AP BIOLOGY

2019 SUMMER WORK

Directions:

- All students should have access to the eText - Campbell BIOLOGY in Focus 2nd Edition, AP Edition with Mastering Biology with Pearson eText © 2017 - homework and experiments will assigned and completed on this platform.

- **Read and Outline** chapters 1-4. Include all key concepts and vocabulary.

- **Answer** chapter questions.

- Complete scientific skills.

Outlines will be checked and all completed work will be handed in **on the first day of school**. Work that is not complete will be marked down 10% each day. Summer work will count as your first test of the school year.

Be prepared to start chapter 5 on the first day of school.

Chapter 1: Introduction: Evolution and the Foundations of Biology

1. _____ DNA is composed of building blocks called _____.
   a. Nucleic acids
   b. Gs
   c. Nucleotides
   d. Adenines
   e. Amino acids

2. _____In eukaryotic cells DNA has the appearance of a _____.
   a. Single strand
   b. Letter U
   c. Double helix
   d. Triple helix
   e. Circle

3. _____What is the correct order for the hierarchy of biological organization from the least to the most complex?
   a. molecule, organelle, cell, tissue, organ, organ system, organism, population, community, ecosystem
   b. molecule, organelle, cell, tissue, organ, organ system, organism, ecosystem, community, population
   c. molecule, organelle, tissue, cell, organ, organ system, organism, population, community, ecosystem
   d. molecule, cell, tissue, organelle, organ, organ system, organism, population, community, ecosystem
   e. molecule, organelle, cell, tissue, organ, organ system, organism, population, ecosystem, community

4. _____ Which of the following statements is true about chemical elements in an ecosystem?
   a. They flow through the system, losing some heat in the process.
   b. They cannot be obtained from decomposition.
   c. They exit the ecosystem in the form of heat.
   d. They recycle within the ecosystem, being constantly reused.
   e. They depend on sunlight as their source.

5. _____ How does DNA (deoxyribonucleic acid) encode information?
   a. Information is encoded in the sequence of nucleotides.
   b. The DNA molecule is composed of many amino acids joined together to form a functional protein.
   c. The genes along the length of DNA molecules encode the information for building all the cell's other molecules.
   d. Information is encoded in the number of each different nucleotide.
   e. Information is encoded in the different shapes of the DNA molecules.

6. _____ Competition is central to the theory of natural selection. Why does competition occur?
   a. Females must choose among possible mates.
   b. Organisms are naturally antagonistic.
   c. Males must defend their territories.
   d. Organisms typically produce too many offspring and resources are limited.
   e. All of the above are correct.

7. _____ Which of the following is an example of "unity in diversity"?
   a. The forelimbs of all mammals have the same basic structure, modified for different environments.
   b. All organisms, including prokaryotes and eukaryotes, use essentially the same genetic code.
   c. The structure of DNA is the same in all organisms.
   d. All of the above are correct.

The Scientific Method:

Learning Goal:

To understand how the scientific method can be used to search for explanations of nature.

The *scientific method* is a procedure used to search for explanations of nature. The scientific method consists of making observations, formulating hypotheses, designing and carrying out experiments, and repeating this cycle.
Observations can be either quantitative or qualitative. *Quantitative observations* are measurements consisting of both numbers and units, such as the observation that ice melts at 0∘C . In contrast, *qualitative observations* are observations that do not rely on numbers or units, such as the observation that water is clear.

A *hypothesis* is a tentative explanation of the observations. The hypothesis is not necessarily correct, but it puts the scientist's understanding of the observations into a form that can be tested through experimentation.

Experiments are then performed to test the validity of the hypothesis. *Experiments* are observations preferably made under conditions in which the variable of interest is clearly distinguishable from any others.

If the experiment shows that the hypothesis is incorrect, the hypothesis can be modified, and further experiments can be carried out to test the modified hypothesis. This cycle is repeated, continually refining the hypothesis.

If a large set of observations follow a reproducible pattern, this pattern can be summarized in a *law*—a verbal or mathematical generalization of a phenomenon. For example, over the years people observed that every morning the sun rises in the east, and every night the sun sets in the west. These observations can be described in a law stating, "The sun always rises in the east and sets in the west."

After a great deal of refinement, a hypothesis can lead to a theory. A *theory* is an explanation of why something happens. For example, Newton's theory of gravitation explains why objects tend to fall toward the Earth (as well as explaining the interactions between the Earth and the other planets, etc). However, theories can still be further refined or even replaced. Einstein's theory of general relativity was able to better explain certain astronomical observations related to gravity, and therefore it replaced Newton's theory of gravitation (although Newton's theory still holds true under most everyday conditions). Similarly, the geocentric theory (that the Earth is the center of the universe) was replaced by the heliocentric theory (that the Earth revolves around the sun) based on further observations and testing of predictions. Note that a scientific theory is not the same as the popular definition of a theory—namely, a "guess" or "speculation." Instead, a theory is an explanation that can hold up against repeated experimentation. It may not be perfect, but it is the best explanation possible based on available evidence.

In the course of a conversation, you observe that three of your friends like horror movies. Horror movies happen to be your favorite type of movie as well. You also know that all of these friends were born in the same week that you were, even in the same year.

An astrology-loving friend hypothesizes that people born in that week like horror movies more than other genres of movies. You decide to use the scientific method to test this hypothesis.

8. _____ What should you do next?
   a. Come up with a theory to explain why movie preference is related to birth week.
   b. Perform experiments to test your hypothesis.
   c. Propose several alternative hypotheses.
   d. Refine your hypothesis.

9. _____ Which of the following experiments would best test your hypothesis?
   a. Ask your friends if they also like the same type of music that you like.
   b. Interview all of your friends and find out if the ones born in other weeks also like the same types of movies that you like.
   c. Find other people born in the same week and ask them what their favorite type of movie is.
   d. Find other people born in the same week and tell them what your favorite movie is. Ask them if they also liked that movie.

