud during development.

sessile A term that relates to the unmoving state of certain organisms, including the hydra.

seta One of several small, chitinous structures (setae) that aid the earthworm in its locomotor function.

sex chromosomes A pair of homologous

chromosomes carrying genes that determine the sex of an individual; these chromosomes are designated as X and Y.

sex determination A pattern of inheritance in which the conditions of maleness and femaleness are determined by the inheritance of a pair of sex chromosomes (XX = female; XY = male).

sex linkage A pattern of inheritance in which certain nonsex genes are located on the X sex chromosome but have no corresponding alleles on the Y sex chromosome.

sex-linked trait A genetic trait whose inheritance is controlled by the genetic pattern of sex linkage (for example, color blindness).

sexual reproduction A type of reproduction in which new organisms form as a result of the fusion of gametes from two parent organisms.

shell An adaptation for embryonic development in many terrestrial, externally developing species that protects the developing embryo from drying and physical damage (for example, birds).

sickle-cell anemia A genetically related human disorder in which the homozygous combination of a mutant gene leads to the production of abnormal hemoglobin and crescent-shaped red blood cells.

skeletal muscle A type of muscle tissue associated with the voluntary movements of skeletal levers in locomotion.

small intestine In human beings, the longest portion of the food tube, in which final digestion and absorption of soluble end products occur.

smooth muscle See visceral muscle.

somatic nervous system A subdivision of the peripheral nervous system that is made up of nerves associated with voluntary actions.

speciation The process by which new species are thought to arise from previously existing species.

species A biological grouping of organisms so closely related that they are capable of interbreeding and producing fertile offspring (for example, human being).

species presentation The establishment of game lands and wildlife refuges that have permitted the recovery of certain endangered species-a positive aspect of human involvement with the environment.

sperm A type of gamete produced as a result of spermatogenesis in male animals; the male reproductive cell.

spermatogenesis A type of meiotic cell division in which four sperm cells are produced from each primary sex cell.

spinal cord The part of the central nervous system responsible for reflex action as well as impulse conduction between the peripheral nervous system and the brain.

spindle apparatus A network of fibers that form during cell division and to which centromeres attach during the separation of chromosomes.

spiracle One of several small pores in arthropods, including the grasshopper, that serve as points of entry of respiratory gases from the atmosphere to the tracheal tubes.

spongy layer A cell layer found in most leaves that is loosely packed and contains many air spaces to aid in gas exchange.

spore A specialized asexual reproductive cell produced by certain plants.

sporulation A type of asexual reproduction in which spores released from special spore cases on the parent plant germinate and grow into new adult organisms of the species.

staining A technique of cell study in which chemical stains are used to make cell parts more visible for microscopic study.

stamen The male reproductive structure in a flower. (See anther; filament.)

starch A type of polysaccharide produced and stored by plants.

stem A plant organ specialized to support the leaves and flowers of a plant

as well as to conduct materials between the roots and the leaves.

stigma The sticky upper portion of the pistil, which serves to receive pollen.

stimulus Any change in the environment to which an organism responds.

Stomach A muscular organ that acts to liquefy food and that produces gastric protease for the hydrolysis of protein.

stomate A small opening that penetrates the lower epidermis of a leaf and through which respiratory and photosynthetic gases diffuse.

strata The layers of sedimentary rock that contain fossils, whose ages may be determined by studying the patterns of sedimentation.

stroke A disorder of the human regulatory system in which brain function is impaired because of oxygen starvation of brain centers.

stroma An area of the chloroplast within which the carbon-fixation reactions occur; each stroma lies between pairs of grana.

style The portion of the pistil that connects the stigma to the ovary.

substrate A chemical metabolized by the action of a specific enzyme.

succession A situation in which an established ecological community is gradually replaced by another until a climax community is established.

survival of the fittest The concept, frequently associated with Darwin's theory of evolution, that in the intraspecies competition among naturally occurring species, the organisms best adapted to the particular environment will survive.

sweat glands In human beings, the glands responsible for the production of perspiration.

Symbiosis A term that refers to a variety of biotic relationships in which organisms of different species live together in close physical association.

synapse The gap that separates the terminal branches of one neuron from the dendrites of an adjacent neuron.

synapsis The intimate, highly specific pairing of homologous chromosomes that occurs in the first meiotic division, forming tetrads.

synthesis The life function by which living things manufacture the complex compounds required to sustain life.

systemic circulation The circulation of blood from the heart through the body tissues (except the lungs) and back to the heart.

systole The higher pressure registered during blood pressure testing. (See diastole.)

taiga A terrestrial biome characterized by long, severe winters and climax flora that includes coniferous trees.

Tay-Sachs disease A genetically related human disorder in which fatty deposits in the cells, particularly of the brain, inhibit proper functioning of the nervous system.

technological oversight A term relating to human activities that adversely affect environmental quality due to failure to assess the environmental impact of a technological development adequately.

teeth Structures located in the mouth that are specialized to aid in the mechanical digestion of foods.

temperate deciduous forest A terrestrial biome characterized by moderate climatic conditions and climax flora that includes deciduous trees.

template A pattern or design provided by the DNA molecule for the synthesis of protein molecules.

tendon A type of connective tissue that attaches a skeletal muscle to a bone.

tendonitis A disorder of the human locomotor system in which the junction between a tendon and a bone becomes irritated and inflamed.

tentacle A grasping structure in certain organisms, including the hydra, that contains stinging cells and is used for capturing prey.

terminal branch A cytoplasmic extension of the neuron that transmits a nerve impulse to adjacent neurons via the secretion of neurotransmitters.

terrestrial biome A biome that comprises primarily land ecosystems, the characteristics of which are determined by the major climate zone of the earth.

testcross A genetic cross to determine the genotype of an organism expressing a dominant phenotype; the unknown is crossed with a homozygous recessive.

testis A gonad in human males that secretes the hormone testosterone, which regulates male secondary sex characteristics; the testis also produces sperm cells for reproduction.

testosterone A hormone secreted by the testis that regulates the production of male secondary sex characteristics.

tetrad A grouping of four chromatids that results from synapsis.

thymine A nitrogenous base found only in DNA.

thyroid gland An endocrine gland that regulates the body's general rate of metabolism through secretion of the hormone thyroxin.

thyroid-stimulating hormone (TSH) A pituitary hormone that regulates the secretions of the thyroid gland.

thyroxin A thyroid hormone that regulates the body's general metabolic rate.

tongue A structure that aids in the mechanical digestion of foods.

trachea A cartilage-ringed tube that conducts air from the mouth to the bronchi.

tracheal tube An adaptation in arthropods (for example, grasshopper) that functions to conduct respiratory gases from the environment to the moist internal tissues.

Tracheophyta A phylum of the plant kingdom whose members (tracheophytes) contain vascular tissues and true roots, stems, and leaves (for example, geranium, fern, bean, maple tree, corn).

transfer RNA (tRNA) A type of RNA that transports specific amino acids from the cytoplasm to the ribosome for protein synthesis.

translocation A type of chromosome mutation in which a section of a chromosome is transferred to a nonhomologous chromosome.

transpiration The evaporation of water from leaf stomates.

transpiration pull A force that aids the upward conduction of materials in the xylem by means of the evaporation of water (transpiration) from leaf surfaces.

transport The life function by which substances are absorbed, circulated, and released by living things.

triplet cation A group of three nitrogenous bases that provide information for the placement of amino acids in the synthesis of proteins.

tropical forest A terrestrial biome characterized by a warm, moist climate and a climax flora that includes many species of broad-leaved trees.

tropism A plant growth response to an environmental stimulus.

tuber A type of vegetative propagation in which an underground stem (tuber) produces new tubers, each of which is capable of producing new organisms with identical characteristics.

tundra A terrestrial biome characterized by permanently frozen soil and climax flora that includes lichens and mosses.

tympanum A receptor organ in arthropods (for example, grasshopper) that is specialized to detect vibrational stimuli.

ulcer A disorder of the human digestive tract in which a portion of its lining erodes and becomes irritated.

ultracentrifuge A tool of biological study that uses very high speeds of centrifugation to separate cell parts for examination.

umbilical cord In placental mammals, a structure containing blood vessels that connects the placenta to the embryo.

unicellular Having a body that consists of a single cell (for example, paramecium).

uracil A nitrogenous base that is a component part of the nucleotides of RNA molecules only.

urea A type of nitrogenous waste with moderate solubility and moderate toxicity.

ureter In human beings, a tube that conducts urine from the kidney to the urinary bladder.

urethra In human beings, a tube that conducts urine from the urinary bladder to the exterior of the body. The urethra also conducts semen to the outside of the body.

uric acid A type of nitrogenous waste with low solubility and low toxicity.

urinary bladder An organ responsible for the temporary storage of urine.

urine A mixture of water, salts, and urea excreted from the kidney.

use and disuse A term associated with the evolutionary theory of Lamarck, since proved incorrect.

uterus In female placental mammals, the organ within which embryonic development occurs.

vaccination An inoculation of dead or weakened disease organisms that stimulates the body's immune system to produce active immunity.

vacuole A cell organelle that contains storage materials (for example, starch, water) housed inside the cell.

vagina In female placental mammals, the portion of the reproductive tract into which sperm are implanted during sexual intercourse and through which the baby passes during birth.

variation A concept, central to Darwin's theory of evolution, that refers to the range of adaptation that can be observed in all species.

vascular tissues Tubelike plant tissues specialized for the conduction of water and dissolved materials within the plant. (See xylem; phloem.)

vegetative propagation A type of asexual reproduction in which new plant organisms are produced from the veg etative (nonfloral) parts of the parent plant.

vein (human) A relatively thin-walled blood vessel that carries blood from capillary networks back toward the heart.

vein (plant) An area of vascular tissues located in the leaf that aid the upward transport of water and minerals through the leaf and the transport of dissolved sugars to the stem and roots.

vena Cava One of two major arteries that return blood to the heart from the body tissues.

ventral nerve cord The main pathway for nerve impulses between the brain and peripheral nerves of the grasshopper and earthworm.

ventricle One of two thick-walled, muscular chambers of the heart that pump blood out to the lungs and body.

All Microscopic projections of the lining of the small intestine that absorb the soluble end products of digestion. (See lacteal.)

visceral muscle A type of muscle tissue associated with the involuntary movements of internal organs (for example, peristalsis in the small intestine).

vitamin a type of nutrient that acts as a coenzyme in various enzyme-controlled reactions.

water cycle The mechanism by which

water is made available to living things in the environment through the processes of precipitation, evaporation, runoff, and percolation.

water pollution A type of technological oversight that involves the addition of some unwanted factor (for example, sewage, heavy metals, heat, toxic chemicals) to our water resources.

Watson-Crick model A model of DNA structure devised by J. Watson and F. Crick that hypothesizes a twisted ladder arrangement for the DNA molecule also known as a "double helix."

white blood cell A type of blood cell that functions in disease control. (See phagocyte; lymphocyte.)

xylem A type of vascular tissue through which water and dissolved minerals are transported upward through a plant from the root to the stems and leaves.

yolk A food substance, rich in protein and lipid, found in the eggs of many animal species.

yolk sac The membrane that surrounds the yolk food supply of the embryos of many animal species.

zygote The single diploid cell that results from the fusion of gametes in sexual reproduction; a fertilized egg.

Examination August 2002

Living Environment

PART A

Answer all 35 questions in this part. [35]

Directions (1-35): For each statement or question, select the word or expression that, of those given, best completes the statement or answers the question. Record your answers in the spaces provided.

1 A student formulated a hypothesis that cotton will grow larger bolls (pods) if magnesium is added to the soil. The student has two experimental fields of cotton, one with magnesium and one without. Which data should be collected to support this hypothesis?

1 height of the cotton plants in both fields
2 diameter of the cotton bolls in both fields
3 length of the growing season in both fields
4 color of the cotton bolls in both fields 1_____

2 To separate leaf pigments, a biologist should use

1 chromatography
2 dissection
3 an electronic balance
4 a dichotomous key 2_____

3 A food web is more stable than a food chain because a food web

1 transfers all of the producer energy to herbivores
2 reduces the number of niches in the ecosystem
3 includes alternative pathways for energy flow
4 includes more consumers than producers 3_____

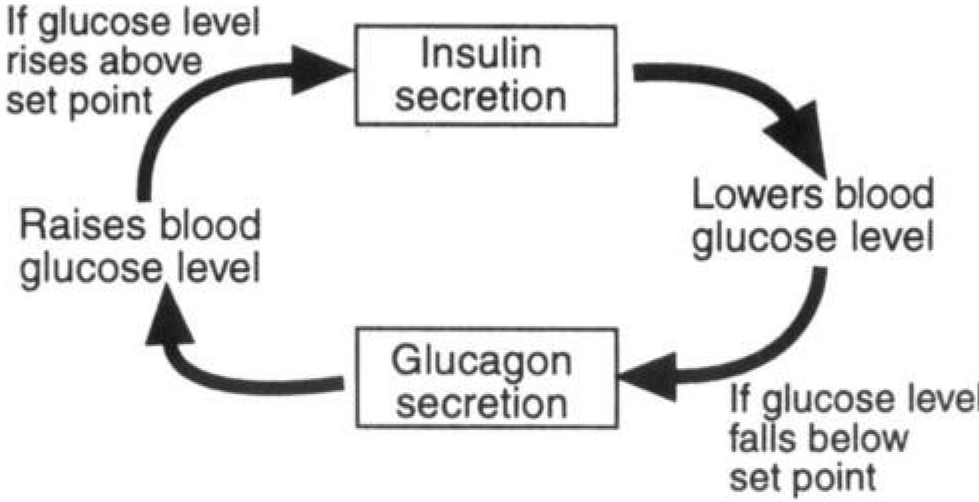
4 Which sequence of terms is in the correct order from simplest to most complex?

1 cells → tissues → organs → organ systems
2 tissues → organisms → cells → organ systems
3 cells → tissues → organ systems → organs
4 organs → organisms → organ systems → cells 4_____

5 For which organic compounds must information be encoded in DNA for green plants to synthesize the other three compounds?

