SUPPLEMENT TO OPENSTAX BIOLOGY 2E FOR NORCO COLLEGE



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Norco College

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Supplement to OpenStax Biology 2e for Norco College

Teresa Friedrich Finnern

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Licensing

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CHAPTER OVERVIEW

1: THE STUDY OF LIFE

1.1: Key Terms

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1.1: KEY TERMS

abstract
opening section of a scientific paper that summarizes the research and conclusions

applied science
form of science that aims to solve real-world problems

atom
smallest and most fundamental unit of matter that retains the properties of an element

basic science
science that seeks to expand knowledge and understanding regardless of the short-term application of that knowledge

biochemistry
study of the chemistry of biological organisms

biology
the study of life

biosphere
collection of all the ecosystems on Earth

botany
study of plants

cell
smallest fundamental unit of structure and function in living things

community
set of populations inhabiting a particular area

conclusion
section of a scientific paper that summarizes the importance of the experimental findings

control
part of an experiment that does not change during the experiment

deductive reasoning
form of logical thinking that uses a general inclusive statement to predict specific results

descriptive science
(also, discovery science) form of science that aims to observe, explore, and investigate

discussion
section of a scientific paper in which the author interprets experimental results, describes how variables may be related, and attempts to explain the phenomenon in question

ecosystem
all the living things in a particular area together with the abiotic, nonliving parts of that environment

eukaryote
organism with cells that have nuclei and membrane-bound organelles

evolution
the process of gradual change in a population or species over time

falsifiable
able to be disproven by experimental results

homeostasis
ability of an organism to maintain constant internal conditions

hypothesis
suggested explanation for an observation, which one can test

hypothesis-based science
form of science that begins with a specific question and potential testable answers

inductive reasoning
form of logical thinking that uses related observations to arrive at a general conclusion

introduction
opening section of a scientific paper, which provides background information about what was known in the field prior to the research reported in the paper

life science
field of science, such as biology, that studies living things

macromolecule
large molecule, typically formed by the joining of smaller molecules

materials and methods
section of a scientific paper that includes a complete description of the substances, methods, and techniques that the researchers used to gather data

microbiology
study of the structure and function of microorganisms

molecular biology
study of biological processes and their regulation at the molecular level, including interactions among molecules such as DNA, RNA, and proteins

molecule
chemical structure consisting of at least two atoms held together by one or more chemical bonds

natural science
field of science that is related to the physical world and its phenomena and processes

neurobiology
study of the biology of the nervous system

organ
collection of related tissues grouped together performing a common function

organ system
level of organization that consists of functionally related interacting organs

organelle
small structures that exist within cells and carry out cellular functions

organism
individual living entity

paleontology

study of life’s history by means of fossils

peer-reviewed manuscript
scientific paper that a scientist’s colleagues review who are experts in the field of study

phylogenetic tree
diagram showing the evolutionary relationships among various biological species based on similarities and differences in genetic or physical traits or both; in essence, a hypothesis concerning evolutionary connections

physical science
field of science, such as geology, astronomy, physics, and chemistry, that studies nonliving matter

plagiarism
using other people’s work or ideas without proper citation, creating the false impression that those are the author’s original ideas

population
all of the individuals of a species living within a specific area

prokaryote
single-celled organism that lacks organelles and does not have nuclei surrounded by a nuclear membrane

results
section of a scientific paper in which the author narrates the experimental findings and presents relevant figures, pictures, diagrams, graphs, and tables, without any further interpretation

review article
paper that summarizes and comments on findings that were published as primary literature

science
knowledge that covers general truths or the operation of general laws, especially when acquired and tested by the scientific method

scientific method
method of research with defined steps that include observation, formulation of a hypothesis, testing, and confirming or falsifying the hypothesis

serendipity
fortunate accident or a lucky surprise

theory
tested and confirmed explanation for observations or phenomena

tissue
group of similar cells carrying out related functions

variable
part of an experiment that the experimenter can vary or change

zoology
study of animals

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1.2: VISUAL CONNECTION QUESTIONS

1.

Figure 1.6 In the example below, the scientific method is used to solve an everyday problem. Match the scientific method steps (numbered items) with the process of solving the everyday problem (lettered items). Based on the results of the experiment, is the hypothesis correct? If it is incorrect, propose some alternative hypotheses.

1. Observation	a. There is something wrong with the electrical outlet.
2. Question	b. If something is wrong with the outlet, my coffeemaker also won't work when plugged into it.
3. Hypothesis (answer)	c. My toaster doesn't toast my bread.
4. Prediction	d. I plug my coffee maker into the outlet.
5. Experiment	e. My coffeemaker works.
6. Result	f. Why doesn't my toaster work?

2.

Figure 1.7 Decide if each of the following is an example of inductive or deductive reasoning.

1. All flying birds and insects have wings. Birds and insects flap their wings as they move through the air. Therefore, wings enable flight.
2. Insects generally survive mild winters better than harsh ones. Therefore, insect pests will become more problematic if global temperatures increase.
3. Chromosomes, the carriers of DNA, separate into daughter cells during cell division. Therefore, each daughter cell will have the same chromosome set as the mother cell.
4. Animals as diverse as humans, insects, and wolves all exhibit social behavior. Therefore, social behavior must have an evolutionary advantage.

3.

Figure 1.16 Which of the following statements is false?

1. Tissues exist within organs which exist within organ systems.
2. Communities exist within populations which exist within ecosystems.
3. Organelles exist within cells which exist within tissues.
4. Communities exist within ecosystems which exist in the biosphere.

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1.3: REVIEW QUESTIONS

4.

The first forms of life on Earth were _____.

1. plants
2. microorganisms
3. birds
4. dinosaurs

5.

A suggested and testable explanation for an event is called a _____.

1. hypothesis
2. variable
3. theory
4. control

6.

Which of the following sciences is not considered a natural science?

1. biology
2. astronomy
3. physics
4. computer science

7.

The type of logical thinking that uses related observations to arrive at a general conclusion is called _____.

1. deductive reasoning
2. the scientific method
3. hypothesis-based science
4. inductive reasoning

8.

The process of _____ helps to ensure that a scientist's research is original, significant, logical, and thorough.

1. publication
2. public speaking
3. peer review
4. the scientific method

9.

A person notices that her houseplants that are regularly exposed to music seem to grow more quickly than those in rooms with no music. As a result, she determines that plants grow better when exposed to music. This example most closely resembles which type of reasoning?

1. inductive reasoning
2. deductive reasoning
3. neither, because no hypothesis was made
4. both inductive and deductive reasoning

10.

The smallest unit of biological structure that meets the functional requirements of "living" is the _____.

1. organ
2. organelle
3. cell
4. macromolecule

11.

Viruses are not considered living because they _____.

1. are not made of cells

2. lack cell nuclei
3. do not contain DNA or RNA
4. cannot reproduce

12.

The presence of a membrane-enclosed nucleus is a characteristic of _____.

1. prokaryotic cells
2. eukaryotic cells
3. living organisms
4. bacteria

13.

A group of individuals of the same species living in the same area is called a(n) _____.

1. family
2. community
3. population
4. ecosystem

14.

Which of the following sequences represents the hierarchy of biological organization from the most inclusive to the least complex level?

1. organelle, tissue, biosphere, ecosystem, population
2. organ, organism, tissue, organelle, molecule
3. organism, community, biosphere, molecule, tissue, organ
4. biosphere, ecosystem, community, population, organism

15.

Where in a phylogenetic tree would you expect to find the organism that had evolved most recently?

1. at the base
2. within the branches
3. at the nodes
4. at the branch tips

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1.4: CRITICAL THINKING QUESTIONS

16.

Although the scientific method is used by most of the sciences, it can also be applied to everyday situations. Think about a problem that you may have at home, at school, or with your car, and apply the scientific method to solve it.

17.

Give an example of how applied science has had a direct effect on your daily life.

18.

Name two topics that are likely to be studied by biologists, and two areas of scientific study that would fall outside the realm of biology.

19.

Thinking about the topic of cancer, write a basic science question and an applied science question that a researcher interested in this topic might ask.

20.

Select two items that biologists agree are necessary in order to consider an organism “alive.” For each, give an example of a nonliving object that otherwise fits the definition of “alive.”

21.

Consider the levels of organization of the biological world, and place each of these items in order from smallest level of organization to most encompassing: skin cell, elephant, water molecule, planet Earth, tropical rainforest, hydrogen atom, wolf pack, liver.

22.

You go for a long walk on a hot day. Give an example of a way in which homeostasis keeps your body healthy.

23.

Using examples, explain how biology can be studied from a microscopic approach to a global approach.

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CHAPTER OVERVIEW

2: THE CHEMICAL FOUNDATION OF LIFE

Elements in various combinations comprise all matter, including living things. Some of the most abundant elements in living organisms include carbon, hydrogen, nitrogen, oxygen, sulfur, and phosphorus. These form the nucleic acids, proteins, carbohydrates, and lipids that are the fundamental components of living matter. Biologists must understand these important building blocks and the unique structures of the atoms that make up molecules, allowing for the formation of cells, tissues, organ systems, and entire organisms.