You want to be as careful as possible that the variable of interest--namely, favorite movie genre--is clearly distinguishable from any other variables. To do so, first you must be careful to find a random sampling of people who share your birth week, avoiding simply talking to friends with whom you share common interests. Second, you need to provide your subjects with a questionnaire on which they are asked to circle their favorite genre from a list, so that you are not tempted to interpret their answers in your favor. You must be certain not to tell them what you are seeking to prove or disprove; that way their answers will not be influenced by your stated goal. You must also make the surveys anonymous to ensure that your subjects aren't simply giving you the answers they think you want them to give.

After finding a random sample of 10 people born in the same week as you and your friends, you obtain these results from their questionnaires:

- 4 of them prefer comedies,
- 3 of them prefer dramas,
- 2 of them prefer action movies, and
- 1 of them prefers westerns.

As a control, you also interview 14 random people with birthdays throughout the year. You obtain results similar to the results of your experimental group and your friends:

1. 3 of them prefer comedies,
2. 4 of them prefer dramas,
3. 3 of them prefer action movies, and
4. 1 of them prefers westerns

10. _____ What should you do next?
    a. Refine your hypothesis.
    b. Come up with a theory to explain why movie preference is only sometimes related to birth week.
    c. Perform further interviews until you find more people who prefer horror movies.
    d. Assume that the 10 people you interviewed were lying about their birth week. Conduct further interviews in which you ask movie preference first and only ask about birth week when people say they like horror movies.

11. _____ In order for a hypothesis to be used in science, which of the following must be true?
    a. The hypothesis must be proven correct.
    b. The hypothesis is testable and falsifiable.
    c. The hypothesis must be popularly accepted.
    d. The hypothesis represents established facts.
    e. The hypothesis must be reproducible.

12. _____Which of the following is true of a scientific theory?
    a. It is only accepted after the person who formulated it has died.
    b. It is a method or device that applies scientific knowledge for some specific purpose.
    c. It is formulated by many scientists over drinks at a convention.
    d. It must demonstrate the effect of one variable by testing control groups and experimental groups.
    e. It generates testable hypotheses, is supported by a large body of evidence, and is broad in scope.

13. _____ Which example illustrates a property that emerges at the community level?
    a. Metabolic cooperation between prokaryotic cells forms a biofilm that allows bacterial colonies to transport nutrients and wastes. Biofilms may damage industrial equipment or cause tooth decay.
    b. Nitrogen cycling is the process by which nitrogen from the atmosphere and decomposed organic material are converted by soil bacteria to compounds that can be assimilated by plants.
    c. Photosynthesis takes place only when pigment molecules are arranged in a specific way in an intact chloroplast

14. _____ Select the most accurate statement about the interaction between a tree and its physical environment.
    a. A tree alters its physical environment.
    b. A tree is affected by its physical environment.
   c. A tree and its physical environment alter each other.

Learning Goal:
To understand the relationship between atomic number and mass number.

Atoms are described by an atomic number and a mass number. The atomic number is the number of protons in the nucleus. The mass number represents the sum of the protons and the neutrons in the nucleus. If the number of negative electrons is equal to the number of positive protons, then the atom is neutral. If the number of protons and electrons are not equal, then the atom will have a charge.

For example, a phosphorus ion with 15 protons, 17 neutrons, and 18 electrons would have an atomic number of 15, a mass number of 32, and a charge of −3.

1. What is the mass number of an ion with 109 electrons, 158 protons and a +1 charge? Express your answer as an integer.
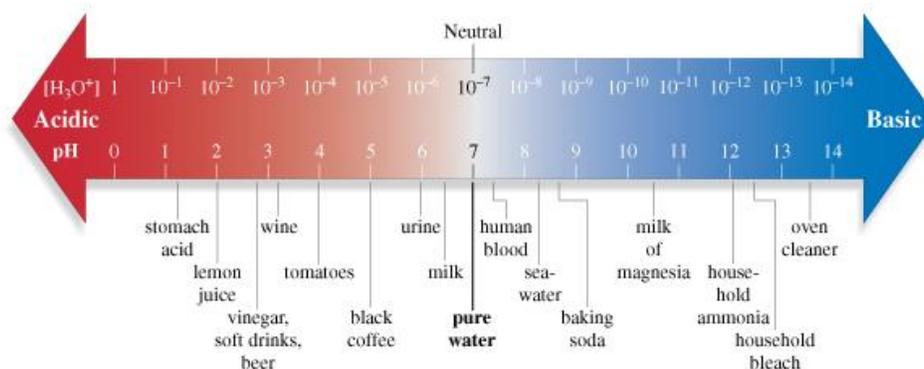
Adapted from *Biological Science* by Freeman © 2008 Pearson Education, Inc.

pH expresses the molar concentration of hydronium ions in an aqueous solution on a logarithmic scale. (Note that it is common to use the hydrogen ion, H^+, to represent the hydronium ion, H_3O^+.)

$$pH = -\log[H3O^+]$$

$$[H3O^+] = 10-pH$$

As pH decreases, acidity increases. As pH increases, acidity decreases.
*   Acidic solution: $pH < 7$
*   Neutral solution: $pH = 7$
*   Basic solution: $pH > 7$

2. What is the pH of an aqueous solution with the hydronium ion concentration $[H_3O^+] = 2 \times 10^{-14}\ M$?

3. _____ Carbonated cola is more acidic than coffee or even orange juice because cola contains phosphoric acid. **What is the molar concentration of $[H_3O^+]$ in a cola that has a pH of 3.120?**
    a. 7.58×10^{-4}
    b. 7.59×10^{-4}
    c. 7.6×10^{-4}
    d. 3.120×10^{-3}

4. _____ A substance that cannot be broken down into other substances by ordinary chemical procedures is a(n) _____.
   a. Proton
   b. Molecule
   c. Isotope
   d. Compound
   e. Element

5. _____ What is the atomic number of an atom that has 6 protons, 6 neutrons, and 6 electrons?
   a. 0
   b. -1
   c. 6
   d. 18
   e. 12

6. _____ Which of these refers to atoms with the same atomic number but different atomic masses?
   a. These atoms are isotopes.
   b. These atoms have different numbers of electrons.
   c. These atoms are different elements.
   d. These atoms are isomers.
   e. These atoms have different numbers of protons.