1 sugars
2 starches
3 fats
4 proteins 5_____

6 The diagram below represents the actions of two hormones in the human body.



This diagram best illustrates

1 recombination
2 feedback
3 insertion
4 deletion

6_____

7 The pancreas is an organ connected to the digestive tract of humans by a duct (tube) through which digestive enzymes flow. These enzymes are important to the digestive system because they

1 form proteins needed in the stomach
2 form the acids that break down food
3 change food substances into molecules that can pass into the bloodstream and cells
4 change food materials into wastes that can be passed out of the body

7_____

8 While viewing a slide of rapidly moving sperm cells, a student concludes that these cells require a large amount of energy to maintain their activity. The organelles that most directly provide this energy are known as

1 vacuoles
2 ribosomes
3 chloroplasts
4 mitochondria

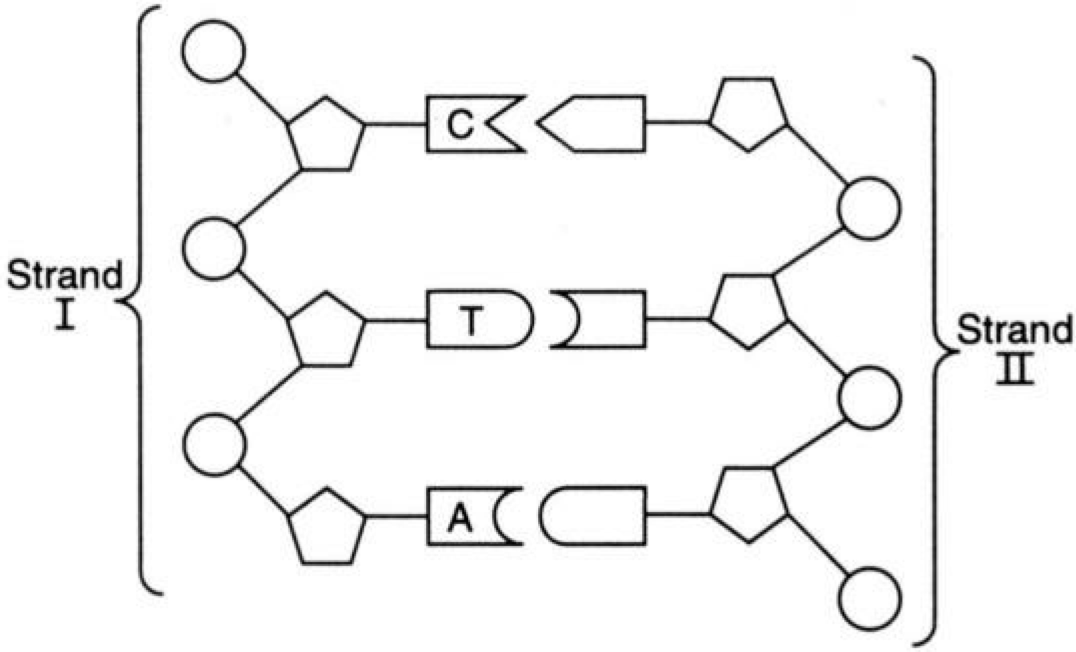
8_____

9 Meiosis and fertilization are important processes because they may most immediately result in

1 many body cells
2 immune responses
3 genetic variation
4 natural selection

9_____

10 In the diagram below, strands I and II represent portions of a DNA molecule.



Strand II would normally include

1 AGC
1 TCG
3 TAC
4 GAT

10_____

11 In Siamese cats, the fur on the ears, paws, tail, and face is usually black or brown, while the rest of the body fur is almost white. If a Siamese cat is kept indoors where it is warm, it may grow fur that is almost white on the ears, paws, tail, and face, while a Siamese cat that stays outside where it is cold, will grow fur that is quite dark on these areas. The best explanation for these changes in fur color is that

1 an environmental factor influences the expression of this inherited trait
2 the location of pigment-producing cells determines the DNA code of the genes
3 skin cells that produce pigments have a higher mutation rate than other cells
4 the gene for fur color is modified by interactions with the environment

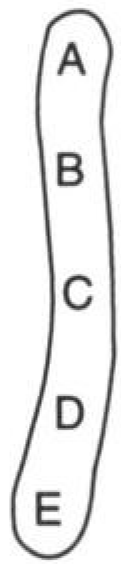
11_____

12 After a series of cell divisions, an embryo develops different types of body cells such as muscle cells, nerve cells, and blood cells. This development occurs because

1 the genetic code changes as the cells divide
2 different segments of the genetic instructions are used to produce different types of cells
3 different genetic instructions are synthesized to meet the needs of new types of cells
4 some parts of the genetic materials are lost as a result of fertilization

12_____

13 The letters in the diagram below represent genes on a particular chromosome.

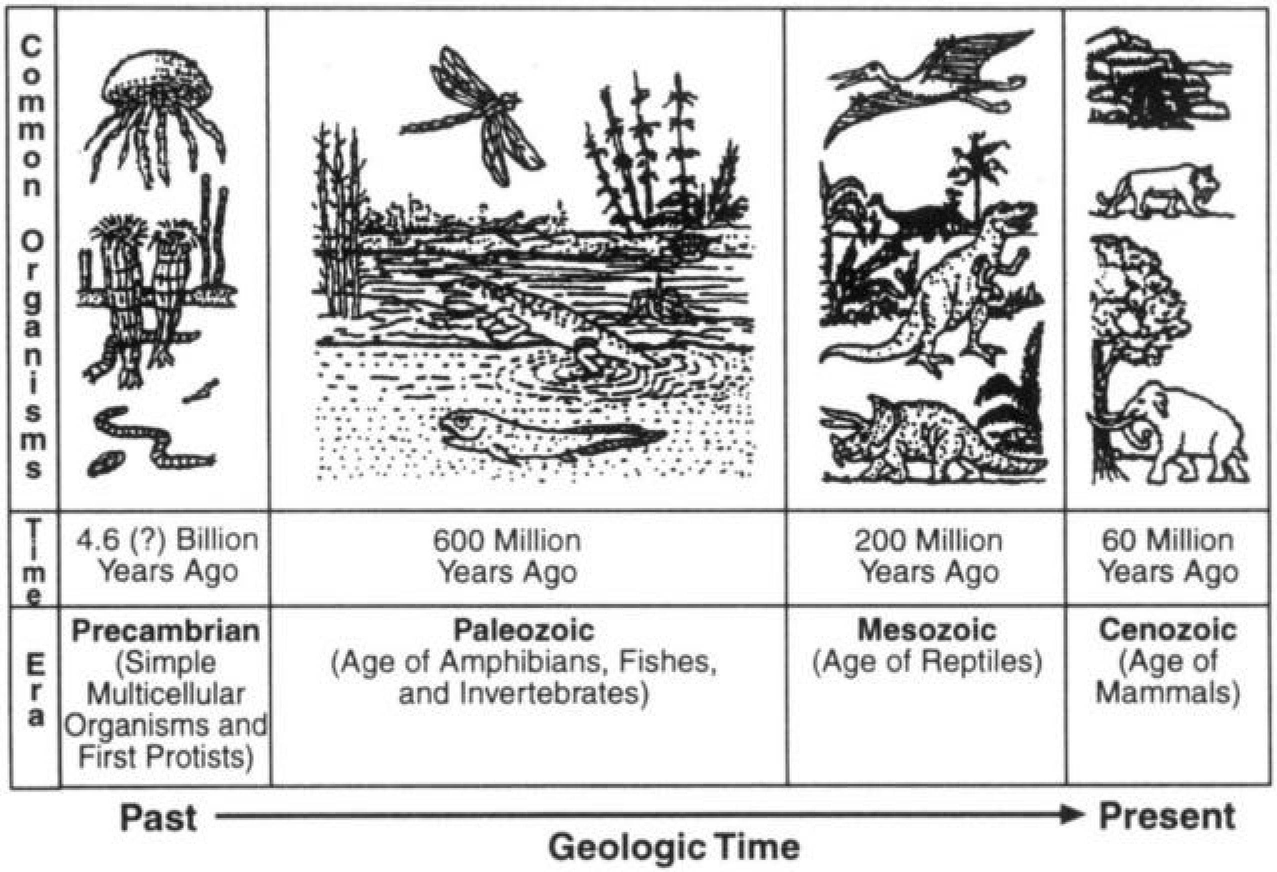


Gene B contains the code for an enzyme that cannot be synthesized unless gene A is also active. Which statement best explains why this can occur?

1 A hereditary trait can be determined by more than one gene.
2 Genes are made up of double-stranded segments of DNA.
3 All the genes on a chromosome act to produce a single trait.
4 The first gene on each chromosome controls all the other genes on the chromosome.

13_____

14 Information related to the organisms found on Earth during various geological time periods is represented in the chart below.



Which statement concerning the first appearance of the organisms over the time period represented in this chart is most likely correct?

1 Life on Earth has remained the same.
2 Life on Earth has changed from primitive organisms to more complex organisms.
3 Life on Earth began with complex organisms and changed to more complex organisms.
4 Life on Earth has changed rapidly.

14_____

15 In an area in Africa, temporary pools form where rivers flow during the rainy months. Some fish have developed the ability to use their ventral fins as "feet" to travel on land from one of these temporary pools to another. Other fish in these pools die when the pools dry up. What can be expected to happen in this area after many years?

1 The fish using ventral fins as "feet" will be present in increasing numbers.
2 "Feet" in the form of ventral fins will develop on all fish.
3 The fish using ventral fins as "feet" will develop real feet.
4 All of the varieties of fish will survive and produce many offspring. 15_____

16 Some stages in the development of an individual are listed below.

(A) differentiation of cells into tissues

(B) fertilization of egg by sperm

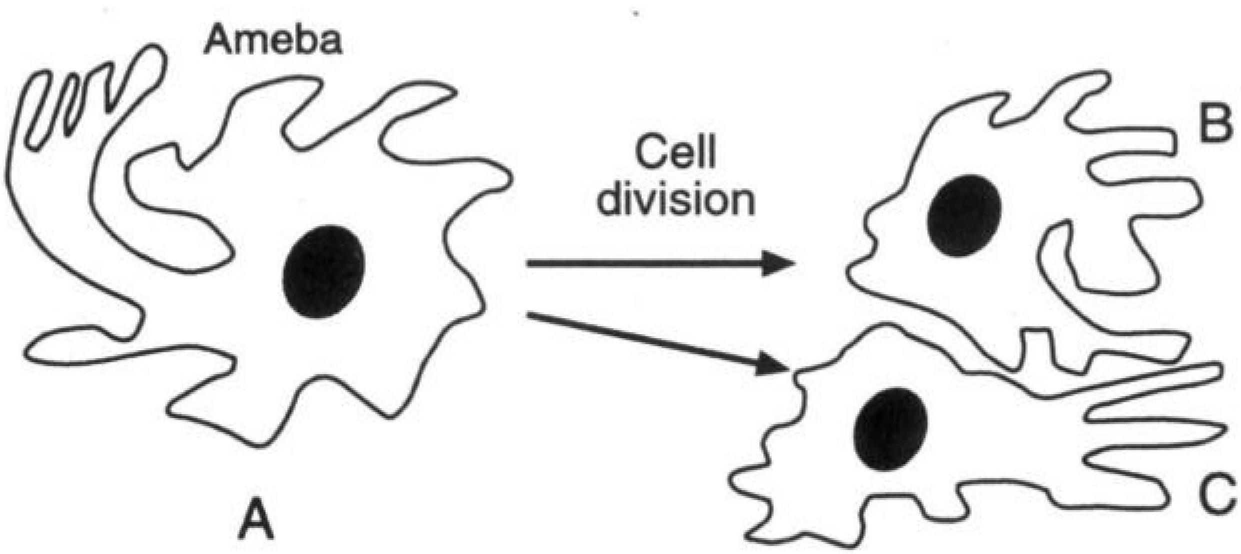
(C) organ development

(D) mitotic cell division of zygote

Which sequence represents the correct order of these stages?

(1) *A–B–C–D* (3) *D–B–C–A*
(2) *B–C–A–D* (4) *B–D–A–C* 16_____

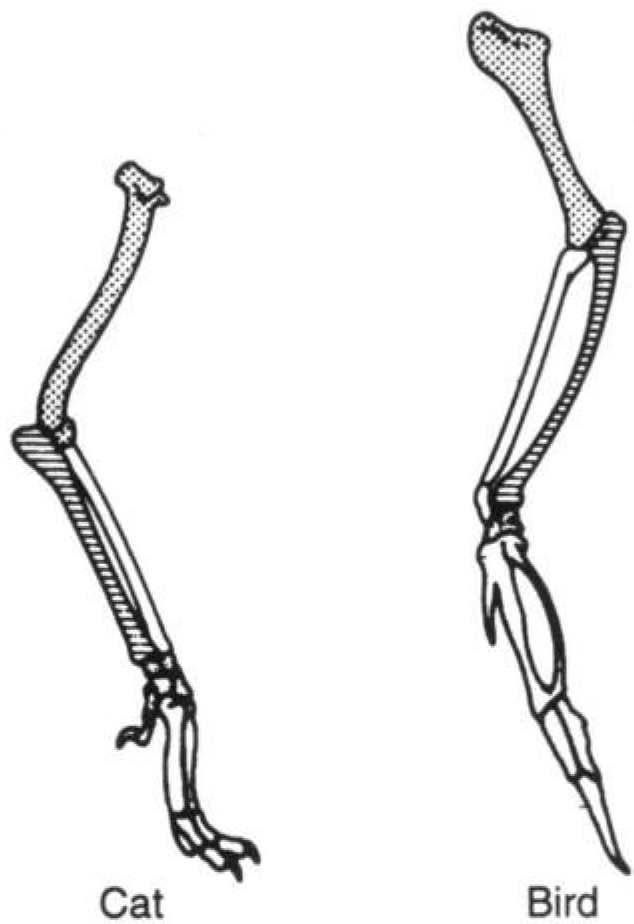
17 The diagram below represents a cell process.



Which statement regarding this process is correct?

1 Cell B contains the same genetic information that cells A and C contain.
2 Cell C has DNA that is only 50% identical to cell B.
3 Cell A has DNA that is only 75% identical to cell B.
4 Cells A, B, and C contain completely different genetic information. 17_____

18 The diagram below shows the bones in the forelimbs of two different vertebrate species.



The position and structure of these bones could best be used to make inferences about the

1 food preferences of these vertebrate species
2 intelligence of these vertebrate species
3 history of these vertebrate species
4 reproductive behavior of these vertebrate species 18_____

19 Which statement does not correctly describe an adaptation of the human female reproductive system?

1 It produces gametes in ovaries.
2 It provides for external fertilization of an egg.
3 It provides for internal development of the embryo.
4 It removes excretions produced by the fetus. 19_____

20 Testes are adapted to produce

1 body cells involved in embryo formation
2 immature gametes that undergo mitosis
3 sperm cells that may be involved in fertilization
4 gametes with large food supplies that nourish a developing embryo 20_____

21 In nature, during a 24-hour period, green plants continuously use

1 carbon dioxide, only
2 both carbon dioxide and oxygen
3 oxygen, only
4 neither carbon dioxide nor oxygen 21_____

22 To remain healthy, organisms must be able to obtain materials, change the materials, move the materials around, and get rid of waste. These activities directly require

1 energy from ATP
2 the replication of DNA
3 nutrients from inorganic sources
4 manipulation of altered genes 22_____

23 Which statement describes all enzymes?

1 They control the transport of materials.
2 They provide energy for chemical reactions.
3 They affect the rate of chemical reactions.
4 They absorb oxygen from the environment. 23_____

24 Organisms undergo constant chemical changes as they maintain an internal balance known as

1 interdependence
2 homeostasis
3 synthesis
4 recombination 24_____

25 Which condition would most likely result in a human body being unable to defend itself against pathogens and cancerous cells?