2.1: Key Terms

2.2: Visual Connection Questions

2.3: Review Questions

2.4: Critical Thinking Questions

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2.1: KEY TERMS

acid
molecule that donates hydrogen ions and increases the concentration of hydrogen ions in a solution

adhesion
attraction between water molecules and other molecules

aliphatic hydrocarbon
hydrocarbon consisting of a linear chain of carbon atoms

anion
negative ion that is formed by an atom gaining one or more electrons

aromatic hydrocarbon
hydrocarbon consisting of closed rings of carbon atoms

atom
the smallest unit of matter that retains all of the chemical properties of an element

atomic mass
calculated mean of the mass number for an element’s isotopes

atomic number
total number of protons in an atom

balanced chemical equation
statement of a chemical reaction with the number of each type of atom equalized for both the products and reactants

base
molecule that donates hydroxide ions or otherwise binds excess hydrogen ions and decreases the hydrogen ions' concentration in a solution

buffer
substance that resists a change in pH by absorbing or releasing hydrogen or hydroxide ions

calorie
amount of heat required to change the temperature of one gram of water by one degree Celsius

capillary action
occurs because water molecules are attracted to charges on the inner surfaces of narrow tubular structures such as glass tubes, drawing the water molecules to the tubes' sides

cation
positive ion that is formed by an atom losing one or more electrons

chemical bond
interaction between two or more of the same or different atoms that results in forming molecules

chemical reaction
process leading to rearranging atoms in molecules

chemical reactivity
the ability to combine and to chemically bond with each other

cohesion

intermolecular forces between water molecules caused by the polar nature of water; responsible for surface tension

compound

substance composed of molecules consisting of atoms of at least two different elements

covalent bond

type of strong bond formed between two atoms of the same or different elements; forms when electrons are shared between atoms

dissociation

release of an ion from a molecule such that the original molecule now consists of an ion and the charged remains of the original, such as when water dissociates into H^+ and OH^-

electrolyte

ion necessary for nerve impulse conduction, muscle contractions, and water balance

electron

negatively charged subatomic particle that resides outside of the nucleus in the electron orbital; lacks functional mass and has a negative charge of –1 unit

electron configuration

arrangement of electrons in an atom's electron shell (for example, $1s^2 2s^2 2p^6$)

electron orbital

how electrons are spatially distributed surrounding the nucleus; the area where we are most likely to find an electron

electron transfer

movement of electrons from one element to another; important in creating ionic bonds

electronegativity

ability of some elements to attract electrons (often of hydrogen atoms), acquiring partial negative charges in molecules and creating partial positive charges on the hydrogen atoms

element

one of 118 unique substances that cannot break down into smaller substances; each element has unique properties and a specified number of protons

enantiomers

molecules that share overall structure and bonding patterns, but differ in how the atoms are three dimensionally placed such that they are mirror images of each other

equilibrium

steady state of relative reactant and product concentration in reversible chemical reactions in a closed system

evaporation

change from liquid to gaseous state at a body of water's surface, plant leaves, or an organism's skin

functional group

group of atoms that provides or imparts a specific function to a carbon skeleton

geometric isomer

isomer with similar bonding patterns differing in the placement of atoms alongside a double covalent bond

heat of vaporization of water

high amount of energy required for liquid water to turn into water vapor

hydrocarbon

molecule that consists only of carbon and hydrogen

hydrogen bond
weak bond between slightly positively charged hydrogen atoms and slightly negatively charged atoms in other molecules

hydrophilic
describes ions or polar molecules that interact well with other polar molecules such as water

hydrophobic
describes uncharged nonpolar molecules that do not interact well with polar molecules such as water

inert gas
(also, noble gas) element with filled outer electron shell that is unreactive with other atoms

ion
atom or chemical group that does not contain equal numbers of protons and electrons

ionic bond
chemical bond that forms between ions with opposite charges (cations and anions)

irreversible chemical reaction
chemical reaction where reactants proceed unidirectionally to form products

isomers
molecules that differ from one another even though they share the same chemical formula

isotope
one or more forms of an element that have different numbers of neutrons

law of mass action
chemical law stating that the rate of a reaction is proportional to the concentration of the reacting substances

litmus paper
(also, pH paper) filter paper treated with a natural water-soluble dye that changes its color as the pH of the environment changes in order to use it as a pH indicator

mass number
total number of protons and neutrons in an atom

matter
anything that has mass and occupies space

molecule
two or more atoms chemically bonded together

neutron
uncharged particle that resides in an atom's nucleus; has a mass of one amu

noble gas
see inert gas

nonpolar covalent bond
type of covalent bond that forms between atoms when electrons are shared equally between them

nucleus
core of an atom; contains protons and neutrons

octet rule
rule that atoms are most stable when they hold eight electrons in their outermost shells

orbital
region surrounding the nucleus; contains electron(s)

organic molecule
any molecule containing carbon (except carbon dioxide)

periodic table
organizational chart of elements indicating each element's atomic number and atomic mass; provides key information about the elements' properties

pH paper
see litmus paper

pH scale
scale ranging from zero to 14 that is inversely proportional to the hydrogen ions' concentration in a solution

polar covalent bond
type of covalent bond that forms as a result of unequal electron sharing, resulting in creating slightly positive and negative charged molecule regions

product
molecule that is result of chemical reaction

proton
positively charged particle that resides in the atom's nucleus; has a mass of one amu and a charge of +1

radioisotope
isotope that emits radiation comprised of subatomic particles to form more stable elements

reactant
molecule that takes part in a chemical reaction

reversible chemical reaction
chemical reaction that functions bidirectionally, where products may turn into reactants if their concentration is great enough

solvent
substance capable of dissolving another substance

specific heat capacity
the amount of heat one gram of a substance must absorb or lose to change its temperature by one degree Celsius

sphere of hydration
when a polar water molecule surrounds charged or polar molecules thus keeping them dissolved and in solution

structural isomers
molecules that share a chemical formula but differ in the placement of their chemical bonds

substituted hydrocarbon
hydrocarbon chain or ring containing an atom of another element in place of one of the backbone carbons

surface tension
tension at the surface of a body of liquid that prevents the molecules from separating; created by the attractive cohesive forces between the liquid's molecules

valence shell
outermost shell of an atom

van der Waals interaction

very weak interaction between molecules due to temporary charges attracting atoms that are very close together

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2.2: VISUAL CONNECTION QUESTIONS

1.

Figure 2.3 How many neutrons do carbon-12 and carbon-13 have, respectively?

2.

Figure 2.7 An atom may give, take, or share electrons with another atom to achieve a full valence shell, the most stable electron configuration. Looking at this figure, how many electrons do elements in group 1 need to lose in order to achieve a stable electron configuration? How many electrons do elements in groups 14 and 17 need to gain to achieve a stable configuration?

3.

Figure 2.24 Which of the following statements is false?

1. Molecules with the formulas CH_3CH_2COOH and $C_3H_6O_2$ could be structural isomers.
2. Molecules must have a double bond to be *cis-trans* isomers.
3. To be enantiomers, a molecule must have at least three different atoms or groups connected to a central carbon.
4. To be enantiomers, a molecule must have at least four different atoms or groups connected to a central carbon.

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2.3: REVIEW QUESTIONS

4.

If xenon has an atomic number of 54 and a mass number of 108, how many neutrons does it have?

1. 54
2. 27
3. 100
4. 108

5.

Atoms that vary in the number of neutrons found in their nuclei are called _____.

1. ions
2. neutrons
3. neutral atoms
4. isotopes

6.

Potassium has an atomic number of 19. What is its electron configuration?

1. shells 1 and 2 are full, and shell 3 has nine electrons
2. shells 1, 2 and 3 are full and shell 4 has three electrons
3. shells 1, 2 and 3 are full and shell 4 has one electron
4. shells 1, 2 and 3 are full and no other electrons are present

7.

Which type of bond represents a weak chemical bond?

1. hydrogen bond
2. atomic bond
3. covalent bond
4. nonpolar covalent bond

8.

Which of the following statements is not true?

1. Water is polar.
2. Water stabilizes temperature.
3. Water is essential for life.
4. Water is the most abundant molecule in the Earth’s atmosphere.

9.

When acids are added to a solution, the pH should _____.

1. decrease
2. increase
3. stay the same
4. cannot tell without testing

10.

We call a molecule that binds up excess hydrogen ions in a solution a(n) _____.

1. acid
2. isotope
3. base
4. donator

11.

Which of the following statements is true?

1. Acids and bases cannot mix together.
2. Acids and bases will neutralize each other.

3. Acids, but not bases, can change the pH of a solution.
4. Acids donate hydroxide ions (OH^-); bases donate hydrogen ions (H^+).

12.

Each carbon atom can bond with as many as_____ other atom(s) or molecule(s).

1. one
2. two
3. six
4. four

13.

Which of the following is not a functional group that can bond with carbon?

1. sodium
2. hydroxyl
3. phosphate
4. carbonyl

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2.4: CRITICAL THINKING QUESTIONS

14.

What makes ionic bonds different from covalent bonds?

15.

Why are hydrogen bonds and van der Waals interactions necessary for cells?

16.

Discuss how buffers help prevent drastic swings in pH.

17.

Why can some insects walk on water?