7. _____ Fluorine's atomic number is 9 and its atomic mass is 19. How many neutrons does fluorine have?
   a. 81
   b. 9
   c. 10
   d. 19
   e. 28

8. _____ An uncharged atom of boron has an atomic number of 5 and an atomic mass of 11. How many protons does boron have?
   a. 16
   b. 11
   c. 0
   d. 6
   e. 5

9. _____ Which of the following subatomic particles always has a positive charge?
   a. Element
   b. Electron
   c. Proton
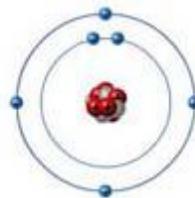   d. Neutron
   e. Atom

10. _____ What type of bond is joining the two hydrogen atoms?
    a. Ionic
    b. Covalent
    c. Hydrophobic
    d. Hydrogen
    e. Hydrophilic
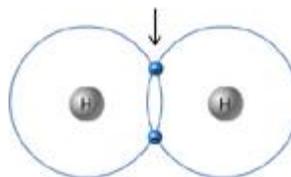
11. _____ A(n) _____ refers to two or more atoms held together by covalent bonds.
    a. Isotope
    b. Ion
    c. Shell
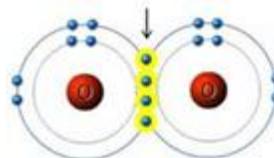   d. Molecule
    e. Community

12. _____ This atom can form up to _____ single covalent bond(s).
   a. 4
   b. 1
   c. 2
   d. 3
   e. 0

13. _____ A(n) _____ bond joins these two oxygen atoms.
   a. Quadruple covalent
   b. Hydrogen
   c. Double covalent
   d. Ionic
   e. Single covalent

14. _____ Atoms with the same number of protons but with different electrical charges _____.
   a. Are different isotopes
   b. Are different ions
   c. Have different numbers of neutrons
   d. Have different atomic numbers
   e. Have different atomic masses

15. _____ In salt, what is the nature of the bond between sodium and chlorine?
   a. Nonpolar covalent
   b. Hydrophobic
   c. Polar covalent
   d. Hydrogen
   e. Ionic

16. _____ An ionic bond involves ____.
   a. The unequal sharing of an electron pair
   b. The sharing of a single pair of electrons
   c. An attraction between ions of opposite charge
   d. Water avoidance
   e. No atoms other than sodium and chlorine

17. _____ Which of these figures correctly illustrates the nature of the bonding of H_2O?

   a.

   c.

   b.

   d.
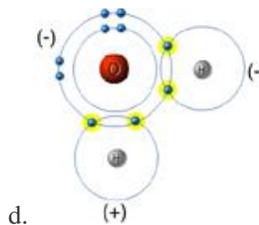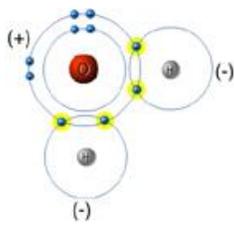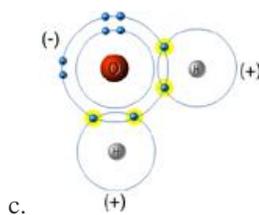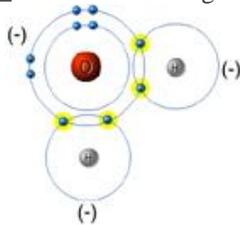
Chapter 3: Carbon and the Molecular Diversity of Life

Hydrocarbons are molecules consisting of only carbon atoms and hydrogen atoms. Hydrocarbons form the basis of many types of organic molecules. In addition to carbon atoms and hydrogen atoms, many organic molecules also have groups of atoms called functional groups. These functional groups may be substituted for one or more of the hydrogen atoms of a hydrocarbon. The functional groups present in an organic molecule determine the chemical behavior of that molecule.

1. _____Which molecules show an appropriate number of bonds around each carbon atom? **(select all that apply)**

a.

b.

c.

d.

e.
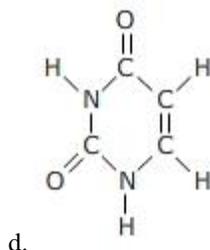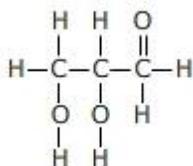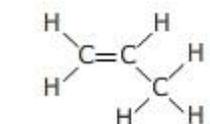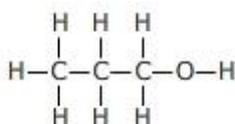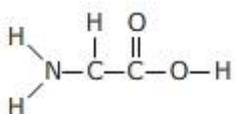
2. **Match** the functional group with the appropriate chemical property. If one property can apply to more than one functional group, choose the best answer for each functional group.

_____ Carboxylic acid	a. is polar and makes compounds more soluble in water
_____ Aldehyde	b. forms disulfide bonds
_____ Thiol	c. acts as an acid
_____ Amine	d. contributes negative charge
_____ Organic phosphate	e. may be a structural isomer of a ketone
_____ Alcohol	f. acts as a base

Carbohydrates, more commonly known as sugars, are made up of carbon, oxygen, and hydrogen atoms. The smallest unit of a carbohydrate is a monosaccharide. Two monosaccharides make up a disaccharide, and many monosaccharides make up a polysaccharide. Disaccharides and polysaccharides can be hydrolyzed back into the individual monosaccharide units.