1 a genetic tendency toward a disorder such as diabetes
2 a parasitic infestation of ringworm on the body
3 the production of antibodies in response to an infection in the body
4 the presence in the body of the virus that causes AIDS

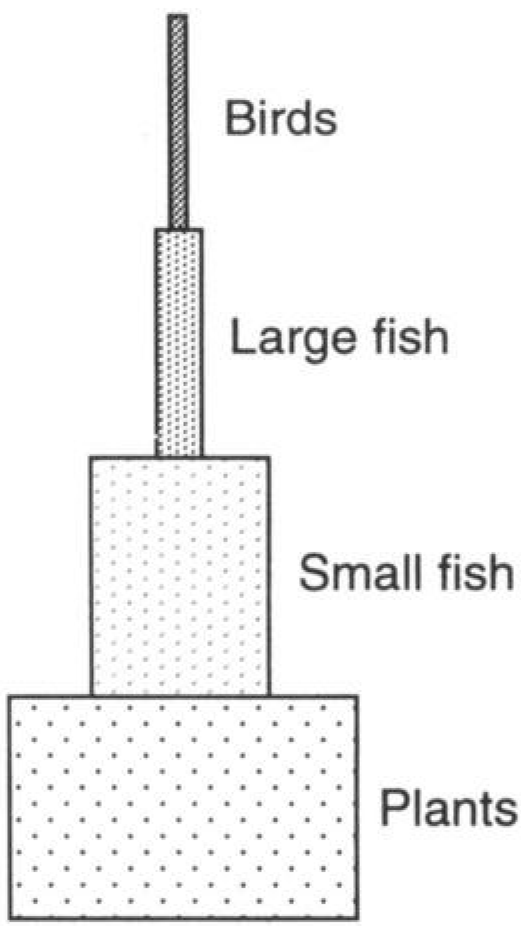
25_____

26 Scientific studies have indicated that there is a higher percentage of allergies in babies fed formula containing cow's milk than in breast-fed babies. Which statement represents a valid inference made from these studies?

1 Milk from cows causes allergic reactions in all infants.
2 Breast feeding prevents all allergies from occurring.
3 There is no relationship between drinking cow's milk and having allergies.
4 Breast milk most likely contains fewer substances that trigger allergies.

26_____

27 The diagram below represents a model of a food pyramid.



Which statement best describes what happens in this food pyramid?

1 More organisms die at higher levels than at lower levels, resulting in less mass at higher levels.
2 Energy is lost to the environment at each level, so less mass can be supported at each higher level.
3 When organisms die at higher levels, their remains sink to lower levels, increasing the mass of lower levels.
4 Organisms decay at each level, and thus less mass can be supported at succeedingly higher levels. 27_____

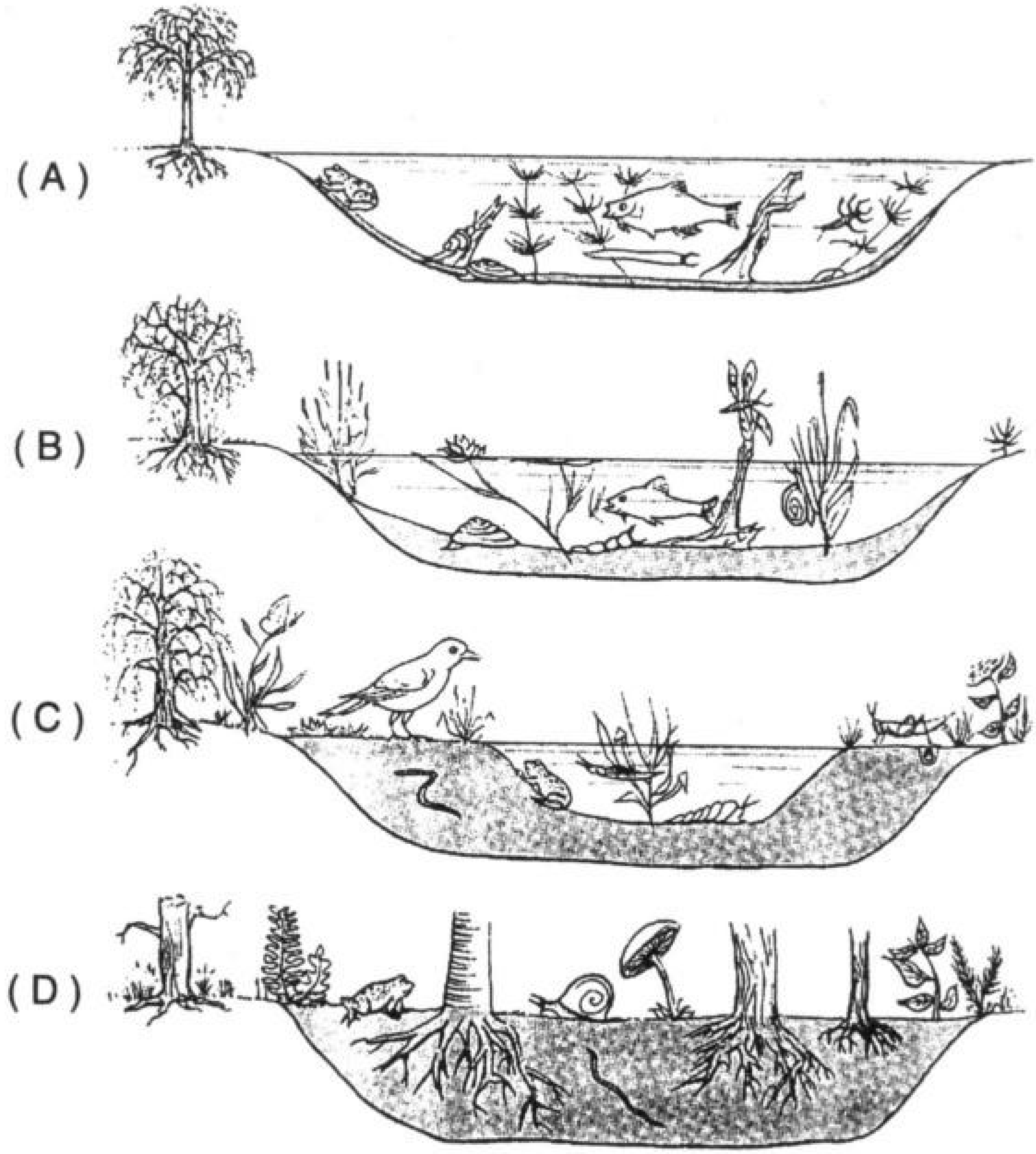
28 Which energy transfer is least likely to be found in nature?

1 consumer to consumer
2 producer to consumer
3 host to parasite
4 predator to prey 28_____

29 Which ecosystem has a better chance of surviving when environmental conditions change over a long period of time?

1 one with a great deal of genetic diversity
2 one with plants and animals but no bacteria
3 one with animals and bacteria but no plants
4 one with little or no genetic diversity 29_____

30 The diagrams below show some changes in an environment over time.



Which phrase best describes this sequence of diagrams?

1 the path of energy through a food web in a natural community
2 the altering of an ecosystem by a natural disaster
3 natural communities replacing each other in an orderly sequence
4 similarities between an aquatic ecosystem and a terrestrial ecosystem

30_____

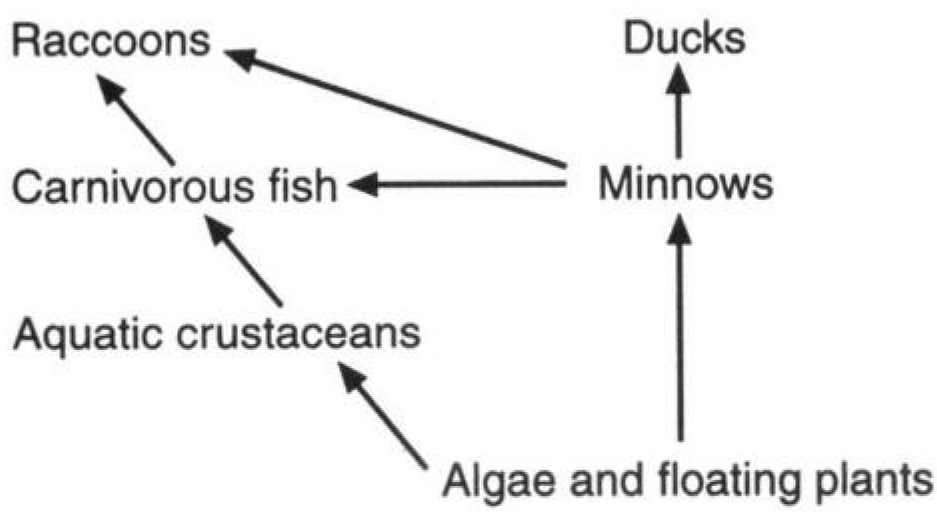
31 Which factor is often responsible for the other three?

1 increase in levels of toxins in both water and air
2 increase in human population
3 increased poverty and malnutrition
4 increased depletion of finite resources 31_____

32 By causing atmospheric changes through activities such as polluting and careless harvesting, humans have

1 caused the destruction of habitats
2 affected global stability in a positive way
3 established equilibrium in ecosystems
4 replaced nonrenewable resources 32_____

33 The diagram below illustrates the relationships between organisms in an ecosystem.



Which change would most likely reduce the population size of the carnivorous fish?

1 an increase in the autotroph populations
2 a decrease in the duck population
3 an increase in the raccoon population
4 a decrease in pathogens of carnivorous fish 33_____

34 Dumping raw sewage into a river will lead to a reduction in dissolved oxygen. in the water. This reduction will most likely cause

1 an increase in all fish populations
2 a decrease in most aquatic animal populations
3 an increase in depth of the water
4 a decrease in water temperature 34_____

35 Which method of controlling populations of mosquitoes most likely involves the least risk of

causing damage to the environment?

1 draining swamps where mosquitoes deposit eggs
2 spraying adult mosquitoes with pesticides from airplanes
3 releasing more predators of mosquitoes native to mosquito habitats
4 spraying oil on wet areas where mosquitoes breed 35_____

PART B

Answer all questions in this part. [30]

For those questions that are+followed by four choices, record your answers in the spaces provided. For all other questions in this part, record your answers in accordance with the directions given in the question.

36 A researcher needs information on antigenantibody reactions. Searching for which phrase would best lead the researcher to information about these reactions?

1 protein synthesis
2 energy sources in nature
3 white blood cell activity
4 DNA replication 36_____

Base your answers to questions 37 and 38 on the table below and on your knowledge of biology.

Volunteer	Injected with Dead Chicken Pox Virus	Injected with Dead Mumps Virus	Injected with Distilled Water
A	X		
B		X	
C			X
D	X	X	

37 None of these volunteers ever had chicken pox. After the injection, there would most likely be antibodies to chicken pox in the bloodstream of

1 volunteers *A* and *D*, only
2 volunteers *A*, *B*, and *D*
3 volunteer *C*
4 volunteer *D*, only 37_____

38 Volunteers A, B, and D underwent a procedure known as

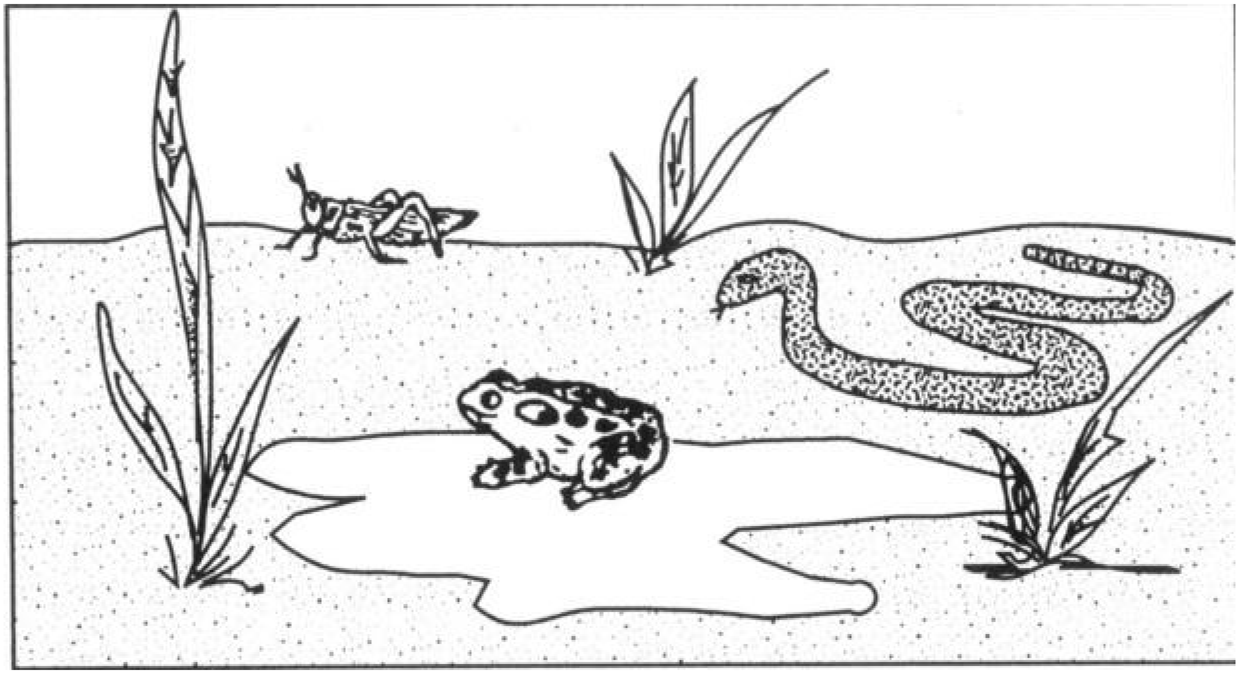
1 cloning
2 vaccination
3 electrophoresis
4 chromatography 38_____

39 The photograph below shows a microscopic view of the lower surface of a leaf.

What is the main function of the cells indicated by the black pointer?