18.

What property of carbon makes it essential for organic life?

19.

Compare and contrast saturated and unsaturated triglycerides.

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CHAPTER OVERVIEW

3: BIOLOGICAL MACROMOLECULES

Food provides the body with the nutrients it needs to survive. Many of these critical nutrients are biological macromolecules, or large molecules, necessary for life. These macromolecules (polymers) are built from different combinations of smaller organic molecules (monomers). What specific types of biological macromolecules do living things require? How are these molecules formed? What functions do they serve? In this chapter, these questions will be explored.

3.1: Key Terms

3.2: Visual Connection Questions

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3.1: KEY TERMS

alpha-helix structure (*α*-helix)
type of secondary protein structure formed by folding the polypeptide into a helix shape with hydrogen bonds stabilizing the structure

amino acid
a protein's monomer; has a central carbon or alpha carbon to which an amino group, a carboxyl group, a hydrogen, and an R group or side chain is attached; the R group is different for all 20 common amino acids

beta-pleated sheet (*β*-pleated)
secondary structure in proteins in which hydrogen bonding forms “pleats” between atoms on the polypeptide chain's backbone

biological macromolecule
large molecule necessary for life that is built from smaller organic molecules

carbohydrate
biological macromolecule in which the ratio of carbon to hydrogen and to oxygen is 1:2:1; carbohydrates serve as energy sources and structural support in cells and form arthropods' cellular exoskeleton

cellulose
polysaccharide that comprises the plants' cell wall; provides structural support to the cell

chaperone
(also, chaperonin) protein that helps nascent protein in the folding process

chitin
type of carbohydrate that forms the outer skeleton of all arthropods that include crustaceans and insects; it also forms fungi cell walls

dehydration synthesis
(also, condensation) reaction that links monomer molecules, releasing a water molecule for each bond formed

denaturation
loss of shape in a protein as a result of changes in temperature, pH, or chemical exposure

deoxyribonucleic acid (DNA)
double-helical molecule that carries the cell's hereditary information

disaccharide
two sugar monomers that a glycosidic bond links

enzyme
catalyst in a biochemical reaction that is usually a complex or conjugated protein

glycogen
storage carbohydrate in animals

glycosidic bond
bond formed by a dehydration reaction between two monosaccharides with eliminating a water molecule

hormone
chemical signaling molecule, usually protein or steroid, secreted by endocrine cells that act to control or regulate specific physiological processes

hydrolysis
reaction that causes breakdown of larger molecules into smaller molecules by utilizing water

lipid

macromolecule that is nonpolar and insoluble in water

messenger RNA (mRNA)
RNA that carries information from DNA to ribosomes during protein synthesis

monomer
smallest unit of larger molecules that are polymers

monosaccharide
single unit or monomer of carbohydrates

nucleic acid
biological macromolecule that carries the cell's genetic blueprint and carries instructions for the cell's functioning

nucleotide
monomer of nucleic acids; contains a pentose sugar, one or more phosphate groups, and a nitrogenous base

omega fat
type of polyunsaturated fat that the body requires; numbering the carbon omega starts from the methyl end or the end that is farthest from the carboxylic end

peptide bond
bond formed between two amino acids by a dehydration reaction

phosphodiester
linkage covalent chemical bond that holds together the polynucleotide chains with a phosphate group linking neighboring nucleotides' two pentose sugars

phospholipid
membranes' major constituent; comprised of two fatty acids and a phosphate-containing group attached to a glycerol backbone

polymer
chain of monomer residues that covalent bonds link; polymerization is the process of polymer formation from monomers by condensation

polynucleotide
long chain of nucleotides

polypeptide
long chain of amino acids that peptide bonds link

polysaccharide
long chain of monosaccharides; may be branched or unbranched

primary structure
linear sequence of amino acids in a protein

protein
biological macromolecule comprised of one or more amino acid chains

purine
type of nitrogenous base in DNA and RNA; adenine and guanine are purines

pyrimidine
type of nitrogenous base in DNA and RNA; cytosine, thymine, and uracil are pyrimidines

quaternary structure

association of discrete polypeptide subunits in a protein

ribonucleic acid (RNA)
single-stranded, often internally base paired, molecule that is involved in protein synthesis

ribosomal RNA (rRNA)
RNA that ensures the proper alignment of the mRNA and the ribosomes during protein synthesis and catalyzes forming the peptide linkage

saturated fatty acid
long-chain hydrocarbon with single covalent bonds in the carbon chain; the number of hydrogen atoms attached to the carbon skeleton is maximized

secondary structure
regular structure that proteins form by intramolecular hydrogen bonding between the oxygen atom of one amino acid residue and the hydrogen attached to the nitrogen atom of another amino acid residue

starch
storage carbohydrate in plants

steroid
type of lipid comprised of four fused hydrocarbon rings forming a planar structure

tertiary structure
a protein's three-dimensional conformation, including interactions between secondary structural elements; formed from interactions between amino acid side chains

trans fat
fat formed artificially by hydrogenating oils, leading to a different arrangement of double bond(s) than those in naturally occurring lipids

transcription
process through which messenger RNA forms on a template of DNA

transfer RNA (tRNA)
RNA that carries activated amino acids to the site of protein synthesis on the ribosome

translation
process through which RNA directs the protein's formation

triacylglycerol (also, triglyceride)
fat molecule; consists of three fatty acids linked to a glycerol molecule

unsaturated fatty acid
long-chain hydrocarbon that has one or more double bonds in the hydrocarbon chain

wax
lipid comprised of a long-chain fatty acid that is esterified to a long-chain alcohol; serves as a protective coating on some feathers, aquatic mammal fur, and leaves

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3.2: VISUAL CONNECTION QUESTIONS

1.

Figure 3.5 What kind of sugars are these, aldose or ketose?

2.

Figure 3.23 Which categories of amino acid would you expect to find on the surface of a soluble protein, and which would you expect to find in the interior? What distribution of amino acids would you expect to find in a protein embedded in a lipid bilayer?

3.

Figure 3.33 A mutation occurs, and cytosine is replaced with adenine. What impact do you think this will have on the DNA structure?

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3.3: REVIEW QUESTIONS

4.

Dehydration synthesis leads to formation of

1. monomers
2. polymers
3. water and polymers
4. none of the above

5.

During the breakdown of polymers, which of the following reactions takes place?

1. hydrolysis
2. dehydration
3. condensation
4. covalent bond

6.

The following chemical reactants produce the ester ethyl ethanoate ($C_4H_8O_2$):

$C_2H_6O + CH_3COOH$

What type of reaction occurs to make ethyl ethanoate?

1. condensation
2. hydrolysis
3. combustion
4. acid-base reaction

7.

An example of a monosaccharide is _____.

1. fructose
2. glucose
3. galactose
4. all of the above

8.

Cellulose and starch are examples of:

1. monosaccharides
2. disaccharides
3. lipids
4. polysaccharides

9.

Plant cell walls contain which of the following in abundance?

1. starch
2. cellulose
3. glycogen
4. lactose

10.

Lactose is a disaccharide formed by the formation of a _____ bond between glucose and _____.

1. glycosidic; lactose
2. glycosidic; galactose
3. hydrogen; sucrose
4. hydrogen; fructose

11.

Which of the following is not an extracellular matrix role of carbohydrates?

1. protect an insect's internal organs from external trauma
2. prevent plant cells from lysing after the plant is watered
3. maintain the shape of a fungal spore
4. provide energy for muscle movement

12.

Saturated fats have all of the following characteristics except:

1. they are solid at room temperature
2. they have single bonds within the carbon chain
3. they are usually obtained from animal sources
4. they tend to dissolve in water easily

13.

Phospholipids are important components of _____.

1. the plasma membrane of cells
2. the ring structure of steroids
3. the waxy covering on leaves
4. the double bond in hydrocarbon chains

14.

Cholesterol is an integral part of plasma membranes. Based on its structure, where is it found in the membrane?

1. on the extracellular surface
2. embedded with the phospholipid heads
3. within the tail bilayer
4. attached to the intracellular surface

15.

The monomers that make up proteins are called _____.

1. nucleotides
2. disaccharides
3. amino acids
4. chaperones

16.

The α-helix and the β-pleated sheet are part of which protein structure?

1. primary
2. secondary
3. tertiary
4. quaternary

17.

Mad cow disease is an infectious disease where one misfolded protein causes all other copies of the protein to begin misfolding. This is an example of a disease impacting ____ structure.

1. primary
2. secondary
3. tertiary
4. quaternary

18.

A nucleotide of DNA may contain _____.

1. ribose, uracil, and a phosphate group
2. deoxyribose, uracil, and a phosphate group
3. deoxyribose, thymine, and a phosphate group
4. ribose, thymine, and a phosphate group

19.

The building blocks of nucleic acids are _____.

1. sugars
2. nitrogenous bases
3. peptides
4. nucleotides

20.

How does the double helix structure of DNA support its role in encoding the genome?

1. The sugar-phosphate backbone provides a template for DNA replication.
2. tRNA pairing with the template strand creates proteins encoded by the genome.
3. Complementary base pairing creates a very stable structure.
4. Complementary base pairing allows for easy editing of both strands of DNA.