3. _____ Select the statement that is incorrect.
   a. Complex sugars are carbohydrates.
   b. All carbohydrates have the general formula $C_n(H2O)_n$.
   c. Simple sugars are carbohydrates.
   d. Simple sugars contain only carbon, oxygen, and hydrogen atoms.

4. _____ Lactose, the sugar in milk, is a _____, because it can be split into two monosaccharides.
   a. Monosaccharide
   b. Disaccharide
   c. Polysaccharide
   d. Carbohydrate

5. _____ A carbohydrate that yields many monosaccharides when hydrolyzed is a _____.
   a. Monosaccharide
   b. Disaccharide
   c. Polysaccharide
   d. Carbohydrate

6. _____ A simple sugar is composed of equal parts carbon and water, which gave rise to the general name of any sugar as a
   _____.
   a. Monosaccharide
   b. Disaccharide
   c. Polysaccharide
   d. Carbohydrate

7. _____ A _____ cannot be hydrolyzed any further.
   a. Monosaccharide
   b. Disaccharide
   c. Polysaccharide
   d. Carbohydrate

Protein structure is conceptually divided into four levels, from most basic to higher order: Primary structure describes the order of amino acids in the peptide chain. Secondary structure describes the basic three-dimensional structures, α-helices and β-sheets. Tertiary structure describes how the secondary structures come together to form an individual globular protein. Quaternary structure results from individual proteins coming together to form multi-subunit protein complexes.

8. _____ structure is the result of two or more protein subunits assembling to form a larger, biologically active
   protein complex.
   a. Primary
   b. Secondary
   c. Tertiary
   d. Quaternary

9. _____ structure is the sequence of amino acids in a protein.
   a. Primary
   b. Secondary
   c. Tertiary
   d. Quaternary

10. _____ structure describes the alpha-helices and beta-sheets that are formed by hydrogen bonding between backbone atoms located near each other in the polypeptide chain.
    a. Primary
    b. Secondary
    c. Tertiary
    d. Quaternary

11. _____ structure is achieved when a protein folds into a compact, three-dimensional shape stabilized by interactions between side-chain R groups of amino acids.
    a. Primary
    b. Secondary
    c. Tertiary
    d. Quaternary

DNA, or deoxyribonucleic acid, contains the genetic information that is used by all living things to produce their biomolecules essential for life. DNA is a double helix, with two strands. The two strands are held together by hydrogen bonds between complementary nitrogenous bases. The two strands are always complementary, ensuring that the DNA can be replicated accurately. The two complementary DNA strands always run in opposite directions: One runs from 5' to 3', and the other runs from 3' to 5'. The nucleic acids DNA and RNA are made from chains of nucleotides. Nucleotides consist of three components: a five-carbon sugar (either ribose or deoxyribose), a nitrogenous base attached to the sugar's 1'-carbon, and a phosphate group attached to the sugar's 5'-carbon.

12. _____ Which base pairs are purines (two rings)?
    a. Adenine
    b. Cytosine
    c. Guanine
    d. Thymine

13. _____ Which base pairs are pyrimidines (one ring)?
    a. Adenine
    b. Cytosine
    c. Guanine
    d. Thymine

14. _____ What base pairs with Adenine in DNA?
    a. Uracil
    b. Cytosine
    c. Guanine
    d. Thymine

15. _____ What base pairs with Cytosine in DNA?
    a. Adenine
    b. Cytosine
    c. Guanine
    d. Thymine

16. Write the complementary sequence for the following DNA sequence, in order from 3' to 5':

    5' – CGATATTGAGCTAAGCTT - 3'

17. Name three things that make up a DNA nucleotide:

    a. _____

    b. _____

    c. _____

18. Name four nitrogenous bases found in DNA:

    a. _____

    b. _____

    c. _____

    d. _____

19. Name three things that make up a RNA nucleotide:

    a. _____

    b. _____

    c. _____

20. Name four nitrogenous bases found in RNA:

    a. _____

    b. _____

    c. _____

    d. _____

21. _____ The large diversity of shapes of biological molecules is possible because of the extensive presence of _____ in the molecules.
    a. Sulfur
    b. Carbon
    c. Oxygen
    d. Hydrogen
    e. Nitrogen

Chapter 4: A Tour of the Cell

1. Match (draw a line) each function with the appropriate organelle found in the endomembrane system.

Lipid synthesis

Protein modification and sorting   • Smooth ER

Macromolecule digestion

Calcium ion storage   • Rough ER

Cisternal maturation

Autophagy   • Golgi apparatus

Poison detoxification

Protein synthesis   • Lysosomes

2. _____ All proteins are synthesized by ribosomes in the cell. Some ribosomes float freely in the cytosol, while others are bound to the surface of the endoplasmic reticulum. Most proteins made by free ribosomes function in the cytosol. Proteins made by bound ribosomes either function within the endomembrane system or pass through it and are secreted from the cell. **Which of the following proteins are synthesized by bound ribosomes? (select all that apply)**
    a. Lysosomal enzyme
    b. Insulin
    c. Ribosomal protein
    d. DNA polymerase
    e. ER protein
    f. Actin

3. Number the following organelles (1) being the beginning of the secretory protein pathway and (5) being the end.

    a. _____ cis Golgi cisternae

    b. _____ trans Golgi cisternae

    c. _____ endoplasmic reticulum

    d. _____ medial Golgi cisternae

    e. _____ plasma membrane

Pulse-chase experiments and protein location:

Scientists can track the movement of proteins through the endomembrane system using an approach known as a pulse-chase experiment. This experiment involves

- **the "pulse" phase**: Cells are exposed to a high concentration of a radioactively labeled amino acid for a short period to tag proteins that are being synthesized.
- **the "chase" phase**: Any unincorporated radioactively labeled amino acids are washed away and large amounts of the same, but unlabeled, amino acid are added.