1 regulate the rate of gas exchange
2 store food for winter dormancy
3 undergo mitotic cell division
4 give support to the veins in the leaf 39_____

Base your answers to questions 40 and 41 on the diagram below and on your knowledge of biology.



40 Which organism carries out autotrophic nutrition?

1 frog
2 snake
3 plant
4 grasshopper 40_____

41 The base of an energy pyramid for this ecosystem would include a

1 frog
2 snake
3 plant
4 grasshopper 41_____

Base your answers to questions 42 through 46 on the information and data table below and on your knowledge of biology.

A biology student performed an experiment to determine which of two species of single-celled organisms would survive best when cultured together in a certain environment. The student placed 10 organisms of each species into a large test tube. Throughout the experiment, the test tube was maintained at 30°C. After the test tube was set up, the population of each species was determined each day for 5 days. The data collected are shown in the table below.

Data Table

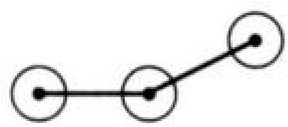
Day	Population	
	Species A	Species B
1	10	10
2	16	16
3	32	32
4	48	12
5	60	4

Directions (42-44): Using the information in the data table, construct a line graph on the grid on the next page, following the directions below.

42 Mark an appropriate scale on each labeled axis. [1]

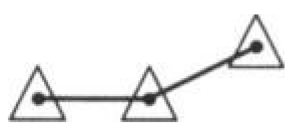
43 Plot the data for species A on the grid. Surround each point with a small circle and connect the points. [1]

Example:

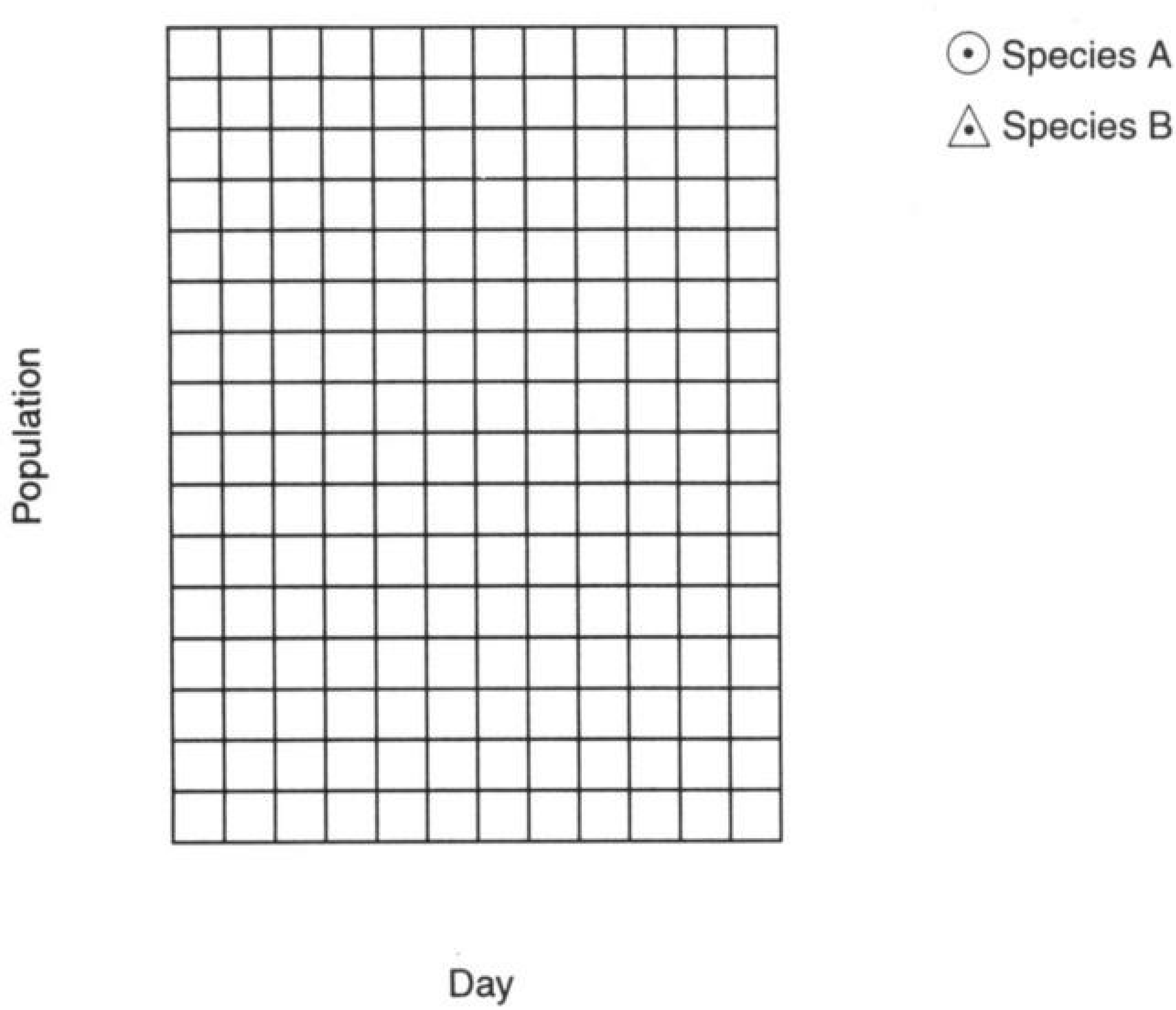


44 Plot the data for species B on the grid. Surround each point with a small triangle and connect the points. [1]

Example:



42–44



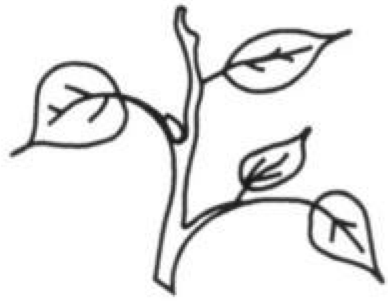
45 Based on the daily counts, on which day did it first become evident that one species was better adapted than the other species for survival in the environment provided? [1]

46 The difference in the population sizes on the fifth day most likely resulted from

1 temperature changes
2 variations in light intensity
3 competition between species
4 the buildup of nitrogen gas 46_____

Base your answers to questions 47 through 49 on the information, diagram, and table below and on your knowledge of biology.

A student wanted to test the hypothesis that rooting hormones will stimulate the production of new roots at a faster rate than would take place without rooting hormones. Two stem cuttings of equal length, similar to the one shown below, were taken from a rose, a begonia, and a geranium plant.



The cut end of one cutting from each plant was dipped into the hormone and then planted in wet sand. The other cutting from each plant was planted in wet sand without dipping it into the hormone. All cuttings were maintained in identical environmental conditions. At the end of 4 weeks, all the cuttings were removed from the sand and the lengths of the roots that had developed were measured. The results are summarized in the data table below.

Plant Cutting	Total Length of Roots in Centimeters	
	Treated with Hormone	Untreated
Begonia	1.50	1.00
Geranium	0.75	0.50
Rose	0.00	0.00

47 The effect of the rooting hormone on the production of new roots was most likely due to the influence of the hormone on the process of

1 photosynthesis
2 meiosis
3 mitosis
4 excretion

47______

48 Describe one way the student could make the experiment more valid. [1]

____

____

____

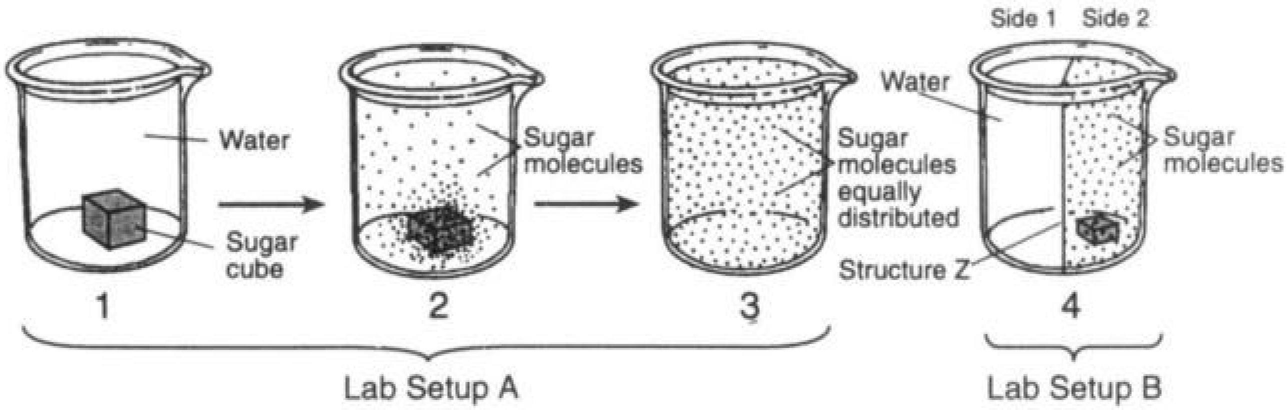
49 What purpose did the untreated cuttings serve in this experiment? [1]

____

____

____

Base your answers to questions 50 and 51 on the diagram below of sugar in a beaker of water and on your knowledge of biology.



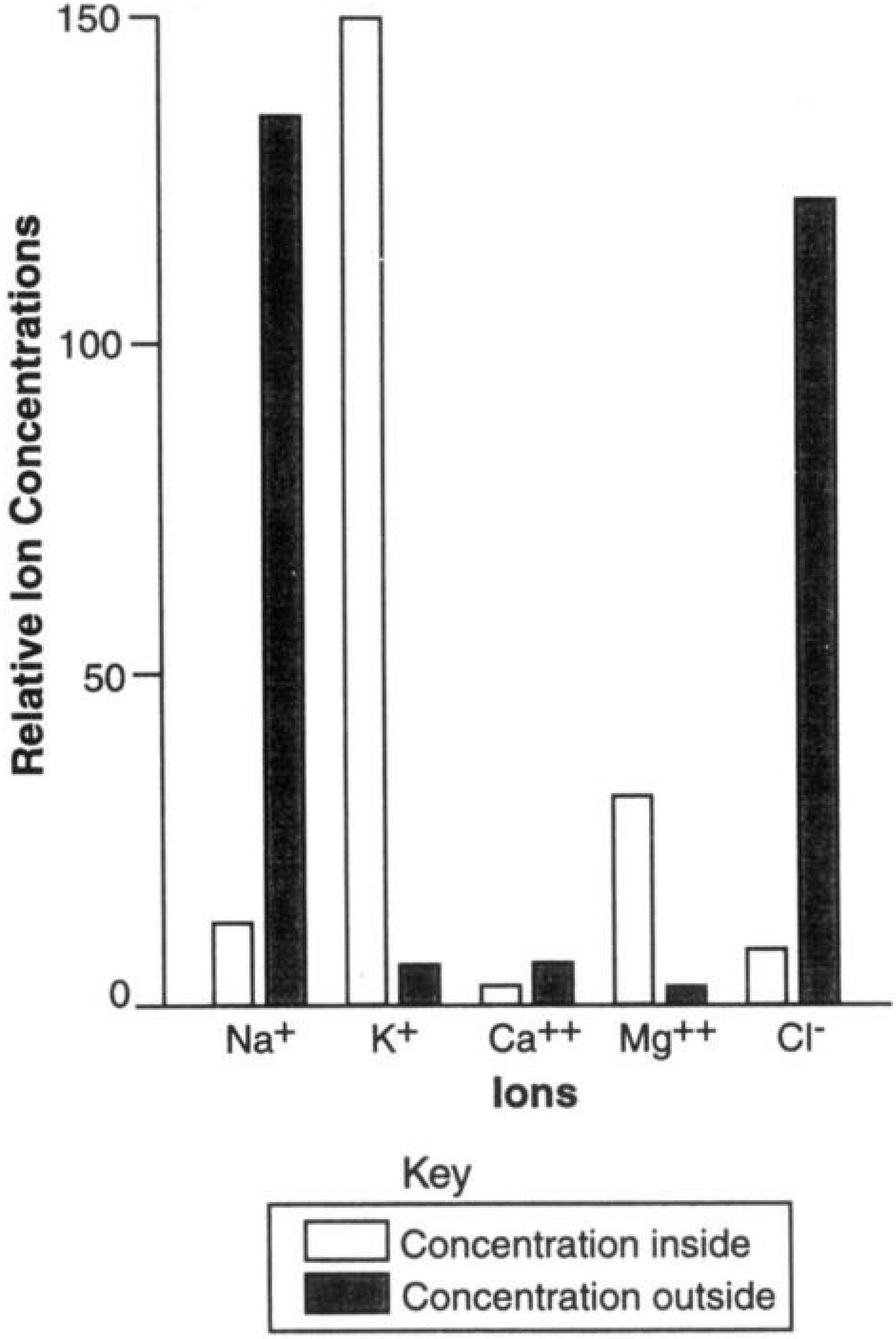
50 What process accounts for the change shown in lab setup A? [1]

____

51 In lab setup B, structure Z prevents the movement of sugar molecules into side 1. Which part of a living cell serves the same purpose as structure Z? [1]

____

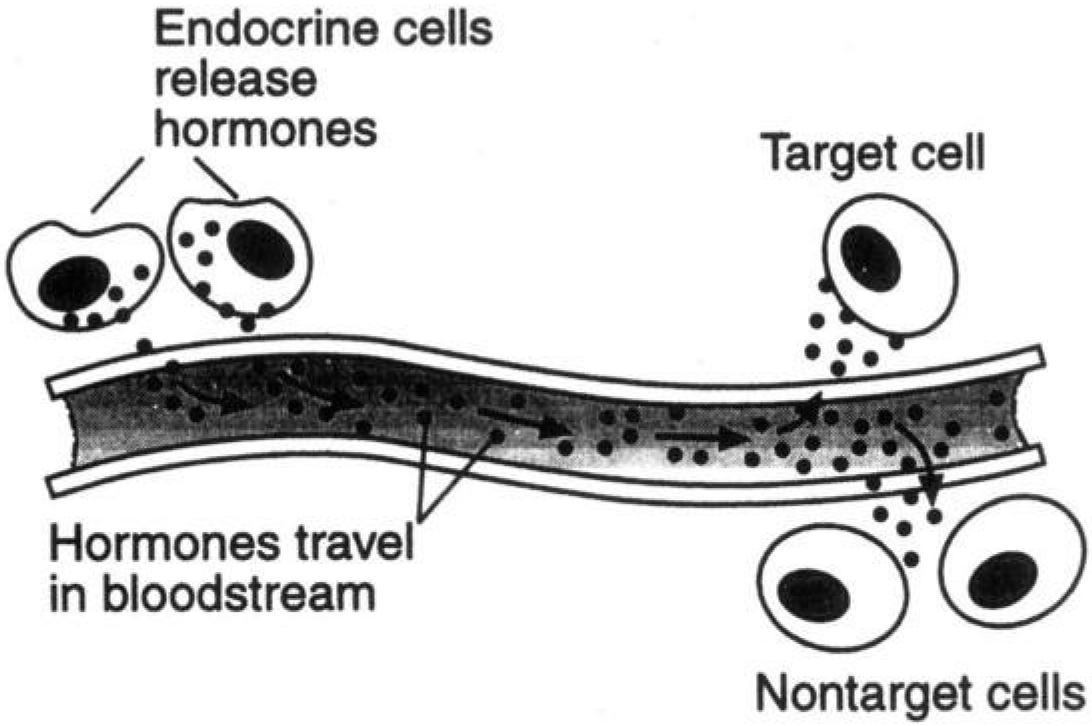
Base your answers to questions 52 and 53 on the graph below and on your knowledge of biology. The graph shows the relative concentrations of different ions inside and outside of an animal cell.