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3.4: CRITICAL THINKING QUESTIONS

21.

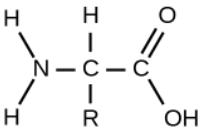
Why are biological macromolecules considered organic?

22.

What role do electrons play in dehydration synthesis and hydrolysis?

23.

Amino acids have the generic structure seen below, where R represents different carbon-based side chains.



Describe how the structure of amino acids allows them to be linked into long peptide chains to form proteins.

24.

Describe the similarities and differences between glycogen and starch.

25.

Why is it impossible for humans to digest food that contains cellulose?

26.

Draw the ketose and aldose forms of a monosaccharide with the chemical formula $C_3H_6O_3$. How is the structure of the monosaccharide changed from one form to the other in the human body?

27.

Explain at least three functions that lipids serve in plants and/or animals.

28.

Why have trans fats been banned from some restaurants? How are they created?

29.

Why are fatty acids better than glycogen for storing large amounts of chemical energy?

30.

Part of cortisol's role in the body involves passing through the plasma membrane to initiate signaling inside a cell. Describe how the structures of cortisol and the plasma membrane allow this to occur.

31.

Explain what happens if even one amino acid is substituted for another in a polypeptide chain. Provide a specific example.

32.

Describe the differences in the four protein structures.

33.

Aquaporins are proteins embedded in the plasma membrane that allow water molecules to move between the extracellular matrix and the intracellular space. Based on its function and location, describe the key features of the protein's shape and the chemical characteristics of its amino acids.

34.

What are the structural differences between RNA and DNA?

35.

What are the four types of RNA and how do they function?

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CHAPTER OVERVIEW

4: CELL STRUCTURE

Your body has many kinds of cells, each specialized for a specific purpose. Just as a home is made from a variety of building materials, the human body is constructed from many cell types. For example, epithelial cells protect the surface of the body and cover the organs and body cavities within. Bone cells help to support and protect the body. Cells of the immune system fight invading bacteria. Additionally, blood and blood cells carry nutrients and oxygen throughout the body while removing carbon dioxide. Each of these cell types plays a vital role during the growth, development, and day-to-day maintenance of the body. In spite of their enormous variety, however, cells from all organisms—even ones as diverse as bacteria, onion, and human—share certain fundamental characteristics.

4.1: Key Terms

4.2: Visual Connection Questions

4.3: Review Questions

4.4: Critical Thinking Questions

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4.1: KEY TERMS

cell theory
see unified cell theory

cell wall
rigid cell covering comprised of various molecules that protects the cell, provides structural support, and gives shape to the cell

central vacuole
large plant cell organelle that regulates the cell’s storage compartment, holds water, and plays a significant role in cell growth as the site of macromolecule degradation

centrosome
region in animal cells made of two centrioles that serves as an organizing center for microtubules

chlorophyll
green pigment that captures the light energy that drives the light reactions of photosynthesis

chloroplast
plant cell organelle that carries out photosynthesis

chromatin
protein-DNA complex that serves as the chromosomes' building material

chromosome
structure within the nucleus that comprises chromatin that contains DNA, the hereditary material

cilium
(plural = cilia) short, hair-like structure that extends from the plasma membrane in large numbers and functions to move an entire cell or move substances along the cell's outer surface

cytoplasm
entire region between the plasma membrane and the nuclear envelope, consisting of organelles suspended in the gel-like cytosol, the cytoskeleton, and various chemicals

cytoskeleton
protein fiber network that collectively maintains the cell's shape, secures some organelles in specific positions, allows cytoplasm and vesicles to move within the cell, and enables unicellular organisms to move independently

cytosol
the cytoplasm's gel-like material in which cell structures are suspended

desmosome
linkages between adjacent epithelial cells that form when cadherins in the plasma membrane attach to intermediate filaments

electron microscope
an instrument that magnifies an object using an electron beam that passes and bends through a lens system to visualize a specimen

endomembrane system
group of organelles and membranes in eukaryotic cells that work together modifying, packaging, and transporting lipids and proteins

endoplasmic reticulum (ER)
series of interconnected membranous structures within eukaryotic cells that collectively modify proteins and synthesize lipids

eukaryotic cell
cell that has a membrane-bound nucleus and several other membrane-bound compartments or sacs

extracellular matrix
material secreted from animal or fungal cells that provides mechanical protection and anchoring for the cells in the tissue

flagellum
(plural = flagella) long, hair-like structure that extends from the plasma membrane and moves the cell

gap junction
channel between two adjacent animal cells that allows ions, nutrients, and low molecular weight substances to pass between cells, enabling the cells to communicate

Golgi apparatus
eukaryotic organelle comprised of a series of stacked membranes that sorts, tags, and packages lipids and proteins for distribution

intermediate filament
cytoskeletal component, comprised of several fibrous protein intertwined strands, that bears tension, supports cell-cell junctions, and anchors cells to extracellular structures

light microscope
an instrument that magnifies an object using a beam of visible light that passes and bends through a lens system to visualize a specimen

lysosome
organelle in an animal cell that functions as the cell's digestive component; it breaks down proteins, polysaccharides, lipids, nucleic acids, and even worn-out organelles

microfilament
the cytoskeleton system's narrowest element; it provides rigidity and shape to the cell and enables cellular movements

microscope
an instrument that magnifies an object

microtubule
the cytoskeleton system's widest element; it helps the cell resist compression, provides a track along which vesicles move through the cell, pulls replicated chromosomes to opposite ends of a dividing cell, and is the structural element of centrioles, flagella, and cilia

mitochondria
(singular = mitochondrion) cellular organelles responsible for carrying out cellular respiration, resulting in producing ATP, the cell's main energy-carrying molecule

nuclear envelope
double-membrane structure that constitutes the nucleus' outermost portion

nucleoid
central part of a prokaryotic cell's central part where the chromosome is located

nucleolus
darkly staining body within the nucleus that is responsible for assembling ribosome subunits

nucleoplasm
semi-solid fluid inside the nucleus that contains the chromatin and nucleolus

nucleus
cell organelle that houses the cell's DNA and directs ribosome and protein synthesis

organelle
compartment or sac within a cell

peroxisome

small, round organelle that contains hydrogen peroxide, oxidizes fatty acids and amino acids, and detoxifies many poisons

plasma membrane

phospholipid bilayer with embedded (integral) or attached (peripheral) proteins, and separates the cell's internal content from its surrounding environment

plasmodesma

(plural = plasmodesmata) channel that passes between adjacent plant cells' cell walls, connects their cytoplasm, and allows transporting of materials from cell to cell

prokaryote

unicellular organism that lacks a nucleus or any other membrane-bound organelle

ribosome

cellular structure that carries out protein synthesis

rough endoplasmic reticulum (RER)

region of the endoplasmic reticulum that is studded with ribosomes and engages in protein modification and phospholipid synthesis

smooth endoplasmic reticulum (SER)

region of the endoplasmic reticulum that has few or no ribosomes on its cytoplasmic surface and synthesizes carbohydrates, lipids, and steroid hormones; detoxifies certain chemicals (like pesticides, preservatives, medications, and environmental pollutants), and stores calcium ions

tight junction

protein adherence that creates a firm seal between two adjacent animal cells

unified cell theory

a biological concept that states that one or more cells comprise all organisms; the cell is the basic unit of life; and new cells arise from existing cells

vacuole

membrane-bound sac, somewhat larger than a vesicle, which functions in cellular storage and transport

vesicle

small, membrane-bound sac that functions in cellular storage and transport; its membrane is capable of fusing with the plasma membrane and the membranes of the endoplasmic reticulum and Golgi apparatus

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4.2: VISUAL CONNECTION QUESTIONS

1.

Figure 4.7 Prokaryotic cells are much smaller than eukaryotic cells. What advantages might small cell size confer on a cell? What advantages might large cell size have?

2.

Figure 4.8 If the nucleolus were not able to carry out its function, what other cellular organelles would be affected?

3.

Figure 4.18 If a peripheral membrane protein were synthesized in the lumen (inside) of the ER, would it end up on the inside or outside of the plasma membrane?

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4.3: REVIEW QUESTIONS

4.

When viewing a specimen through a light microscope, scientists use _____ to distinguish the individual components of cells.

1. a beam of electrons
2. radioactive isotopes
3. special stains
4. high temperatures

5.

The _____ is the basic unit of life.

1. organism
2. cell
3. tissue
4. organ

6.

Prokaryotes depend on _____ to obtain some materials and to get rid of wastes.

1. ribosomes
2. flagella
3. cell division
4. diffusion

7.

Bacteria that lack fimbriae are less likely to _____.

1. adhere to cell surfaces
2. swim through bodily fluids
3. synthesize proteins
4. retain the ability to divide

8.

Which of the following organisms is a prokaryote?

1. amoeba
2. influenza A virus
3. charophyte algae
4. *E. coli*

9.

Which of the following is surrounded by two phospholipid bilayers?

1. the ribosomes
2. the vesicles
3. the cytoplasm
4. the nucleoplasm

10.

Peroxisomes got their name because hydrogen peroxide is:

1. used in their detoxification reactions
2. produced during their oxidation reactions
3. incorporated into their membranes
4. a cofactor for the organelles' enzymes

11.