Only those proteins synthesized during the brief pulse phase are radioactively tagged. These tagged proteins can be tracked through the chase period to determine their location in the cell.

The data below were obtained from a pulse-chase experiment in which cells were examined at different times during the chase period. The numbers represent the radioactivity (measured in counts per minute) recorded at each of the indicated sites. The higher the number, the greater the radioactivity.

Time	ER	Golgi	Cytoplasm	Lysosomes	Extracellular space
3 minutes	162	7	21	5	4
20 minutes	73	88	17	10	8
60 minutes	9	35	14	112	13
120 minutes	11	23	18	151	10

4. _____ Based on these data, what is the most likely function of the cells in this experiment?
   a. Detoxification
   b. Secretion
   c. Muscle contraction
   d. Phagocytosis

5. Match the organelle with its function:

   _____ Smooth ER   a. Produces secretory proteins

   _____ Cytoskeleton   b. Generates ATP

   _____ Lysosome   c. Defines cell shape

   _____ Mitochondria   d. Assembles ribosomes

   _____ Golgi   e. Modifies and sorts proteins

   _____ Rough ER   f. Digests proteins

   _____ Nucleolus   g. Synthesizes lipids

6. Organelles are found in prokaryotic, eukaryotic or both types of cells. Place a P, E, or B next to each of the following organelles to show where they can be found.
   _____ nucleoid
   _____ ribosomes
   _____ flagella
   _____ lysosome
   _____ nucleolus
   _____ plasma membrane
   _____ mitochondria

7. _____ In eukaryotic flagella, the fibers that slide past one another due to the activity of dynein proteins are _____.
   a. Microtubules
   b. Microfilaments
   c. Intermediate filaments

8. _____ Many cell organelles, most notably the nucleus, are anchored by _____ which are assembled from a diverse class of proteins.
   a. Microtubules
   b. Microfilaments
   c. Intermediate filaments

9. _____ Centrosomes are sites where protein dimers assemble into _____.
   a. Microtubules
   b. Microfilaments
   c. Intermediate filaments

10. _____ The extension of pseudopodia in amoeba is due to the regulated assembly and destruction of _____.
    a. Microtubules
    b. Microfilaments
    c. Intermediate filaments

11. _____ The only cytoskeletal fibers not associated with intracellular movement or whole cell locomotion are the _____.
    a. Microtubules
    b. Microfilaments
    c. Intermediate filaments

12. _____ During muscle contractions, myosin motor proteins move across tracks of _____-.
    a. Microtubules
    b. Microfilaments
    c. Intermediate filaments

13. Certain organelles are found in plant cells, animal cells or in both. Please label each of the following organelles according to where they are found: P, A, or B

    _____ Mitochondrion

    _____ Centriole

    _____ Endoplasmic reticulum

    _____ Chloroplast

    _____ Golgi apparatus

    _____ Cytoskeleton

    _____ Cellulose cell wall

    _____ Nucleus

    _____ Central vacuole

    _____ Plasma membrane

14. Match the organelle with its function:

_____ Cell wall   a. Makes sugar by converting light energy into chemical energy

_____ Central vacuole   b. Modifies and packages proteins

_____ Chloroplast   c. Strong, protective structure made from cellulose fibrils

_____ Mitochondrion   d. Regulates cytoplasm composition, creates internal pressure, and stress cell compounds

_____ Golgi apparatus   e. Produces chemical energy (ATP) that can power the cell

15. _____ Which statements are true for chloroplasts? Select the *three* that apply.
    a. They are the sites of reactions that convert solar energy into chemical energy.
    b. They have membranous sacs called thylakoids that are surrounded by a fluid called stroma.
    c. Their inner membrane has infoldings called cristae.
    d. They are the sites of reactions that convert chemical energy from food molecules to ATP.
    e. Their matrix contains enzymes that function in cellular respiration.
    f. They contain the green pigment chlorophyll.

16. Match the extracellular function with the structure. Then say if the structure is found in a plant or animal cell.

Structure	**Plant or Animal?**	**Extracellular Function**
_____ desmosomes		a. membrane proteins that create a water tight seal between cells
_____ gap junctions		b. Long fibers of protein found in the extracellular matrix that provide structural support for cells
_____ tight junctions		c. Membrane protein complexes that strengthen the adhesion between adjacent cells, like rivets, to protect against pulling forces
_____ plasmodesmata		d. A polysaccharide that is used to synthesize cell walls, which protect cells and help maintain their shape
_____ cellulose		e. Small channels that form across the plasma membranes of adjacent cells; especially important in intercellular communication
_____ collagen		f. Small channels between cells that are otherwise surrounded by walls; enable movement of water and solutes between cells

Scientific Skills Exercise: Interpreting a Pair of Bar Graphs

How much does camouflage affect predation on mice by owls with and without moonlight?
Nearly half a century ago, D. W. Kaufman investigated the effect of prey camouflage on predation. Kaufman tested the hypothesis that the amount of contrast between the coat color of a mouse and the color of its surroundings would affect the rate of nighttime predation by owls. He also hypothesized that the color contrast would be affected by the amount of moonlight. In this exercise, you will analyze data from his owl-mouse predation studies.