52 Write the symbol of the ion that is closest to equilibrium inside and outside of the cell. [1]

53 Name the process responsible for maintaining high concentrations of K+ ions inside the cell. [1]

54 The diagram below shows a biological process.



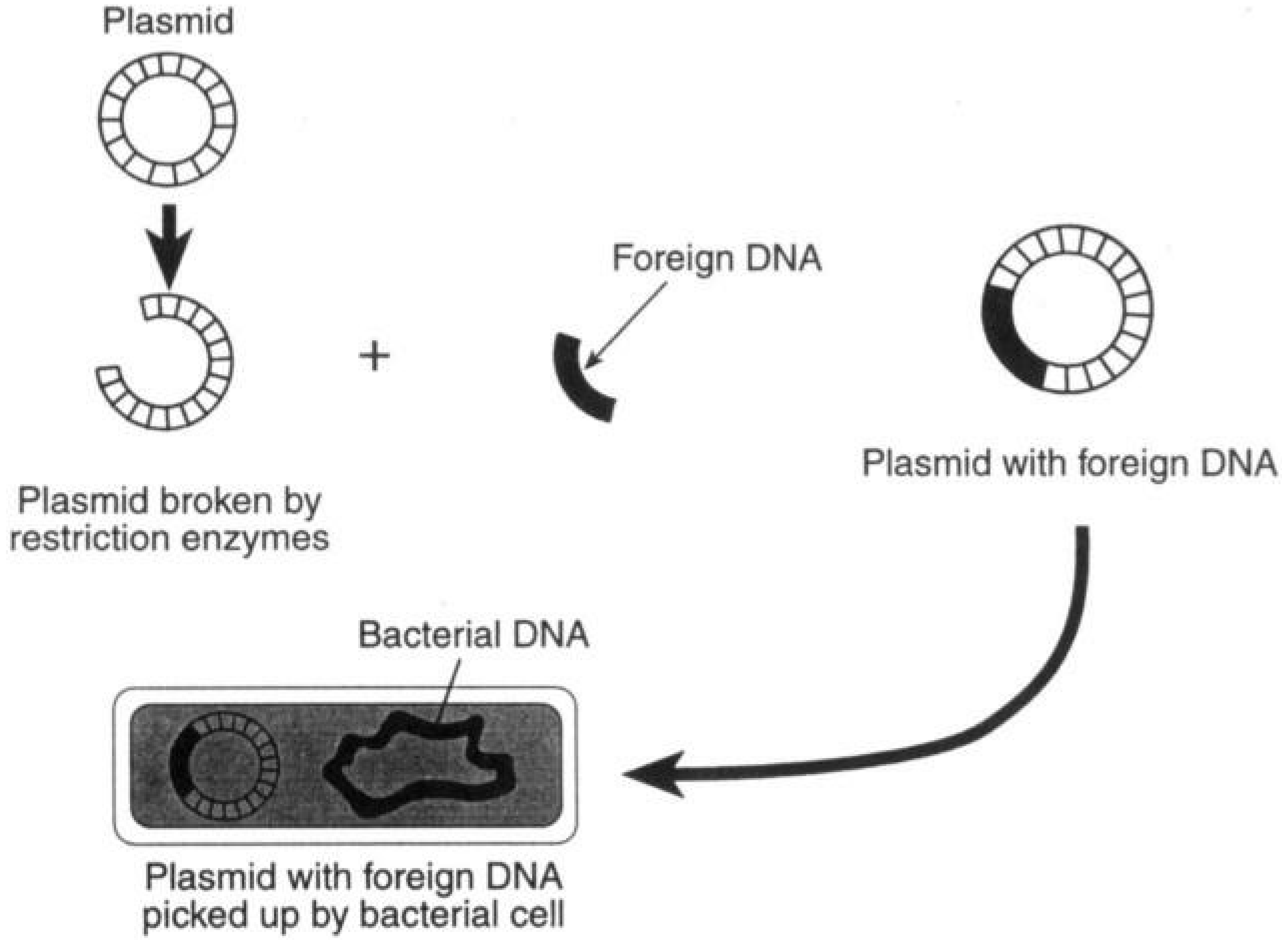
Explain why the hormones attach to the target cell and not to other cells in the diagram. [1]

____

____

____

55 The diagram below represents a technique used in biotechnology.



Name a specific substance that can be produced by this technique and state how humans have benefited from the production of this substance. [2]

Base your answers to questions 56 and 57 on the passage below and on your knowledge of biology.

The Human Genome Project

For a number of years, scientists at Cold Spring Harbor Laboratory have been attempting to map every known human gene. By mapping, scientists mean that they are trying to find out on which of the 46 chromosomes each gene is located and exactly where on the chromosome the gene is located. By locating the exact positions of defective genes, scientists hope to cure diseases by replacing defective genes with normal ones, a technique known as gene therapy. Scientists can use specific enzymes to cut out the defective genes and insert the normal genes. They must be careful to use the enzyme that will splice out only the target gene, since different enzymes will cut DNA at different locations.

While the human genome project should eventually improve the health of humans, many people are skeptical and apprehensive, believing that gene therapy would be working against nature and would have religious, moral, legal, and ethical implications.

56 Using one specific example, explain why the human genome project is considered important. [1]

57 Explain why scientists must use only certain enzymes when inserting or removing a defective gene from a cell. [1]

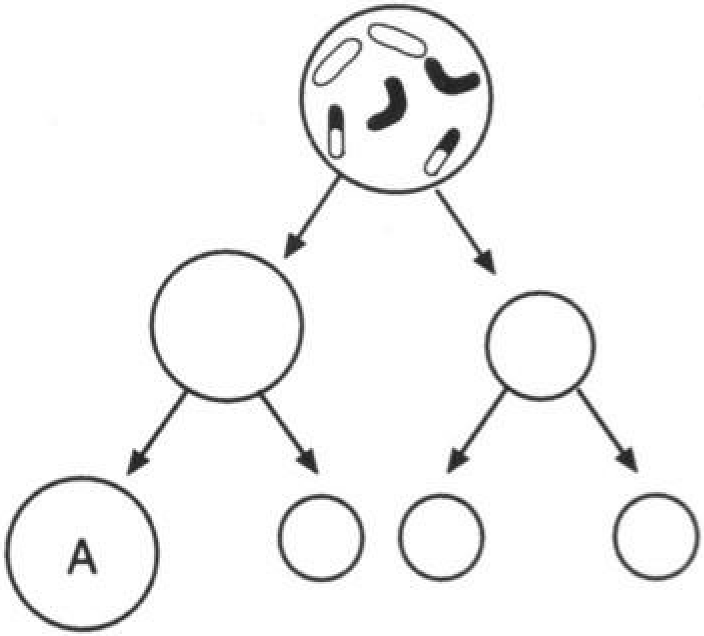
58 Explain why, in a mammal, a mutation in a gamete may contribute to evolution while a mutation in a body cell will not. [1]

59 A certain chemical destroys bacteria that have thin cell walls. Bacteria with thick cell walls are not affected. Describe how the introduction of this chemical into a culture containing both types of bacteria could be used to illustrate the theory of natural selection. [1]

60 The diagram below represents a woolly mammoth, a relative of the modern elephant. Woolly mammoths lived during the Ice Age and eventually became extinct.

State one possible reason this species died out. [1]

61 An incomplete diagram of meiosis in the ovary of an animal is shown below.



On the diagram below, draw in the chromosomes of cell A. Your drawing should show the usual result of the process of meiosis. [1]

62 The loss of ozone in the upper atmosphere results in an increased amount of ultraviolet light reaching Earth from the Sun. Explain how this increase may be harmful, other than contributing in a small way to global warming, to life on Earth. [1]

63 Recycling can extend the use of nonrenewable resources but can not restore them. Humans can restore renewable resources to reduce some negative effects of increased human consumption. Identify one resource that is renewable, and describe one specific way humans can restore this resource if it is being depleted. [2]

PART C

Answer all questions in this part. [35]

Directions (64-78): Record your answers in the spaces provided.

Base your answers to questions 64 and 65 on the information below and on your knowledge of biology.

Mountain lions and big horn sheep are part of the natural food web in the Sierra Nevada mountains. The fish and Wildlife Service recently declared these sheep an endangered species. This action could lead to the shooting of mountain lions.

64 State one reason placing these sheep on an endangered species list could lead to the shooting of mountain lions where the sheep live. [1]

65 State two reasons some people would oppose the shooting of the mountain lions. [2]

(1) ______________________________

____

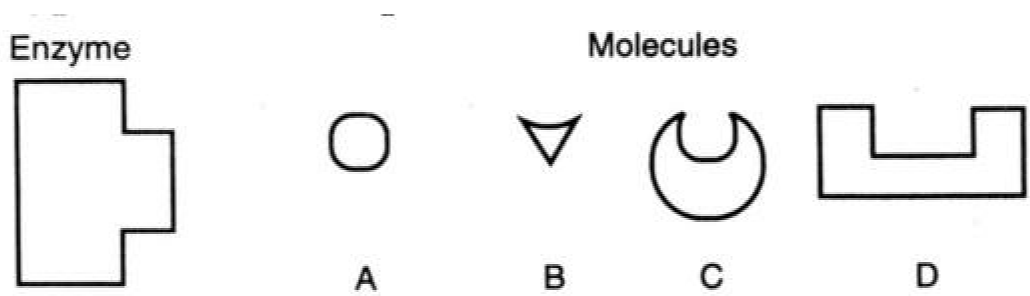
____

(2) ______________________________

____

____

Base your answers to questions 66 through 68 on the diagram below that represents a human enzyme and four types of molecules present in a solution in a flask.



66 Which molecule would most likely react with the enzyme? [1]

____

67 Explain your answer to question 66. [1]

____

____

____

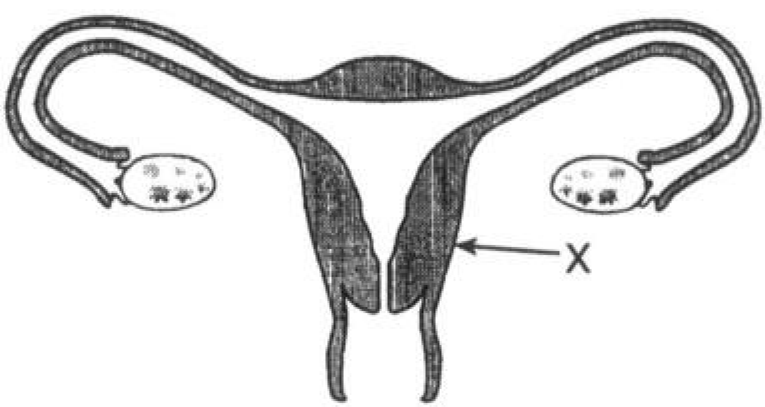
68 State what would most likely happen to the rate of reaction if the temperature of the solution in the flask were increased gradually from 10°C to 30°C. [1]

____

____

____

69 A diagram of the human female reproductive system is shown below.



Identify the structure labeled X and explain how it helps to provide nutrition for a developing fetus. [2]

____

____

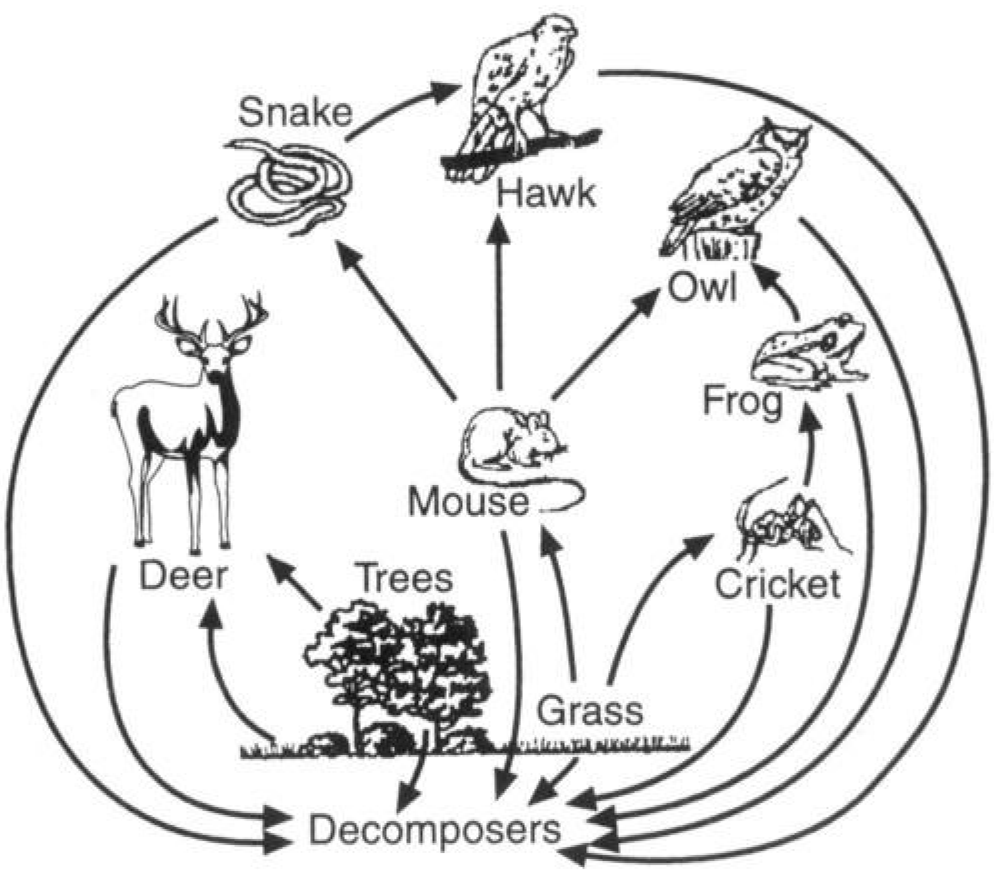
____

____

____

____

Base your answers to questions 70 through 72 on the food web shown below and on your knowledge of biology.