In plant cells, the function of the lysosomes is carried out by _____.

1. vacuoles
2. peroxisomes

3. ribosomes
4. nuclei

12.

Which of the following is both in eukaryotic and prokaryotic cells?

1. nucleus
2. mitochondrion
3. vacuole
4. ribosomes

13.

Tay-Sachs disease is a genetic disorder that results in the destruction of neurons due to a buildup of sphingolipids in the cells. Which organelle is malfunctioning in Tay-Sachs?

1. lysosome
2. endoplasmic reticulum
3. peroxisome
4. mitochondria

14.

Which of the following is not a component of the endomembrane system?

1. mitochondrion
2. Golgi apparatus
3. endoplasmic reticulum
4. lysosome

15.

The process by which a cell engulfs a foreign particle is known as:

1. endosymbiosis
2. phagocytosis
3. hydrolysis
4. membrane synthesis

16.

Which of the following is most likely to have the greatest concentration of smooth endoplasmic reticulum?

1. a cell that secretes enzymes
2. a cell that destroys pathogens
3. a cell that makes steroid hormones
4. a cell that engages in photosynthesis

17.

Which of the following sequences correctly lists in order the steps involved in the incorporation of a proteinaceous molecule within a cell?

1. protein synthesis of the protein on the ribosome; modification in the Golgi apparatus; packaging in the endoplasmic reticulum; tagging in the vesicle
2. synthesis of the protein on the lysosome; tagging in the Golgi; packaging in the vesicle; distribution in the endoplasmic reticulum
3. synthesis of the protein on the ribosome; modification in the endoplasmic reticulum; tagging in the Golgi; distribution via the vesicle
4. synthesis of the protein on the lysosome; packaging in the vesicle; distribution via the Golgi; tagging in the endoplasmic reticulum

18.

Congenital disorders of glycosylation are a growing class of rare diseases. Which organelle would be most commonly involved in the glycoprotein disorder portion of the group?

1. RER
2. ribosomes
3. endosomes
4. Golgi apparatus

19.

Which of the following have the ability to disassemble and reform quickly?

1. microfilaments and intermediate filaments
2. microfilaments and microtubules
3. intermediate filaments and microtubules
4. only intermediate filaments

20.

Which of the following do not play a role in intracellular movement?

1. microfilaments and intermediate filaments
2. microfilaments and microtubules
3. intermediate filaments and microtubules
4. only intermediate filaments

21.

In humans, _____ are used to move a cell within its environment while _____ are used to move the environment relative to the cell.

1. cilia, pseudopodia
2. flagella; cilia
3. microtubules; flagella
4. microfilaments; microtubules

22.

Which of the following are only in plant cells?

1. gap junctions
2. desmosomes
3. plasmodesmata
4. tight junctions

23.

The key components of desmosomes are cadherins and _____.

1. actin
2. microfilaments
3. intermediate filaments
4. microtubules

24.

Diseased animal cells may produce molecules that activate death cascades to kill the cells in a controlled manner. Why would neighboring healthy cells also die?

1. The death molecule is passed through desmosomes.
2. The death molecule is passed through plasmodesmata.
3. The death molecule disrupts the extracellular matrix.
4. The death molecule passes through gap junctions.

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4.4: CRITICAL THINKING QUESTIONS

25.

In your everyday life, you have probably noticed that certain instruments are ideal for certain situations. For example, you would use a spoon rather than a fork to eat soup because a spoon is shaped for scooping, while soup would slip between the tines of a fork. The use of ideal instruments also applies in science. In what situation(s) would the use of a light microscope be ideal, and why?

26.

In what situation(s) would the use of a scanning electron microscope be ideal, and why?

27.

In what situation(s) would a transmission electron microscope be ideal, and why?

28.

What are the advantages and disadvantages of each of these types of microscopes?

29.

Explain how the formation of an adult human follows the cell theory.

30.

Antibiotics are medicines that are used to fight bacterial infections. These medicines kill prokaryotic cells without harming human cells. What part or parts of the bacterial cell do you think antibiotics target? Why?

31.

Explain why not all microbes are harmful.

32.

You already know that ribosomes are abundant in red blood cells. In what other cells of the body would you find them in great abundance? Why?

33.

What are the structural and functional similarities and differences between mitochondria and chloroplasts?

34.

Why are plasma membranes arranged as a bilayer rather than a monolayer?

35.

In the context of cell biology, what do we mean by form follows function? What are at least two examples of this concept?

36.

In your opinion, is the nuclear membrane part of the endomembrane system? Why or why not? Defend your answer.

37.

What are the similarities and differences between the structures of centrioles and flagella?

38.

How do cilia and flagella differ?

39.

Describe how microfilaments and microtubules are involved in the phagocytosis and destruction of a pathogen by a macrophage.

40.

Compare and contrast the boundaries that plant, animal, and bacteria cells use to separate themselves from their surrounding environment.

41.

How does the structure of a plasmodesma differ from that of a gap junction?

42.

Explain how the extracellular matrix functions.

43.

Pathogenic *E. coli* have recently been shown to degrade tight junction proteins during infection. How would this provide an advantage to the bacteria?

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CHAPTER OVERVIEW

5: STRUCTURE AND FUNCTION OF PLASMA MEMBRANES

The plasma membrane, which is also called the cell membrane, has many functions, but the most basic one is to define the borders of the cell and keep the cell functional. The plasma membrane is selectively permeable. This means that the membrane allows some materials to freely enter or leave the cell, while other materials cannot move freely, but require the use of a specialized structure, and occasionally, even energy investment for crossing.

5.1: Key Terms

5.2: Visual Connection Questions

5.3: Review Questions

5.4: Critical Thinking Questions

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5.1: KEY TERMS

active transport
method of transporting material that requires energy

amphiphilic
molecule possessing a polar or charged area and a nonpolar or uncharged area capable of interacting with both hydrophilic and hydrophobic environments

antiporter
transporter that carries two ions or small molecules in different directions

aquaporin
channel protein that allows water through the membrane at a very high rate

carrier protein
membrane protein that moves a substance across the plasma membrane by changing its own shape

caveolin
protein that coats the plasma membrane's cytoplasmic side and participates in the liquid uptake process by potocytosis

channel protein
membrane protein that allows a substance to pass through its hollow core across the plasma membrane

clathrin
protein that coats the plasma membrane's inward-facing surface and assists in forming specialized structures, like coated pits, for phagocytosis

concentration gradient
area of high concentration adjacent to an area of low concentration

diffusion
passive transport process of low-molecular weight material according to its concentration gradient

electrochemical gradient
a combined electrical and chemical force that produces a gradient

electrogenic pump
pump that creates a charge imbalance

endocytosis
type of active transport that moves substances, including fluids and particles, into a cell

exocytosis
process of passing bulk material out of a cell

facilitated transport
process by which material moves down a concentration gradient (from high to low concentration) using integral membrane proteins

fluid mosaic model
describes the plasma membrane's structure as a mosaic of components including phospholipids, cholesterol, proteins, glycoproteins, and glycolipids (sugar chains attached to proteins or lipids, respectively), resulting in a fluid character (fluidity)

glycolipid
combination of carbohydrates and lipids

glycoprotein

combination of carbohydrates and proteins

hydrophilic
molecule with the ability to bond with water; “water-loving”

hydrophobic
molecule that does not have the ability to bond with water; “water-hating”

hypertonic
situation in which extracellular fluid has a higher osmolarity than the fluid inside the cell, resulting in water moving out of the cell

hypotonic
situation in which extracellular fluid has a lower osmolarity than the fluid inside the cell, resulting in water moving into the cell

integral protein
protein integrated into the membrane structure that interacts extensively with the membrane lipids' hydrocarbon chains and often spans the membrane

isotonic
situation in which the extracellular fluid has the same osmolarity as the fluid inside the cell, resulting in no net water movement into or out of the cell

osmolarity
total amount of solutes dissolved in a specific amount of solution

osmosis
transport of water through a semipermeable membrane according to the water's concentration gradient across the membrane that results from the presence of solute that cannot pass through the membrane

passive transport
method of transporting material through a membrane that does not require energy

peripheral protein
protein at the plasma membrane's surface either on its exterior or interior side

pinocytosis
a variation of endocytosis that imports macromolecules that the cell needs from the extracellular fluid

plasmolysis
detaching the cell membrane from the cell wall and constricting the cell membrane when a plant cell is in a hypertonic solution

potocytosis
variation of pinocytosis that uses a different coating protein (caveolin) on the plasma membrane's cytoplasmic side

primary active transport
active transport that moves ions or small molecules across a membrane and may create a difference in charge across that membrane

pump
active transport mechanism that works against electrochemical gradients

receptor-mediated endocytosis
variation of endocytosis that involves using specific binding proteins in the plasma membrane for specific molecules or particles, and clathrin-coated pits that become clathrin-coated vesicles

secondary active transport
movement of material that results from primary active transport to the electrochemical gradient

selectively permeable

membrane characteristic that allows some substances through (also known as semipermeable)

solute

substance dissolved in a liquid to form a solution

symporter

transporter that carries two different ions or small molecules, both in the same direction

tonicity

amount of solute in a solution

transport protein

membrane protein that facilitates a substance's passage across a membrane by binding it

transporter

specific carrier proteins or pumps that facilitate movement

uniporter

transporter that carries one specific ion or molecule

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5.2: VISUAL CONNECTION QUESTIONS

1.