Pairs of mice (*Peromyscus polionotus*) with different coat colors, one light brown and one dark brown, were released simultaneously into an enclosure that contained a hungry owl. The researcher recorded the color of the mouse that was first caught by the owl. If the owl did not catch either mouse within 15 minutes, the test was recorded as a zero. The release trials were repeated multiple times in enclosures with either a dark-colored soil surface or a light-colored soil surface. The presence or absence of moonlight during each assay was recorded.
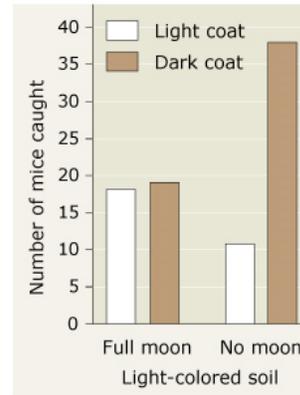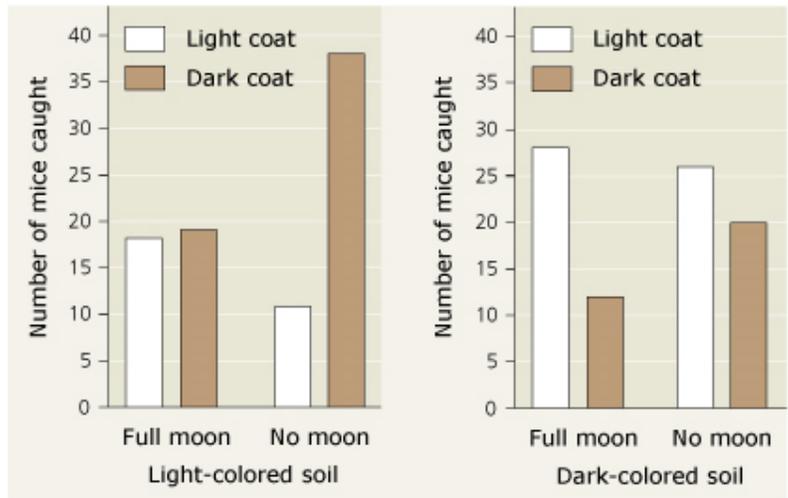
Data from D. W. Kaufman, Adaptive coloration in *Peromyscus polionotus*: Experimental selection by owls, *Journal of Mammalogy* 55:271–283 (1974).

1. _____ The graph shows data from the light-colored soil enclosure. There is one dependent variable and more than one independent variable on the graph. What are the *independent* variables, the variables that were manipulated by the researcher?
   a. The presence or absence of moonlight and the number of mice caught
   b. Mouse coat color and the presence or absence of moonlight
   c. The color of the soil and the presence or absence of moonlight
   d. Mouse coat color and the number of mice caught

2. _____ What is the *dependent* variable, the response to the variables being tested?
   a. The mouse coat color
   b. The presence or absence of moonlight
   c. The color of the soil
   d. The number of mice caught

Select from the dropdown menu above the graph. Now you will look at data from two different enclosures: one with light-colored soil (left), and one with dark-colored soil (right). Use both graphs to answer the next few questions about capture of *dark* brown mice, shown as brown bars in the graphs.

3. _____ How many dark brown mice were caught in the *light*-colored soil enclosure on a moonlit night?
   a. 12
   b. 17
   c. 19
   d. 37

Data from D. W. Kaufman, Adaptive coloration in *Peromyscus polionotus*: Experimental selection by owls, *Journal of Mammalogy* 55:271–283 (1974).

4. _____ How many dark brown mice were caught in the *dark*-colored soil enclosure on a moonlit night?
   a. 12
   b. 20
   c. 28
   d. 37

5. _____ The bars on the graphs show the numbers of mice that were caught, but keep in mind that mice that were not caught by the owl escaped predation. On a moonlit night, would a dark brown mouse be more likely to escape predation by owls on dark- or light-colored soil? What data support your conclusion?
   a. On light-colored soil; fewer dark brown mice were caught on dark soil than on light soil under a full moon.
   b. On light-colored soil; the lowest level of predation was light brown mice on light soil.
   c. On dark-colored soil; fewer dark brown mice were caught on dark soil than on light soil under a full moon.
   d. On dark-colored soil; fewer light brown mice than dark brown mice were caught on light soil under no moon.

6. _____ Is a dark brown mouse on dark-colored soil more likely to escape predation under a full moon or with no moon? What data support your answer?
   a. Under no moon; the owl caught more dark mice when there was no moon (about 20) than when there was a full moon (about 12).
   b. Under no moon; the owl caught more light mice when there was a full moon (about 17) than when there was no moon (about 11).
   c. Under a full moon; the owl caught more dark mice when there was no moon (about 20) than when there was a full moon (about 12).
   d. Under a full moon; the owl caught more dark mice when there was no moon (about 37) than when there was a full moon (about 19).

7. Under which conditions would a dark brown mouse be most likely to escape predation at night?
   a. on dark-colored soil with full moon light
   b. on dark-colored soil with no moon
   c. on light-colored soil with no moon
   d. on light-colored soil with full moon light

8. _____ Now take a look at the data on both graphs for *light* brown mice, shown as white bars on the graphs. How many light brown mice were caught in the *light*-colored soil enclosure on a moonlit night?
   a. 11
   b. 18
   c. 26
   d. 28

9. _____ How many light brown mice were caught in the *dark*-colored soil enclosure on a moonlit night?
   a. 12
   b. 18
   c. 26
   d. 28

10. _____ On a moonlit night, would a light brown mouse be more likely to escape predation by owls on dark- or light-colored soil? What data support your conclusion?
    a. On dark-colored soil; fewer light brown mice were caught on dark soil than on light soil under a full moon.
    b. On light-colored soil; fewer light brown mice were caught on light soil than on dark soil under a full moon.
    c. On light-colored soil; fewer light brown mice were caught under no moon than under a full moon.
    d. On dark-colored soil; fewer dark brown mice were caught on dark soil than on light soil under a full moon.

11. _____ Is a light brown mouse on light-colored soil more likely to escape predation under a full moon or with no moon? What data support your answer?
    a. Under no moon; the owl caught more light mice when there was a full moon (about 28) than when there was no moon (about 26).
    b. Under a full moon; the owl caught more dark mice when there was no moon (about 37) than when there was a full moon (about 19).
    c. Under no moon; the owl caught more light mice when there was a full moon (about 18) than when there was no moon (about 11).
    d. Under a full moon; the owl caught more dark mice when there was no moon (about 20) than when there was a full moon (about 12).