70 A pesticide is sprayed to kill the crickets. State one effect this spraying might have on the food

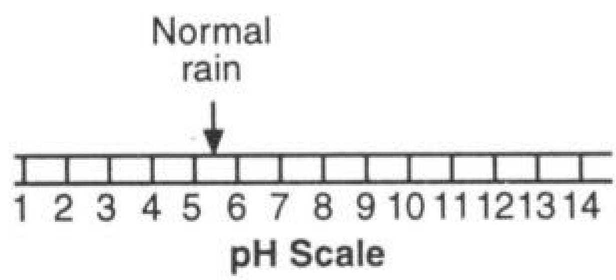
web. [I]

71 What is the significance of the arrow between the trees and the deer in the food web? [1]

72 State the role of the decomposers in the food web. [1]

Base your answers to questions 73 through 76 on the information below.

Acid rain can have a pH between 1.5 and 5.0. The effect of acid rain on the environment depends on the pH of the rain and the characteristics of the environment. It appears that acid rain has a negative effect on plants. The scale below shows the pH of normal rain.



Provide the information requested below that should be included in a research plan to test the effect of pH on the early growth of bean plants in the laboratory.

73 State a hypothesis. [1]

74 Identify the independent variable. [1]

75 State two factors that should be kept constant. [2]

(1)

(2)

76 Construct a data table to organize the results. [1]

____

Base your answers to questions 77 and 78 on the summary equations of two processes below and on your knowledge of biology.

Photosynthesis

$$\text{water} + \text{carbon dioxide} \xrightarrow{\text{enzymes}} \text{glucose} + \text{oxygen} + \text{water}$$

Respiration

$$\text{glucose} + \text{oxygen} \xrightarrow{\text{enzymes}} \text{water} + \text{carbon dioxide}$$

77a Choose one of the processes.

____

b Identify the source of the energy in the process you chose. [1]

____

c Identify where the energy ends up at the completion of that process. [1]

____

78 State one reason each of the two processes is important for living things. [2]

Photosynthesis:____________________________________

____

____

Respiration:______________________________________

____

____

____

____

ANSWERS TO REGENTS EXAMINATION

AUGUST 2002

PART A

1. 2

2. 1

3. 3

4. 1

5. 4

6.2

7. 3

8. 4

9.3

10. 4

11. 1

12. 2

13. 1

14.2

15. 1

16. 4

17. 1

18. 3

19.2

20. 3

21. 3

22. 1

23. 3

24. 2

25. 4

26. 4

27. 2

28. 4

29. 1

30.3

31.2

32. 1

33. 3

34. 2

35. 3

PART B

36. 3

37. 1

38. 2

39. 1

40. 3

41. 3

46.3

47. 3

Examination June 2003

Living Environment

PART A

Answer all 35 questions in this part. [35]

Directions (1-35): For each statement or question, select the word or expression that, of those given, best completes the statement or answers the question. Record your answers in the spaces provided.

1 A student observes that an organism is green. A valid conclusion that can be drawn from this observation is that

1 the organism must be a plant
2 the organism cannot be single celled
3 the organism must be an animal
4 not enough information is given to determine whether the organism is a plant or an animal

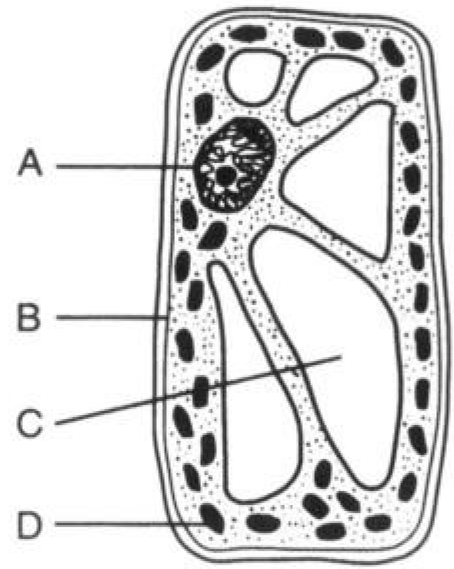
1_____

2 Why do scientists consider any hypothesis valuable?

1 A hypothesis requires no further investigation.
2 A hypothesis may lead to further investigation even if it is disproved by the experiment.
3 A hypothesis requires no further investigation if it is proved by the experiment.
4 A hypothesis can be used to explain a conclusion even if it is disproved by the experiment.

2_____

3 Which letter indicates a cell structure that directly controls the movement of molecules into and out of the cell?



(1) *A* (3) *C*
(2) *B* (4) *D* 3_____

4 A great deal of information can now be obtained about the future health of people by examining the genetic makeup of their cells. There are concerns that this information could be used to deny an individual health insurance or employment. These concerns best illustrate that

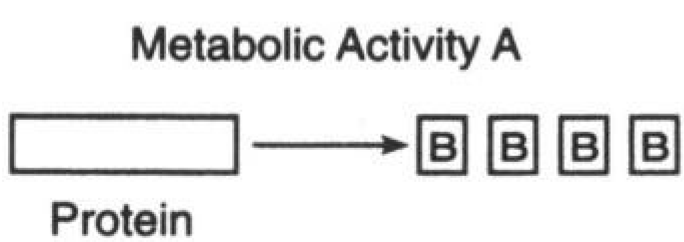
1 scientific explanations depend upon evidence collected from a single source

2 scientific inquiry involves the collection of information from a large number of sources

3 acquiring too much knowledge in human genetics will discourage future research in that area

4 while science provides knowledge, values are essential to making ethical decisions using this knowledge 4_____

5 The diagram below represents one metabolic activity of a human.



Letters A and B are best represented by which row in the chart?

Row	Metabolic Activity A	B
(1)	respiration	oxygen molecules
(2)	reproduction	hormone molecules
(3)	excretion	simple sugar molecules
(4)	digestion	amino acid molecules

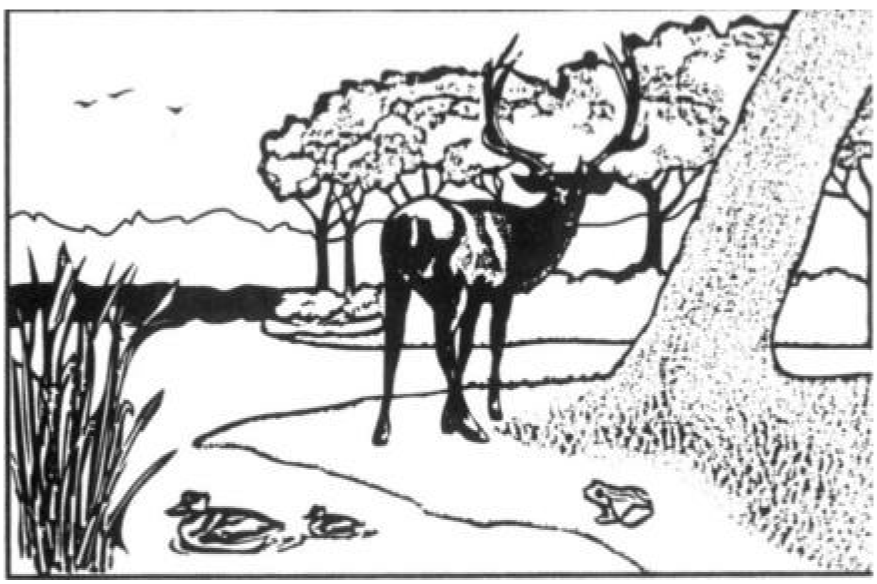
5_____

6 When a person does strenuous exercise, small blood vessels (capillaries) near the surface of the skin increase in diameter. This change allows the body to be cooled. These statements best illustrate

1 synthesis
2 homeostasis
3 excretion
4 locomotion

6_____

7 Which ecological term includes everything represented in the illustration below?



1 ecosystem
2 community
3 population
4 species

7_____

8 Which sequence represents the correct order of levels of organization found in a complex organism?

1 cells → organelles → organs →organ systems → tissues
2 tissues → organs → organ systems → organelles → cells
3 organelles → cells → tissues → organs → organ systems
4 organs → organ systems → cells → tissues → organelles

8_____

9 Scientific studies show that identical twins who were separated at birth and - raised in different homes may vary in height, weight, and intelligence. The most probable explanation for these differences is that

1 original genes of each twin increased in number as they developed
2 one twin received genes only from the mother while the other twin received genes only from the father
3 environments in which they were raised were different enough to affect the expression of their genes
4 environments in which they were raised were different enough to change the genetic makeup of both individuals

9_____

10 When DNA separates into two strands, the DNA would most likely be directly involved in

1 replication
2 fertilization
3 differentiation
4 evolution

10_____

11 The instructions for the traits of an organism are coded in the arrangement of

1 glucose units in carbohydrate molecules
2 bases in DNA in the nucleus
3 fat molecules in the cell membrane
4 energy-rich bonds in starch molecules

11_____

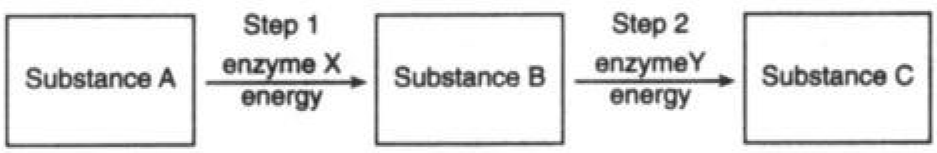
12 Which statement is true regarding an alteration or change in DNA?

1 It is always known as a mutation.
2 It is always advantageous to an individual.
3 It is always passed on to offspring.
4 It is always detected by the process of chromatography. 12_____

13 In heterotrophs, energy for the life processes comes from the chemical energy stored in the bonds of

1 water molecules
2 oxygen molecules
3 organic compounds
4 inorganic compounds 13_____

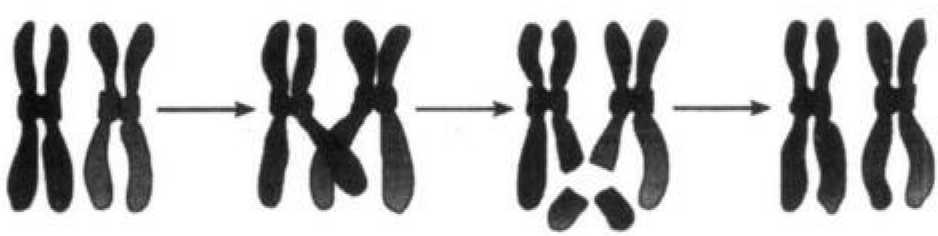
14 The diagram below represents the chemical pathway of a process in a human liver cell.



A particular liver cell is unable to make substance C. One possible explanation for the inability of this cell to make substance C is that

1 excess energy for step 2 prevented the conversion of substance *B* to substance *C*
2 an excess of enzyme *X* was present, resulting in a decrease in the production of substance *B*
3 nuclear DNA was altered resulting in the cell being unable to make enzyme *Y*
4 a mutation occurred causing a change in the ability of the cell to use substance *C* 14_____

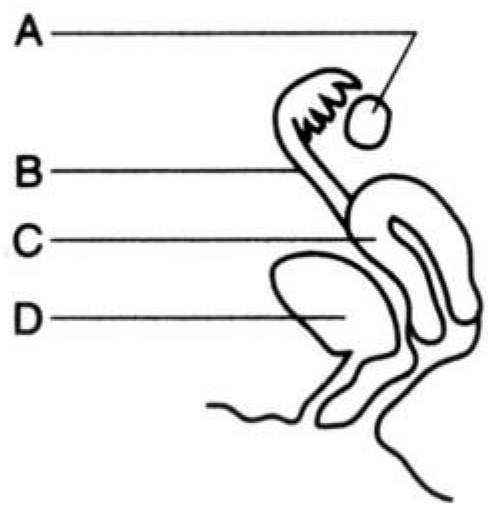
15 The diagram below shows a process that can occur during meiosis.



The most likely result of this process is

1 a new combination of inheritable traits that can appear in the offspring
2 an inability to pass either of these chromosomes on to offspring
3 a loss of genetic information that will produce a genetic disorder in the offspring
4 an increase in the chromosome number of the organism in which this process occurs 15_____

16 Structures in a human female are represented in the diagram below.



A heavy dose of radiation would have the greatest impact on genetic information in future offspring if it reached gametes developing within structure

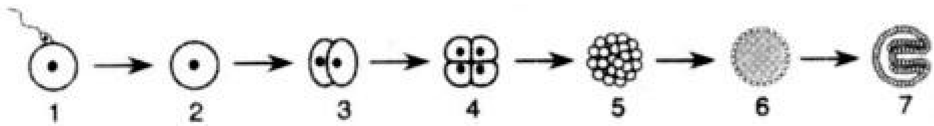
(1) *A*
(2) *B*
(3) *C*
(4) *D* 16_____

17 Organism X appeared on Earth much earlier than organism Y. Many scientists believe organism X appeared between 3 and 4 billion years ago, and organism Y appeared approximately 1 billion years ago. Which row in the chart below most likely describes organisms X and Y?

Row	Organism X	Organism Y
(1)	simple multicellular	unicellular
(2)	complex multicellular	simple multicellular
(3)	unicellular	simple multicellular
(4)	complex multicellular	unicellular

17_____

18 The sequence of diagrams below represents some events in a reproductive process.



To regulate similar events in human reproduction, what adaptations are required?

1 the presence of genes and chemicals in each cell in stages 1 to 7
2 an increase in the number of genes in each cell in stages 3 to 5
3 the removal of all enzymes from the cells in stage 7
4 the elimination of mutations from cells after stage 5

18_____

19 Which statement best describes human insulin that is produced by genetically engineered bacteria?

1 This insulin will not function normally in humans because it is produced by bacteria.
2 This insulin is produced as a result of human insulin being inserted into bacteria cells.
3 This insulin is produced as a result of exposing bacteria cells to radiation, which produces a mutation.
4 This insulin may have fewer side effects than the insulin previously extracted from the pancreas of other animals.