Figure 5.12 A doctor injects a patient with what the doctor thinks is an isotonic saline solution. The patient dies, and an autopsy reveals that many red blood cells have been destroyed. Do you think the solution the doctor injected was really isotonic?

2.

Figure 5.16 Injecting a potassium solution into a person’s blood is lethal. Capital punishment and euthanasia utilize this method in their subjects. Why do you think a potassium solution injection is lethal?

3.

Figure 5.20 If the pH outside the cell decreases, would you expect the amount of amino acids transported into the cell to increase or decrease?

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5.3: REVIEW QUESTIONS

4.

Which plasma membrane component can be either found on its surface or embedded in the membrane structure?

1. protein
2. cholesterol
3. carbohydrate
4. phospholipid

5.

Which characteristic of a phospholipid contributes to the fluidity of the membrane?

1. its head
2. cholesterol
3. a saturated fatty acid tail
4. double bonds in the fatty acid tail

6.

What is the primary function of carbohydrates attached to the exterior of cell membranes?

1. identification of the cell
2. flexibility of the membrane
3. strengthening the membrane
4. channels through membrane

7.

A scientist compares the plasma membrane composition of an animal from the Mediterranean coast with one from the Mojave Desert. Which hypothesis is most likely to be correct?

1. The cells from the Mediterranean coast animal will have more fluid plasma membranes.
2. The cells from the Mojave Desert animal will have a higher cholesterol concentration in the plasma membranes.
3. The cells' plasma membranes will be indistinguishable.
4. The cells from the Mediterranean coast animal will have a higher glycoprotein content, while the cells from the Mojave Desert animal will have a higher lipoprotein content.

8.

Water moves via osmosis _____.

1. throughout the cytoplasm
2. from an area with a high concentration of other solutes to a lower one
3. from an area with a high concentration of water to one of lower concentration
4. from an area with a low concentration of water to higher concentration

9.

The principal force driving movement in diffusion is the _____.

1. temperature
2. particle size
3. concentration gradient
4. membrane surface area

10.

What problem is faced by organisms that live in fresh water?

1. Their bodies tend to take in too much water.
2. They have no way of controlling their tonicity.
3. Only salt water poses problems for animals that live in it.
4. Their bodies tend to lose too much water to their environment.

11.

In which situation would passive transport **not** use a transport protein for entry into a cell?

1. water flowing into a hypertonic environment

1. water flowing into a hypertonic environment
2. glucose being absorbed from the blood
3. an ion flowing into a nerve cell to create an electrical potential
4. oxygen moving into a cell after oxygen deprivation

12.

Active transport must function continuously because _____.

1. plasma membranes wear out
2. not all membranes are amphiphilic
3. facilitated transport opposes active transport
4. diffusion is constantly moving solutes in opposite directions

13.

How does the sodium-potassium pump make the interior of the cell negatively charged?

1. by expelling anions
2. by pulling in anions
3. by expelling more cations than are taken in
4. by taking in and expelling an equal number of cations

14.

What is the combination of an electrical gradient and a concentration gradient called?

1. potential gradient
2. electrical potential
3. concentration potential
4. electrochemical gradient

15.

What happens to the membrane of a vesicle after exocytosis?

1. It leaves the cell.
2. It is disassembled by the cell.
3. It fuses with and becomes part of the plasma membrane.
4. It is used again in another exocytosis event.

16.

Which transport mechanism can bring whole cells into a cell?

1. pinocytosis
2. phagocytosis
3. facilitated transport
4. primary active transport

17.

In what important way does receptor-mediated endocytosis differ from phagocytosis?

1. It transports only small amounts of fluid.
2. It does not involve the pinching off of membrane.
3. It brings in only a specifically targeted substance.
4. It brings substances into the cell, while phagocytosis removes substances.

18.

Many viruses enter host cells through receptor-mediated endocytosis. What is an advantage of this entry strategy?

1. The virus directly enters the cytoplasm of the cell.
2. The virus is protected from recognition by white blood cells.
3. The virus only enters its target host cell type.
4. The virus can directly inject its genome into the cell’s nucleus.

19.

Which of the following organelles relies on exocytosis to complete its function?

1. Golgi apparatus

2. vacuole
3. mitochondria
4. endoplasmic reticulum

20.

Imagine a cell can perform exocytosis, but only minimal endocytosis. What would happen to the cell?

1. The cell would secrete all its intracellular proteins.
2. The plasma membrane would increase in size over time.
3. The cell would stop expressing integral receptor proteins in its plasma membrane.
4. The cell would lyse.

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5.4: CRITICAL THINKING QUESTIONS

21.

Why is it advantageous for the cell membrane to be fluid in nature?

22.

Why do phospholipids tend to spontaneously orient themselves into something resembling a membrane?

23.

How can a cell use an extracellular peripheral protein as the receptor to transmit a signal into the cell?

24.

Discuss why the following affect the rate of diffusion: molecular size, temperature, solution density, and the distance that must be traveled.

25.

Why does water move through a membrane?

26.

Both of the regular intravenous solutions administered in medicine, normal saline and lactated Ringer's solution, are isotonic. Why is this important?

27.

Describe two ways that decreasing temperature would affect the rate of diffusion of molecules across a cell's plasma membrane.

28.

A cell develops a mutation in its potassium channels that prevents the ions from leaving the cell. If the cell's aquaporins are still active, what will happen to the cell? Be sure to describe the tonicity and osmolarity of the cell.

29.

Where does the cell get energy for active transport processes?

30.

How does the sodium-potassium pump contribute to the net negative charge of the interior of the cell?

31.

Glucose from digested food enters intestinal epithelial cells by active transport. Why would intestinal cells use active transport when most body cells use facilitated diffusion?

32.

The sodium/calcium exchanger (NCX) transports sodium into and calcium out of cardiac muscle cells. Describe why this transporter is classified as secondary active transport.

33.

Why is it important that there are different types of proteins in plasma membranes for the transport of materials into and out of a cell?

34.

Why do ions have a difficult time getting through plasma membranes despite their small size?

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CHAPTER OVERVIEW

6: METABOLISM

Cellular processes require a steady supply of energy. From where, and in what form, does this energy come? How do living cells obtain energy, and how do they use it? This chapter will discuss different forms of energy and the physical laws that govern energy transfer. This chapter will also describe how cells use energy and replenish it, and how chemical reactions in the cell are performed with great efficiency.

6.1: Key Terms

6.2: Visual Connection Questions

6.3: Review Questions

6.4: Critical Thinking Questions

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6.1: KEY TERMS

activation energy
energy necessary for reactions to occur

active site
enzyme's specific region to which the substrate binds

allosteric inhibition
inhibition by a binding event at a site different from the active site, which induces a conformational change and reduces the enzyme's affinity for its substrate

anabolic
(also, anabolism) pathways that require an energy input to synthesize complex molecules from simpler ones

ATP
adenosine triphosphate, the cell’s energy currency

bioenergetics
study of energy flowing through living systems

catabolic
(also, catabolism) pathways in which complex molecules break down into simpler ones

chemical energy
potential energy in chemical bonds that releases when those bonds are broken

coenzyme
small organic molecule, such as a vitamin or its derivative, which is required to enhance an enzyme's activity

cofactor
inorganic ion, such as iron and magnesium ions, required for optimal enzyme activity regulation

competitive inhibition
type of inhibition in which the inhibitor competes with the substrate molecule by binding to the enzyme's active site

denature
process that changes a substance's natural properties

endergonic
describes chemical reactions that require energy input

energy coupling
process during which energy released by one reaction is used to drive another reaction

enthalpy
a system's total energy

entropy (S)
measure of randomness or disorder within a system

exergonic
describes chemical reactions that release free energy

feedback inhibition

a product's effect of a reaction sequence to decrease its further production by inhibiting the first enzyme's activity in the pathway that produces it

free energy
Gibbs free energy is the usable energy, or energy that is available to do work

heat
energy transferred from one system to another that is not work (energy of the molecules' motion or particles)

heat energy
total bond energy of reactants or products in a chemical reaction

induced fit
dynamic fit between the enzyme and its substrate, in which both components modify their structures to allow for ideal binding

kinetic energy
energy type that takes place with objects or particles in motion

metabolism
all the chemical reactions that take place inside cells, including anabolism and catabolism

phosphoanhydride bond
bond that connects phosphates in an ATP molecule

potential energy
energy type that has the potential to do work; stored energy

substrate
molecule on which the enzyme acts

thermodynamics
study of energy and energy transfer involving physical matter

transition state
high-energy, unstable state (an intermediate form between the substrate and the product) occurring during a chemical reaction

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6.2: VISUAL CONNECTION QUESTIONS

1.

Figure 6.8 Look at each of the processes, and decide if it is endergonic or exergonic. In each case, does enthalpy increase or decrease, and does entropy increase or decrease?

2.