12. _____ Under which conditions would a light brown mouse be most likely to escape predation at night?
    a. on dark-colored soil with full moon light
    b. on light-colored soil with full moon light
    c. on light-colored soil with no moon
   d. on dark-colored soil with no moon

13. _____ So far you've looked at each color of mice separately. Next, consider the two colors of mice together when looking at the graphs. What combination of independent variables led to the highest predation level in enclosures with *light*-colored soil?
   a. light brown coat with full moon
   b. dark brown coat with no moon
   c. light brown coat with no moon
   d. dark brown coat with full moon

14. _____ Now think about the data from the viewpoint of the owl's hunting success. Combining the data shown in both graphs, estimate the total number of mice caught in moonlight versus no-moonlight conditions.
   a. moonlight: about 83 caught; no moonlight: about 89 caught
   b. moonlight: about 95 caught; no moonlight: about 77 caught
   c. moonlight: about 77 caught; no moonlight: about 95 caught
   d. moonlight: about 86 caught; no moonlight: about 86 caught

15. _____ Which condition is optimal for predation by the owl on mice?
   a. Moonlit nights are better for hunting.
   b. Dark nights are better for hunting.
   c. The moon light has no effect on predation success.

Scientific Skills Exercise: Interpreting a Scatter Plot with a Regression Line

How does the carbonate ion concentration of seawater affect the calcification rate of a coral reef?

Scientists predict that acidification of the ocean due to higher levels of atmospheric CO_2 will lower the concentration of dissolved carbonate ions (CO_3^{2-}), which living corals use to build calcium carbonate ($CaCO_3$) reef structures. In this exercise, you will analyze data from a controlled experiment in the Biosphere 2 aquarium that examined the effect of different carbonate ion concentrations in seawater on the rate of calcium carbonate deposition by reef organisms, a process called calcification.

The graph shows the data from the experiment. The black data points form a scatter plot. The red line is a linear regression, or best-fitting line, to the points.
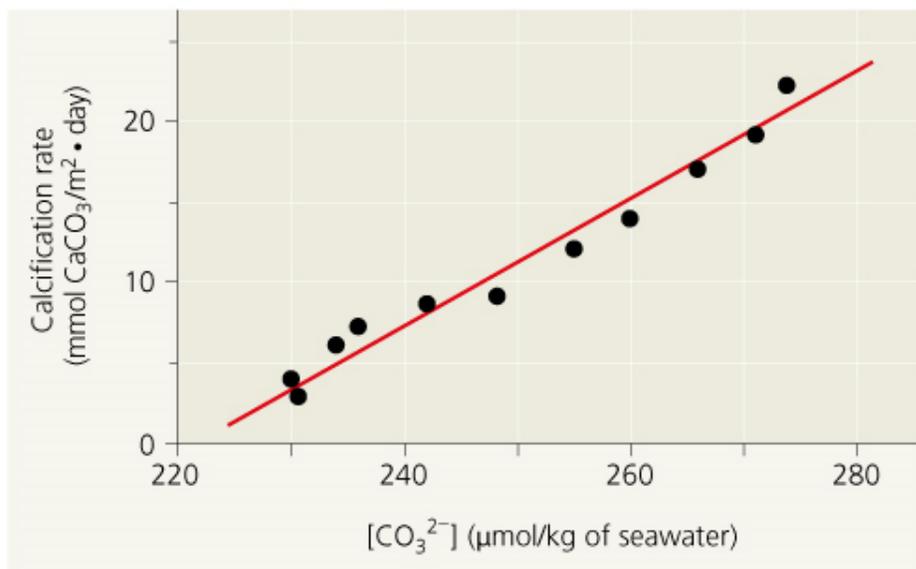
Data from C. Langdon et al., Effect of calcium carbonate saturation state on the calcification rate of an experimental coral reef, *Global Biogeochemical Cycles* 14:639-654 (2000).

1. _____ What is shown on the *x*-axis, and in what units?
   a. the calcification rate in micromoles per kilogram of seawater
   b. the calcium carbonate ($CaCO_3$) concentration of seawater, in micromoles per kilogram of seawater
   c. the calcification rate in millimoles of calcium carbonate ($CaCO_3$) accumulated per square meter of reef per day
   d. the carbonate ion (CO_3^{2-}) concentration of seawater, in micromoles per kilogram of seawater

2. _____ What is shown on the *y*-axis, and in what units?
   a. the calcification rate in millimoles of calcium carbonate ($CaCO_3$) accumulated per square meter of reef per day
   b. the total calcium carbonate ($CaCO_3$) accumulation on the reef in millimoles per day
   c. the carbonate ion (CO_3^{2-}) concentration of seawater, in micromoles per kilogram of seawater
   d. the calcification rate in millimoles of carbonate ion (CO_3^{2-}) accumulated per square meter of reef per day

3. _____ Which variable is the independent variable in this experiment--the variable that was *manipulated* by the researchers?
   a. carbonate ion concentration in the seawater
   b. calcification rate
   c. the surface area of the reef
   d. how many days the reef was measured

4. _____ Which variable is the dependent variable--the variable that responded to or depended on the treatment, and was *measured* by the researchers?
   a. Carbonate ion concentration in the seawater
   b. Calcification rate
   c. The surface area of the reef
   d. The acidity of the seawater

5. _____ Based on this graph, what is the relationship between carbonate ion concentration and calcification rate?
   a. As the rate of calcification is increased, the concentration of carbonate ions increases.
   b. As the concentration of carbonate ions is increased, the rate of calcification decreases.
   c. As the acidity of the seawater is increased, the rate of calcification decreases.
   d. As the concentration of carbonate ions is increased, the rate of calcification increases.