19_____

20 Which population of organisms would be in greatest danger of becoming extinct?

1 A population of organisms having few variations living in a stable environment.
2 A population of organisms having few variations living in an unstable environment.
3 A population of organisms having many variations living in a stable environment.
4 A population of organisms having many variations living in an unstable environment.

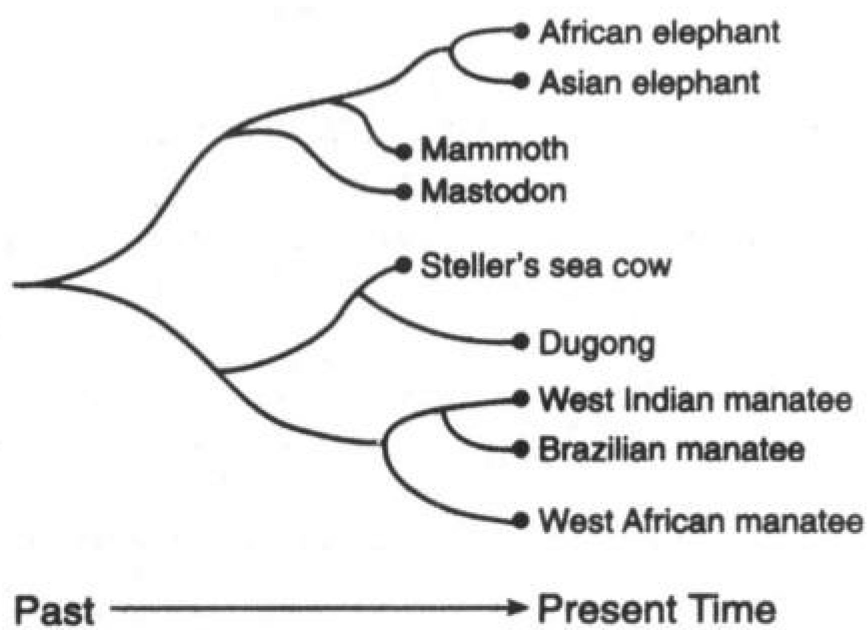
20_____

21 In animals, the normal development of an embryo is dependent on

1 fertilization of a mature egg by many sperm cells
2 production of new cells having twice the number of chromosomes as the zygote
3 production of body cells having half the number of chromosomes as the zygote
4 mitosis and the differentiation of cells after fertilization has occurred

21_____

22 The relationship of some mammals is indicated in the diagram below.



Which statement about the African elephant is correct?

1 It is more closely related to the mammoth than it is to the West African manatee.
2 It is more closely related to the West Indian manatee than it is to the mastodon.
3 It is not related to the Brazilian manatee or the mammoth.
4 It is the ancestor of Steller's sea cow.

22_____

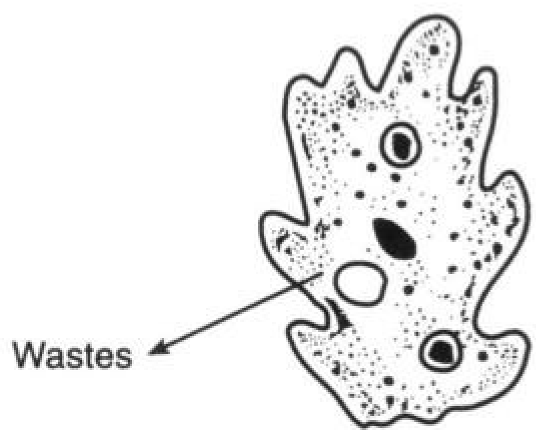
23 Which process normally occurs at the placenta?

1 Oxygen diffuses from fetal blood to maternal blood.
2 Materials are exchanged between fetal and maternal blood.
3 Maternal blood is converted into fetal blood.
4 Digestive enzymes pass from maternal blood to fetal blood. 23_____

24 Individual cells can be isolated from a mature plant and grown with special mixtures of growth hormones to produce a number of genetically identical plants. This process is known as

1 cloning
2 meiotic division
3 recombinant DNA technology
4 selective breeding 24_____

25 A single-celled organism is represented in the diagram below. An activity is indicated by the arrow.



If this activity requires the use of energy, which substance would be the source of this energy?

1 DNA
2 ATP
3 a hormone
4 an antibody 25_____

26 Which activity would stimulate the human immune system to provide protection against an invasion by a microbe?

1 receiving antibiotic injections after surgery
2 choosing a well-balanced diet and following it throughout life
3 being vaccinated against chicken pox
4 receiving hormones contained in mother's milk while nursing 26_____

27 In an ecosystem, the presence of many different species is critical for the survival of some forms of life when

1 ecosystems remain stable over long periods of time
2 significant changes occur in the ecosystem
3 natural selection does not occur
4 the finite resources of Earth increase 27_____

28 The most immediate response to a high level of blood sugar in a human is an increase in the

1 muscle activity in the arms
2 blood flow to the digestive tract
3 activity of all cell organelles
4 release of insulin 28_____

29 Which ecological term best describes the polar bears in the cartoon below?

"I lift, you grab....Was that concept just a little too complex, Carl?"

(adapted)

1 herbivores
2 parasites
3 carnivores
4 producers 29_____

30 A new island formed by volcanic action may eventually become populated with biotic communities as a result of

1 a decrease in the amount of organic material present
2 decreased levels of carbon dioxide in the area
3 the lack of abiotic factors in the area
4 the process of ecological succession 30_____

31 Certain microbes, foreign tissues, and some cancerous cells can cause immune responses in the human body because all three contain

1 antigens
2 enzymes
3 fats
4 cytoplasm 31_____

32 Decomposers are important in the environment because they

1 convert large molecules into simpler molecules that can then be recycled
2 release heat from large molecules so that the heat can be recycled through the ecosystem
3 can take in carbon dioxide and convert it into oxygen
4 convert molecules of dead organisms into permanent biotic parts of an ecosystem 32_____

33 An environment can support only as many organisms as the available energy, minerals, and oxygen will allow. Which term is best described by this statement?

1 biological feedback
2 carrying capacity
3 homeostatic control
4 biological diversity 33_____

34 Communities have attempted to control the size of mosquito populations to prevent the spread of certain diseases such as malaria and encephalitis. Which control method is most likely to cause the least ecological damage?

1 draining the swamps where mosquitoes breed
2 spraying swamps with chemical pesticides to kill mosquitoes
3 spraying oil over swamps to suffocate mosquito larvae
4 increasing populations of native fish that feed on mosquito larvae in the swamps 34_____

35 Which animal has modified ecosystems more than any other animal and has had the greatest negative impact on world ecosystems?

1 gypsy moth
2 zebra mussel
3 human
4 shark

35_____

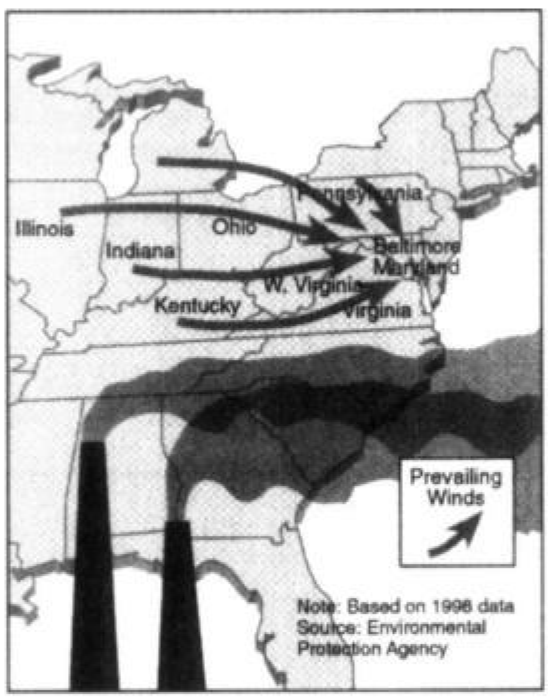
PART B

Answer all questions in this part. [30]

For those questions that are followed by four choices, record your answers in the spaces provided that best completes the statement or answers the question. For all other questions in this part, record your answers in accordance with the directions given in the question.

36 The map below shows the movement of some air pollution across part of the United States.

Movement of Air Pollution



Which statement is a correct inference that can be drawn from this information?

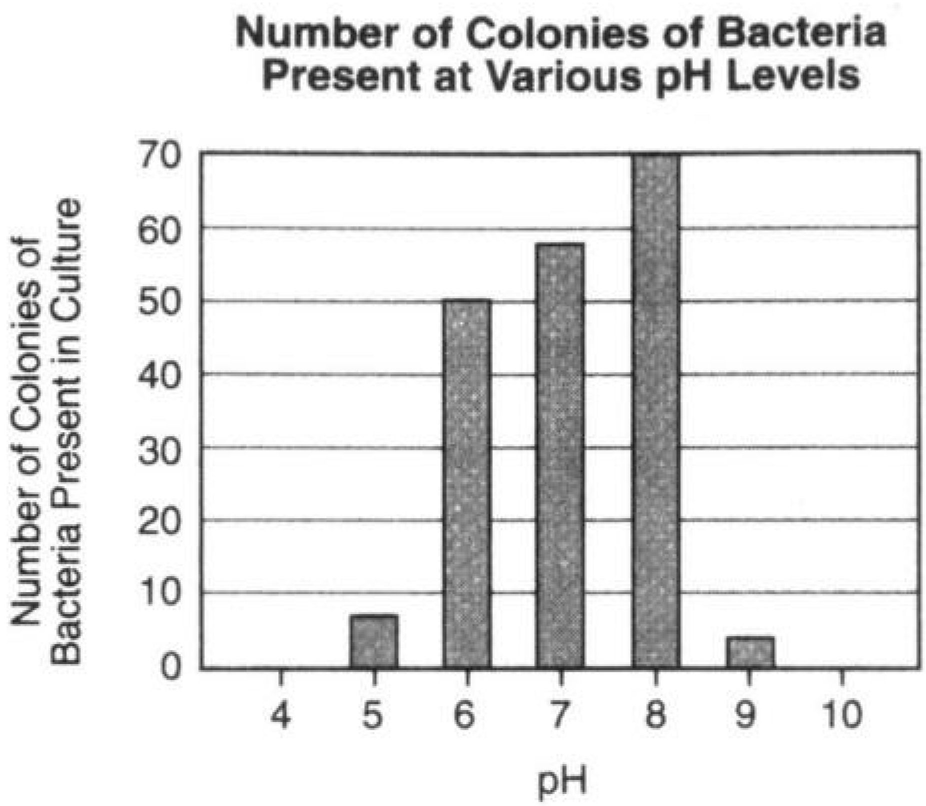
1 Illinois produces more air pollution than the other states shown.

2 The air pollution problem in Baltimore is increased by the addition of pollution from other areas.

3 There are no air pollution problems in southern states.

4 The air pollution problems in Virginia clear up quickly as the air moves toward the sea. 36_____

Base your answers to questions 37 and 38 on the graph below and on your knowledge of biology. The graph illustrates a single species of bacteria grown at various pH levels.



37 The most likely reason there are no colonies in cultures of this species at pH 4 and at pH 10 is that

1 these bacteria could successfully compete with other species of bacteria at these pH values
2 there are more predators feeding on these bacteria at pH 4 and pH 10 than at other pH levels
3 at pH 4 and Ph 10 the environment is too acidic or too basic for the bacteria to grow
4 fertilization cannot occur in these bacteria at pH 4 or pH 10 37_____

38 Which statement is supported by data from this graph?

1 All species of bacteria can grow well at pH 7.
2 This type of bacterium would grow well at pH 7.5.
3 This type of bacterium would grow well at pH 2.
4 Other types of bacteria can grow well at pH 4. 38_____

---

39 In an experiment, DNA from dead pathogenic bacteria was transferred into living bacteria that do not cause disease. These altered bacteria were then injected into healthy mice. These mice died of the same disease caused by the original pathogens. Based on this information, which statement would be a valid conclusion?

1 DNA is present only in living organisms.
2 DNA functions only in the original organism of which it was a part.
3 DNA changes the organism receiving the injection into the original organism.
4 DNA from a dead organism can become active in another organism. 39_____

40 Dodder is a creeping vine that is parasitic on other plants. Which characteristic does dodder share with all other heterotrophs?

1 It produces nutrients by photosynthesis.
2 It must grow in bright locations.
3 It consumes preformed organic molecules.
4 It remains in one place for its entire life. 40_____

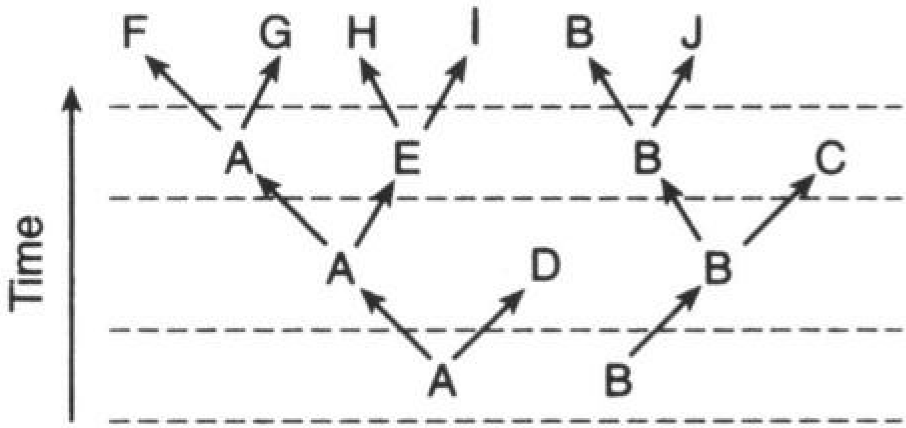
41 In a forest community, a shelf fungus and a slug live on the side of a decaying tree -trunk. The fungus digests and absorbs materials from the tree, while the slug eats algae growing on the outside of the trunk. These organisms do not compete with one another because they occupy

1 the same habitat, but different niches
2 the same niche, but different habitats
3 the same niche and the same habitat
4 different habitats and different niches 41_____

42 Studies of fat cells and thyroid cells show that fat cells have fewer mitochondria than thyroid cells. A biologist would most likely infer that fat tissue

1 does not require energy
2 has energy requirements equal to those of thyroid tissue
3 requires less energy than thyroid tissue
4 requires more energy than thyroid tissue 42_____

Base your answers to questions 43 and 44 on the diagram below and on your knowledge of biology. Letters A through J represent different species of organisms. The vertical distances between the dotted lines represent long periods of time in which major environmental changes occurred.