Figure 6.10 If no activation energy were required to break down sucrose (table sugar), would you be able to store it in a sugar bowl?

3.

Figure 6.14 One ATP molecule's hydrolysis releases 7.3 kcal/mol of energy ($\Delta G = -7.3$ kcal/mol of energy). If it takes 2.1 kcal/mol of energy to move one Na^+ across the membrane ($\Delta G = +2.1$ kcal/mol of energy), how many sodium ions could one ATP molecule's hydrolysis move?

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6.3: REVIEW QUESTIONS

4.

Energy is stored long-term in the bonds of _____ and used short-term to perform work from a(n) _____ molecule.

1. ATP : glucose
2. an anabolic molecule : catabolic molecule
3. glucose : ATP
4. a catabolic molecule : anabolic molecule

5.

DNA replication involves unwinding two strands of parent DNA, copying each strand to synthesize complementary strands, and releasing the parent and daughter DNA. Which of the following accurately describes this process?

1. This is an anabolic process.
2. This is a catabolic process.
3. This is both anabolic and catabolic.
4. This is a metabolic process but is neither anabolic nor catabolic.

6.

Consider a pendulum swinging. Which type(s) of energy is/are associated with the pendulum in the following instances: i. the moment at which it completes one cycle, just before it begins to fall back towards the other end, ii. the moment that it is in the middle between the two ends, and iii. just before it reaches the end of one cycle (just before instant i.).

1. i. potential and kinetic, ii. potential and kinetic, iii. kinetic
2. i. potential, ii. potential and kinetic, iii. potential and kinetic
3. i. potential, ii. kinetic, iii. potential and kinetic
4. i. potential and kinetic, ii. kinetic iii. kinetic

7.

Which of the following comparisons or contrasts between endergonic and exergonic reactions is false?

1. Endergonic reactions have a positive ΔG and exergonic reactions have a negative ΔG.
2. Endergonic reactions consume energy and exergonic reactions release energy.
3. Both endergonic and exergonic reactions require a small amount of energy to overcome an activation barrier.
4. Endergonic reactions take place slowly and exergonic reactions take place quickly.

8.

Which of the following is the best way to judge the relative activation energies between two given chemical reactions?

1. Compare the ΔG values between the two reactions.
2. Compare their reaction rates.
3. Compare their ideal environmental conditions.
4. Compare the spontaneity between the two reactions.

9.

Which of the following is not an example of an energy transformation?

1. turning on a light switch
2. solar panels at work
3. formation of static electricity
4. none of the above

10.

In each of the three systems, determine the state of entropy (low or high) when comparing the first and second: i. the instant that a perfume bottle is sprayed compared with 30 seconds later, ii. an old 1950s car compared with a brand new car, and iii. a living cell compared with a dead cell.

1. i. low, ii. high, iii. low
2. i. low, ii. high, iii. high
3. i. high, ii. low, iii. high
4. i. high, ii. low, iii. low

11.

The energy released by the hydrolysis of ATP is____

1. primarily stored between the alpha and beta phosphates
2. equal to −57 kcal/mol
3. harnessed as heat energy by the cell to perform work
4. providing energy to coupled reactions

12.

Which of the following molecules is likely to have the most potential energy?

1. sucrose
2. ATP
3. glucose
4. ADP

13.

Which of the following is not true about enzymes:

1. They increase ΔG of reactions.
2. They are usually made of amino acids.
3. They lower the activation energy of chemical reactions.
4. Each one is specific to the particular substrate(s) to which it binds.

14.

An allosteric inhibitor does which of the following?

1. Binds to an enzyme away from the active site and changes the conformation of the active site, increasing its affinity for substrate binding.
2. Binds to the active site and blocks it from binding substrate.
3. Binds to an enzyme away from the active site and changes the conformation of the active site, decreasing its affinity for the substrate.
4. Binds directly to the active site and mimics the substrate.

15.

Which of the following analogies best describes the induced-fit model of enzyme-substrate binding?

1. a hug between two people
2. a key fitting into a lock
3. a square peg fitting through the square hole and a round peg fitting through the round hole of a children’s toy
4. the fitting together of two jigsaw puzzle pieces

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6.4: CRITICAL THINKING QUESTIONS

16.

Does physical exercise involve anabolic and/or catabolic processes? Give evidence for your answer.

17.

Name two different cellular functions that require energy that parallel human energy-requiring functions.

18.

Explain in your own words the difference between a spontaneous reaction and one that occurs instantaneously, and what causes this difference.

19.

Describe the position of the transition state on a vertical energy scale, from low to high, relative to the position of the reactants and products, for both endergonic and exergonic reactions.

20.

Imagine an elaborate ant farm with tunnels and passageways through the sand where ants live in a large community. Now imagine that an earthquake shook the ground and demolished the ant farm. In which of these two scenarios, before or after the earthquake, was the ant farm system in a state of higher or lower entropy?

21.

Energy transfers take place constantly in everyday activities. Think of two scenarios: cooking on a stove and driving. Explain how the second law of thermodynamics applies to these two scenarios.

22.

Do you think that the E_A for ATP hydrolysis is relatively low or high? Explain your reasoning.

23.

With regard to enzymes, why are vitamins necessary for good health? Give examples.

24.

Explain in your own words how enzyme feedback inhibition benefits a cell.

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CHAPTER OVERVIEW

7: PLANT FORM AND PHYSIOLOGY

Like animals, plants contain cells with organelles in which specific metabolic activities take place. Unlike animals, however, plants use energy from sunlight to form sugars during photosynthesis. In addition, plant cells have cell walls, plastids, and a large central vacuole: structures that are not found in animal cells. Each of these cellular structures plays a specific role in plant structure and function.

7.1: Key Terms

7.2: Visual Connection Questions

7.3: Review Questions

7.4: Critical Thinking Questions

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7.1: KEY TERMS

abscisic acid (ABA)
plant hormone that induces dormancy in seeds and other organs

abscission
physiological process that leads to the fall of a plant organ (such as leaf or petal drop)

adventitious root
aboveground root that arises from a plant part other than the radicle of the plant embryo

apical bud
bud formed at the tip of the shoot

apical meristem
meristematic tissue located at the tips of stems and roots; enables a plant to extend in length

auxin
plant hormone that influences cell elongation (in phototropism), gravitropism, apical dominance, and root growth

axillary bud
bud located in the axil: the stem area where the petiole connects to the stem

bark
tough, waterproof, outer epidermal layer of cork cells

bulb
modified underground stem that consists of a large bud surrounded by numerous leaf scales

Casparian strip
waxy coating that forces water to cross endodermal plasma membranes before entering the vascular cylinder, instead of moving between endodermal cells

chromophore
molecule that absorbs light

collenchyma cell
elongated plant cell with unevenly thickened walls; provides structural support to the stem and leaves

companion cell
phloem cell that is connected to sieve-tube cells; has large amounts of ribosomes and mitochondria

compound leaf
leaf in which the leaf blade is subdivided to form leaflets, all attached to the midrib

corm
rounded, fleshy underground stem that contains stored food

cortex
ground tissue found between the vascular tissue and the epidermis in a stem or root

cryptochrome
protein that absorbs light in the blue and ultraviolet regions of the light spectrum

cuticle
waxy covering on the outside of the leaf and stem that prevents the loss of water

cuticle
waxy protective layer on the leaf surface

cytokinin
plant hormone that promotes cell division

dermal tissue
protective plant tissue covering the outermost part of the plant; controls gas exchange

endodermis
layer of cells in the root that forms a selective barrier between the ground tissue and the vascular tissue, allowing water and minerals to enter the root while excluding toxins and pathogens

epidermis
single layer of cells found in plant dermal tissue; covers and protects underlying tissue

ethylene
volatile plant hormone that is associated with fruit ripening, flower wilting, and leaf fall

fibrous root system
type of root system in which the roots arise from the base of the stem in a cluster, forming a dense network of roots; found in monocots

gibberellin (GA)
plant hormone that stimulates shoot elongation, seed germination, and the maturation and dropping of fruit and flowers

ground tissue
plant tissue involved in photosynthesis; provides support, and stores water and sugars

guard cells
paired cells on either side of a stoma that control stomatal opening and thereby regulate the movement of gases and water vapor

intercalary meristem
meristematic tissue located at nodes and the bases of leaf blades; found only in monocots

internode
region between nodes on the stem

jasmonates
small family of compounds derived from the fatty acid linoleic acid

lamina
leaf blade

lateral meristem
meristematic tissue that enables a plant to increase in thickness or girth

lenticel
opening on the surface of mature woody stems that facilitates gas exchange

megapascal (MPa)
pressure units that measure water potential

meristem
plant region of continuous growth

meristematic tissue
tissue containing cells that constantly divide; contributes to plant growth

negative gravitropism

growth away from Earth’s gravity

node
point along the stem at which leaves, flowers, or aerial roots originate

oligosaccharin
hormone important in plant defenses against bacterial and fungal infections

palmately compound leaf
leaf type with leaflets that emerge from a point, resembling the palm of a hand

parenchyma cell
most common type of plant cell; found in the stem, root, leaf, and in fruit pulp; site of photosynthesis and starch storage