6. _____ You can determine the rate of calcification at any given carbonate ion concentration as follows: Draw a vertical line up from the x-axis at that concentration value until it intersects the red linear regression line; then draw a horizontal line from the intersection over to the y-axis to see what the calcification rate is at that carbonate ion concentration. If the seawater carbonate ion (CO_3^{2-}) concentration is 270 µmol/kg, a) what is the approximate rate of calcification, and b) approximately how many days would it take 1 square meter of reef to accumulate 30 mmol of calcium carbonate ($CaCO_3$)?

   a. 10 mmol $CaCO_3$ per m^2 per day; 3 days
   b. 20 mmol $CaCO_3$ per m^2 per day; 0.67 days
   c. 20 mmol $CaCO_3$ per m^2 per day; 1.5 days
   d. 20 mmol $CaCO_3$ per m^2 per day; 600 days

7. _____ If the seawater carbonate ion concentration is 250 µmol/kg, a) what is the approximate rate of calcification, and b) approximately how many days would it take 1 square meter of reef to accumulate 30 mmol of calcium carbonate?

   a. 5 mmol $CaCO_3$ per m^2 per day; 6 days
   b. 10 mmol $CaCO_3$ per m^2 per day; 0.33 days
   c. 10 mmol $CaCO_3$ per m^2 per day; 3 days
   d. 10 mmol $CaCO_3$ per m^2 per day; 300 days

8. _____ What happens when carbonate ion concentration in seawater *decreases*?

   a. The rate of calcification decreases, and it takes less time for the reef coral to grow.
   b. The rate of calcification decreases, and it takes longer for the reef coral to grow.
   c. The rate of calcification increases, and it takes longer for the reef coral to grow.
   d. The rate of calcification increases, and it takes less time for the reef coral to grow.

Scientific Skills Exercise: Analyzing Polypeptide Sequence Data

Species	Alignment of Amino Acid Sequences of *β*-globin					
Human	1	VHLTPEEKSA	VTALWGKVNV	DEVGGEALGR	LLVVYPWTQR	FFESFGDLST	PDAVMGNPKV
Monkey	1	VHLTPEEKNA	VTTLWGKVNV	DEVGGEALGR	LLLVYPWTQR	FFESFGDLSS	PDAVMGNPKV
Gibbon	1	VHLTPEEKSA	VTALWGKVNV	DEVGGEALGR	LLVVYPWTQR	FFESFGDLST	PDAVMGNPKV
Human	61	KAHGKKVLGA	FSDGLAHLDN	LKGTFATLSE	LHCDKLHVDP	ENFRLLGNVL	VCVLAHHFGK
Monkey	61	KAHGKKVLGA	FSDGLNHLDN	LKGTFAQLSE	LHCDKLHVDP	ENFKLLGNVL	VCVLAHHFGK
Gibbon	61	KAHGKKVLGA	FSDGLAHLDN	LKGTFAQLSE	LHCDKLHVDP	ENFRLLGNVL	VCVLAHHFGK
Human	121	EFTPPVQAAY	QKVVAGVANA	LAHKYH			
Monkey	121	EFTPQVQAAY	QKVVAGVANA	LAHKYH			
Gibbon	121	EFTPQVQAAY	QKVVAGVANA	LAHKYH			

Data from http://www.ncbi.nlm.nih.gov/protein/AAA21113.1 (human);
https://www.ncbi.nlm.nih.gov/protein/122634 (rhesus monkey);
https://www.ncbi.nlm.nih.gov/protein/122616 (gibbon).

Are rhesus monkeys or gibbons more closely related to humans?
DNA and polypeptide sequences from closely related species are more similar to each other than sequences from more distantly related species. In this exercise, you will look at amino acid sequence data for the β polypeptide chain of hemoglobin, often called β-globin. You will then interpret the data to hypothesize whether the monkey or the gibbon is more closely related to humans.

In the alignment shown here, the letters give the sequences of the 146 amino acids in β-globin from humans, rhesus monkeys, and gibbons. Because a complete sequence would not fit on one line, the sequences are broken into segments. The sequences for the three different species are aligned so that you can compare them easily. For example, you can see that, for all three species, the first amino acid is "V" (valine) and the 146th amino acid is "H" (histidine).

1. _____ Scan along the aligned sequences, letter by letter, noting any positions where the amino acids in the monkey or gibbon sequences do not match the human sequence. How many amino acids differ between the monkey and the human sequences?
   a. 2
   b. 6
   c. 8
   d. 10

2. _____ How many amino acids differ between the gibbon and the human sequences?
   a. 1
   b. 2
   c. 6
   d. 8

3. _____ What percent of monkey β-globin amino acids are *identical* to the human sequence? (This is called the percent identity between the monkey and human β-globin sequences.)
   a. 5.48%
   b. 94.5%
   c. 95.9%
   d. 98.6%

4. _____ What percent of gibbon β-globin amino acids are *identical* to the human sequence? (This is called the percent identity between the gibbon and human β-globin sequences.)
   a. 1.37%
   b. 94.5%
   c. 95.9%
   d. 98.6%

5. _____ Based on the β-globin alignment, identify the best hypothesis about how humans are related to monkeys and gibbons.
   a. Monkeys are more closely related to humans than gibbons are because monkeys' β-globin sequence has the lower percent identity with humans.
   b. Gibbons are more closely related to humans than monkeys are because the gibbon β-globin sequence is a closer match with the human sequence.
   c. Both monkeys and gibbons are equally related to humans because they both have less than a 10% difference in β-globin sequence with humans.
   d. Both monkeys and gibbons are equally unrelated to humans because neither monkeys nor gibbons have the exact same β-globin sequence as humans.

6. _____ What other evidence could you use to analyze evolutionary relatedness among gibbons, monkeys, and humans?
   a. the amount of habitat overlap among gibbons, monkeys, and humans
   b. the amino acid sequences of other proteins from gibbons, monkeys, and humans
   c. the β-globin amino acid sequence from gorillas
   d. the frequency of albinism (mutants that lack hair and skin pigment) in populations of gibbons, monkeys, and humans