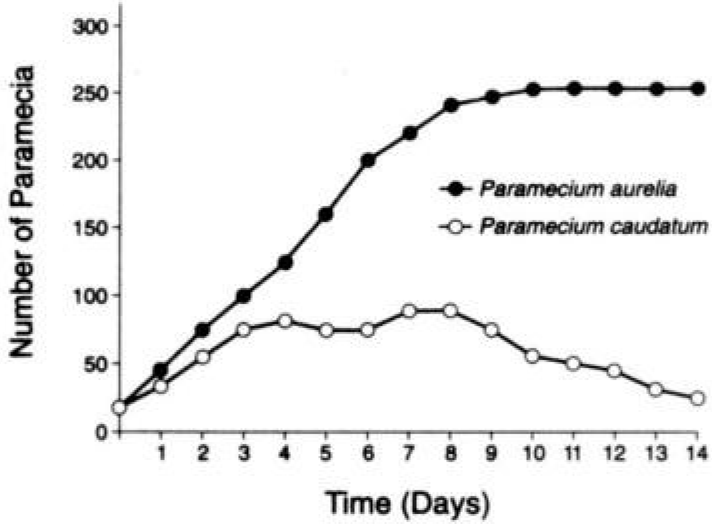
43 Which species was the first to become extinct?

(1) *E*
(2) *J*
(3) *C*
(4) *D* 43_____

44 Which species appears to have been most successful in surviving changes in the environment over time?

(1) *A*
(2) *B*
(3) *C*
(4) *H* 44_____

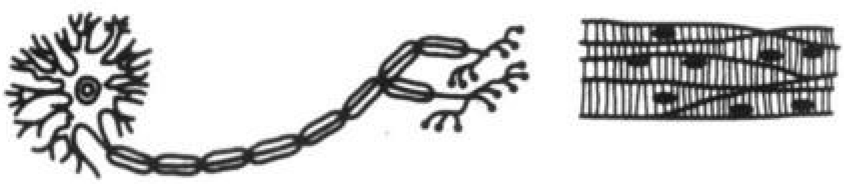
45 The graph below shows the growth of two populations of paramecia grown in the same culture dish for 14 days.



Which ecological concept is best represented by the graph?

1 recycling
2 equilibrium
3 competition
4 decomposition 45_____

46 Two different types of cells from an organism are shown below.



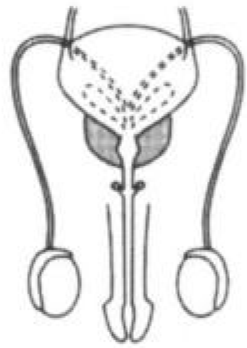
Explain how these two different types of cells can function differently in the same organism even though they both contain the same genetic instructions. [1]

____

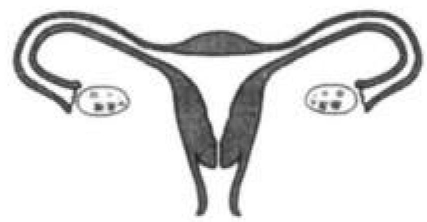
____

____

Directions (47-49): The diagrams below represent organs of two individuals. The diagrams are followed by a list of sentences. For each phrase in questions 47 through 49, select the sentence from the list below that best applies to that phrase. Then record its number in the space provided.



Individual A



Individual B

Sentences

1. The phrase is correct for both Individual A and Individual B.

2. The phrase is not correct for either Individual A or Individual B.

3. The phrase is correct for Individual A, only.

4. The phrase is correct for Individual B, only.

47 Contains organs that produce gametes [1]

48 Contains organs involved in internal fertilization [1]

49 Contains a structure in which a zygote divides by mitosis [11

Base your answers to questions 50 and 51 on the information below and on your knowledge of biology.

Amphibians have long been considered an indicator of the health of life on Earth. Scientists are concerned because amphibian populations have been declining worldwide since the 1980s. In fact, in the past decade, twenty species of amphibians have become extinct and many others are endangered.

Scientists have linked this decline in amphibians to global climatic changes. Warmer weather during the last three decades has resulted in the destruction of many of the eggs produced by the Western toad. Warmer weather has also led to a decrease in rain and snow in the Cascade Mountain Range in Oregon, reducing the water level in lakes and ponds that serve as the reproductive sites for the Western toad. As a result, the eggs are exposed to more ultraviolet light. This makes the eggs more susceptible to water mold that kills the embryos by the hundreds of thousands.

50 The term used to identify the worldwide climatic changes referred to in the passage is

1 global warming
2 deforestation
3 mineral depletion
4 industrialization 50______

51 State two ways the decline in amphibian populations could disrupt the stability of the ecosystems they inhabit. [2]

1. ____

____

____

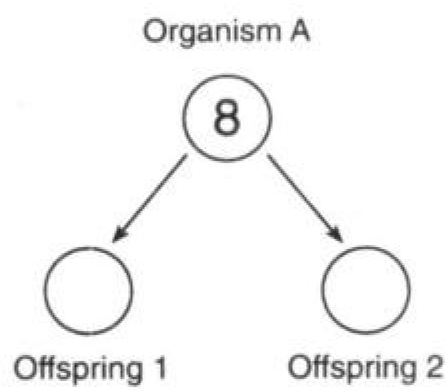
2. ____

____

____

____

52 The diagram below represents reproduction of single-celled organism A, which has a normal chromosome number of 8.



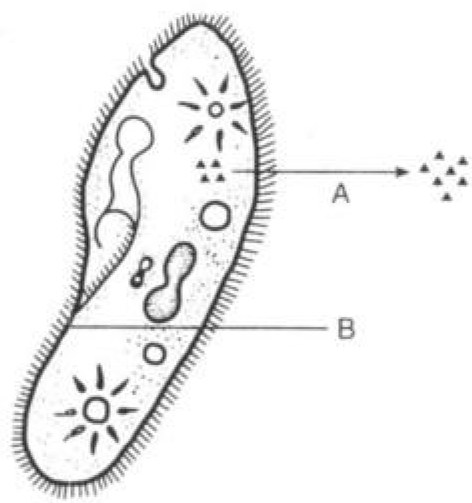
In the circles representing offspring 1 and offspring 2, write the number of chromosomes that result from the normal asexual reproduction of organism A. [1]

Base your answers to questions 53 and 54 on the structures in the diagram of human blood below that help to maintain homeostasis in humans.

53 Identify the cell labeled X. [1]

54 State one way a cell such as cell X helps to maintain homeostasis. [1]

Base your answers to questions 55 and 56 on the diagram below, which represents a unicellular organism in a watery environment. The. s represent molecules of a specific substance.



55 Arrow A represents active transport. State two ways that active transport is different from diffusion. [2]

1. ______________________________________

____

____

2. ______________________________________

____

____

56 In cells of multicellular organisms, structure B often contains molecules involved in cell communication. What specific term is used to identify these molecules? [1]

____

57 Diagram A below represents a microscopic view of the lower surface of a leaf. Diagram B represents a portion of the human body.

Diagram A

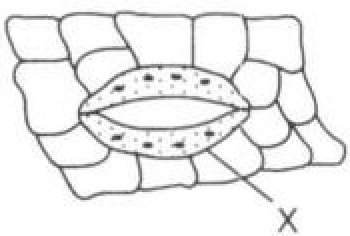
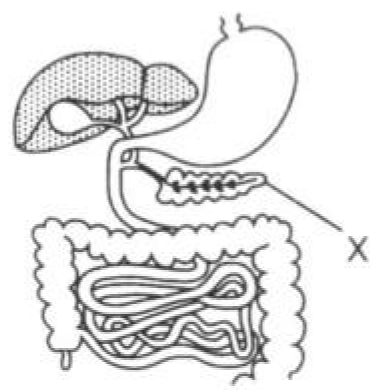


Diagram B



a Choose one diagram and record its letter, A or B, in the space provided.

Diagram: ____________________

b Identify the structure labeled X in the diagram you chose. [1]

____

c State one problem for the organism that would result from a malfunction of the structure you identified. [1]

____

____

____

Base your answers to questions 58 through 62 on the information below and on your knowledge of biology.

In an investigation, plants of the same species and the same initial height were exposed to a constant number of hours of light each day. The number of hours per day was different for each plant, but all other environmental factors were the same. At the conclusion of the investigation, the final height of each plant was measured. The following data were recorded:

8 hours, 25 cm; 4 hours, 12 cm; 2 hours, 5 cm; 14 hours, 35 cm; 12 hours, 35 cm; 10 hours, 34 cm; 6 hours, 18 cm

58 Organize the data by completing both columns in the data table provided, so that the hours of daily light exposure increase from the top to the bottom of the table. [1]

Data Table

Daily Light Exposure (hours)	**Final Height** (cm)

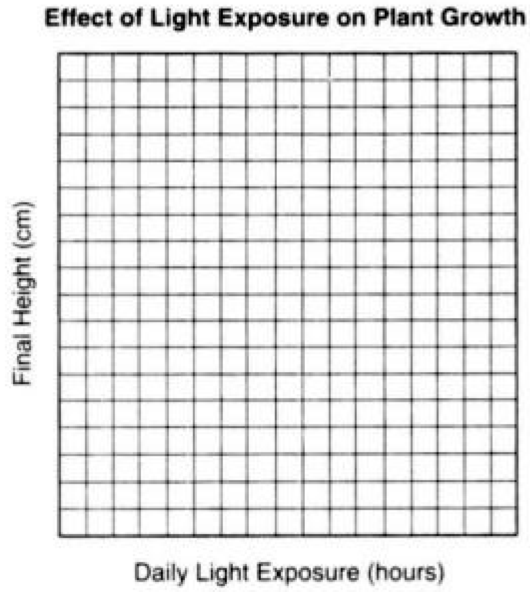
59 State one possible reason that the plant exposed to 2 hours of light per day was the shortest. [1]

___

___

___

Directions (60-61): Using the information given, construct a line graph on the grid provided, following the directions below.



60 Mark an appropriate scale on each axis. [1]

61 Plot the data for final height on the grid. Surround each point with a small circle and connect the points. [1]

Example:

62 If another plant of the same species had been used in the investigation and exposed to 16 hours of light per day, what would the final height of the plant probably have been? Support your answer. [1]

PART C

Answer all questions in this part. [20]

Directions (63-72): Record your answers in the spaces provided.

Base your answers to questions 63 through 65 on the article below which was written in response to an article entitled "Let all predators become extinct."

Predators Contribute to a Stable Ecosystem

In nature, energy flows in only one direction. Transfer of energy must occur in an ecosystem because all life needs energy to live, and only certain organisms can change energy solar into chemical energy._

by eaten are Producers turn, in are, that consumers by eaten other consumers. Stable ecosystems must contain predators to help control the populations of consumers.

Since ecosystems contain many predators, exterminating predators would require a massive effort that would wipe out predatory species from barnacles to blue whales. Without the population control provided by predators, some organisms would soon overpopulate.

63 Draw an energy pyramid in the space below that illustrates the information underlined in the second paragraph. Include three different, specific organisms in the energy pyramid. [I]

64 Explain the phrase "only certain organisms can change solar energy into chemical energy," in the underlined portion of the first paragraph. In your answer be sure to identify:

- the type of nutrition carried out by these organisms [1]
- the process being carried out in this type of nutrition [1]
- the organelles present in the cells of these organisms that are directly involved in changing solar energy into chemical energy [1]

65 Explain why an ecosystem with a variety of predator species might be more stable over a long period of time than an ecosystem with only one predator species. [1]

Base your answers to questions 66 and 67 on the information and data table below and on your knowledge of biology.

Trout and black bass are freshwater fish that normally require at least 8 parts per million (ppm) of dissolved oxygen (02) in the water for survival. Other freshwater fish, such as carp, may be able to live in water that has an 02 level of 5 ppm. No freshwater fish are able to survive when the 02 level in water is 2 ppm or less.

Some factories or power plants are built along rivers so that they can use the water to cool their equipment. They then release the water (sometimes as much as 8°C warmer) back into the same river.

The Rocky River presently has an average summer temperature of about 25°C and contains populations of trout, bass, and carp. A proposal has been made to build a new power plant on the banks of the Rocky River. Some people are concerned that this will affect the river ecosystem in a negative way.

The data table below shows the amount of oxygen that will dissolve in fresh water at different temperatures. The amount of oxygen is expressed in parts per million (ppm).

Data Table

Temperature (°C)	Fresh Water Oxygen Content (ppm)
1	14.24
10	11.29
15	10.10
20	9.11
25	8.27
30	7.56

66 State one effect of temperature change on the oxygen content of fresh water. Support your answer using specific information from the data table. [2]

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67 Explain how a new power plant built on the banks of the Rocky River could have an environmental impact on the Rocky River ecosystem downstream from the plant. Your explanation must include the effects of the power plant on:

• water temperature [1]

• dissolved oxygen [1]

• fish species [1]

68 Enzyme molecules are affected by changes in conditions within organisms.

Explain how a prolonged, excessively high body temperature during an illness could be fatal to humans. Your answer must include:

• the role of enzymes in a human [1]

• the effect of this high body temperature on enzyme activity [1]

• the reason this high body temperature can result in death [1]

Base your answers to questions 69 through 71 on the quotation below and on your knowledge of biology.

"Today I planted something new in my vegetable garden-something very new, as a matter of fact. It's a potato called the New Leaf Superior, which has been genetically engineered-by Monsanto, the chemical giant recently turned "life sciences" giantto produce its own insecticide.

This it can do in every cell of every leaf, stein, flower, root, and (here's the creepy part) spud [the potato]."

Source: New York Times Sunday Magazine, Michael Pollan, 10/25/98

69 State two reasons that a gardener might choose to grow this new variety of plant. - [2]

1. ______________________________

2. ______________________________

70 State one possible disadvantage of the synthesis of an insecticide by potatoes. [1]

71 Explain why every cell in the New Leaf Superior potato plant is able to produce its own insecticide. [I]

72 Select one of the following ecological problems.

Ecological Problems

Acid rain

Increased amounts of nitrogen and phosphorous in a lake

Loss of biodiversity

For the ecological problem that you selected, briefly, describe the problem and state one way to reduce it. In your answer be sure to:

- state the ecological problem you selected
- state how humans have caused the problem you selected [1]
- describe one specific effect that the problem you selected will have on the ecosystem [1]

• state one specific action humans could take to reduce the problem you selected [1]

ANSWERS TO REGENTS EXAMINATION

JUNE 2003

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