pericycle
outer boundary of the stele from which lateral roots can arise

periderm
outermost covering of woody stems; consists of the cork cambium, cork cells, and the phelloderm

permanent tissue
plant tissue composed of cells that are no longer actively dividing

petiole
stalk of the leaf

photomorphogenesis
growth and development of plants in response to light

photoperiodism
occurrence of plant processes, such as germination and flowering, according to the time of year

phototropin
blue-light receptor that promotes phototropism, stomatal opening and closing, and other responses that promote photosynthesis

phototropism
directional bending of a plant toward a light source

phyllotaxy
arrangement of leaves on a stem

phytochrome
plant pigment protein that exists in two reversible forms (Pr and Pfr) and mediates morphologic changes in response to red light

pinnately compound leaf
leaf type with a divided leaf blade consisting of leaflets arranged on both sides of the midrib

pith
ground tissue found towards the interior of the vascular tissue in a stem or root

positive gravitropism
growth toward Earth’s gravitational center

primary growth
growth resulting in an increase in length of the stem and the root; caused by cell division in the shoot or root apical meristem

rhizome
modified underground stem that grows horizontally to the soil surface and has nodes and internodes

root cap
protective cells covering the tip of the growing root

root hair
hair-like structure that is an extension of epidermal cells; increases the root surface area and aids in absorption of water and minerals

root system
belowground portion of the plant that supports the plant and absorbs water and minerals

runner
stolon that runs above the ground and produces new clone plants at nodes

sclerenchyma cell
plant cell that has thick secondary walls and provides structural support; usually dead at maturity

secondary growth
growth resulting in an increase in thickness or girth; caused by the lateral meristem and cork cambium

sessile
leaf without a petiole that is attached directly to the plant stem

shoot system
aboveground portion of the plant; consists of nonreproductive plant parts, such as leaves and stems, and reproductive parts, such as flowers and fruits

sieve-tube cell
phloem cell arranged end to end to form a sieve tube that transports organic substances such as sugars and amino acids

simple leaf
leaf type in which the lamina is completely undivided or merely lobed

sink
growing parts of a plant, such as roots and young leaves, which require photosynthate

source
organ that produces photosynthate for a plant

statolith
(also, **amyloplast**) plant organelle that contains heavy starch granules

stele
inner portion of the root containing the vascular tissue; surrounded by the endodermis

stipule
small green structure found on either side of the leaf stalk or petiole

stolon
modified stem that runs parallel to the ground and can give rise to new plants at the nodes

strigolactone
hormone that promotes seed germination in some species and inhibits lateral apical development in the absence of auxins

tap root system
type of root system with a main root that grows vertically with few lateral roots; found in dicots

tendril
modified stem consisting of slender, twining strands used for support or climbing

thigmomorphogenesis
developmental response to touch

thigmonastic
directional growth of a plant independent of the direction in which contact is applied

thigmotropism
directional growth of a plant in response to constant contact

thorn
modified stem branch appearing as a sharp outgrowth that protects the plant

tracheid
xylem cell with thick secondary walls that helps transport water

translocation
mass transport of photosynthates from source to sink in vascular plants

transpiration
loss of water vapor to the atmosphere through stomata

trichome
hair-like structure on the epidermal surface

tuber
modified underground stem adapted for starch storage; has many adventitious buds

vascular bundle
strands of stem tissue made up of xylem and phloem

vascular stele
strands of root tissue made up of xylem and phloem

vascular tissue
tissue made up of xylem and phloem that transports food and water throughout the plant

venation
pattern of veins in a leaf; may be parallel (as in monocots), reticulate (as in dicots), or dichotomous (as in *ginkgo biloba*)

vessel element
xylem cell that is shorter than a tracheid and has thinner walls

water potential (Ψ_w)
the potential energy of a water solution per unit volume in relation to pure water at atmospheric pressure and ambient temperature

whorled
pattern of leaf arrangement in which three or more leaves are connected at a node

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7.2: VISUAL CONNECTION QUESTIONS

1.

Figure 30.7 Which layers of the stem are made of parenchyma cells?

1. cortex and pith
2. phloem
3. sclerenchyma
4. xylem

2.

Figure 30.32 Positive water potential is placed on the left side of the tube by increasing Ψ_p such that the water level rises on the right side. Could you equalize the water level on each side of the tube by adding solute, and if so, how?

3.

Figure 30.34 Which of the following statements is false?

1. Negative water potential draws water into the root hairs. Cohesion and adhesion draw water up the xylem. Transpiration draws water from the leaf.
2. Negative water potential draws water into the root hairs. Cohesion and adhesion draw water up the phloem. Transpiration draws water from the leaf.
3. Water potential decreases from the roots to the top of the plant.
4. Water enters the plants through root hairs and exits through stoma.

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7.3: REVIEW QUESTIONS

4.

Plant regions of continuous growth are made up of _____.

1. dermal tissue
2. vascular tissue
3. meristematic tissue
4. permanent tissue

5.

Which of the following is the major site of photosynthesis?

1. apical meristem
2. ground tissue
3. xylem cells
4. phloem cells

6.

Stem regions at which leaves are attached are called _____.

1. trichomes
2. lenticels
3. nodes
4. internodes

7.

Which of the following cell types forms most of the inside of a plant?

1. meristem cells
2. collenchyma cells
3. sclerenchyma cells
4. parenchyma cells

8.

Tracheids, vessel elements, sieve-tube cells, and companion cells are components of _____.

1. vascular tissue
2. meristematic tissue
3. ground tissue
4. dermal tissue

9.

The primary growth of a plant is due to the action of the _____.

1. lateral meristem
2. vascular cambium
3. apical meristem
4. cork cambium

10.

Which of the following is an example of secondary growth?

1. increase in length
2. increase in thickness or girth
3. increase in root hairs
4. increase in leaf number

11.

Secondary growth in stems is usually seen in _____.

1. monocots
2. dicots

3. both monocots and dicots
4. neither monocots nor dicots

12.

Roots that enable a plant to grow on another plant are called _____.

1. epiphytic roots
2. prop roots
3. adventitious roots
4. aerial roots

13.

The _____ forces selective uptake of minerals in the root.

1. pericycle
2. epidermis
3. endodermis
4. root cap

14.

Newly-formed root cells begin to form different cell types in the _____.

1. zone of elongation
2. zone of maturation
3. root meristem
4. zone of cell division

15.

The stalk of a leaf is known as the _____.

1. petiole
2. lamina
3. stipule
4. rachis

16.

Leaflets are a characteristic of _____ leaves.

1. alternate
2. whorled
3. compound
4. opposite

17.

Cells of the _____ contain chloroplasts.

1. epidermis
2. vascular tissue
3. periderm
4. mesophyll

18.

Which of the following is most likely to be found in a desert environment?

1. broad leaves to capture sunlight
2. spines instead of leaves
3. needle-like leaves
4. wide, flat leaves that can float

19.

When stomata open, what occurs?

1. Water vapor is lost to the external environment, increasing the rate of transpiration.
2. Water vapor is lost to the external environment, decreasing the rate of transpiration.

3. Water vapor enters the spaces in the mesophyll, increasing the rate of transpiration.
4. Water vapor enters the spaces in the mesophyll, decreasing the rate of transpiration.

20.

Which cells are responsible for the movement of photosynthates through a plant?

1. tracheids, vessel elements
2. tracheids, companion cells
3. vessel elements, companion cells
4. sieve-tube elements, companion cells

21.

The main photoreceptor that triggers phototropism is a _____.

1. phytochrome
2. cryptochrome
3. phototropin
4. carotenoid

22.

Phytochrome is a plant pigment protein that:

1. mediates plant infection
2. promotes plant growth
3. mediates morphological changes in response to red and far-red light
4. inhibits plant growth

23.

A mutant plant has roots that grow in all directions. Which of the following organelles would you expect to be missing in the cell?

1. mitochondria
2. amyloplast
3. chloroplast
4. nucleus

24.

After buying green bananas or unripe avocadoes, they can be kept in a brown bag to ripen. The hormone released by the fruit and trapped in the bag is probably:

1. abscisic acid
2. cytokinin
3. ethylene
4. gibberellic acid

25.

A decrease in the level of which hormone releases seeds from dormancy?

1. abscisic acid
2. cytokinin
3. ethylene
4. gibberellic acid

26.

A seedling germinating under a stone grows at an angle away from the stone and upward. This response to touch is called _____.

1. gravitropism
2. thigmonasty
3. thigmotropism
4. skototropism

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7.4: CRITICAL THINKING QUESTIONS

27.

What type of meristem is found only in monocots, such as lawn grasses? Explain how this type of meristematic tissue is beneficial in lawn grasses that are mowed each week.

28.

Which plant part is responsible for transporting water, minerals, and sugars to different parts of the plant? Name the two types of tissue that make up this overall tissue, and explain the role of each.

29.

Describe the roles played by stomata and guard cells. What would happen to a plant if these cells did not function correctly?

30.

Compare the structure and function of xylem to that of phloem.

31.

Explain the role of the cork cambium in woody plants.

32.

What is the function of lenticels?

33.

Besides the age of a tree, what additional information can annual rings reveal?

34.

Give two examples of modified stems and explain how each example benefits the plant.

35.

Compare a tap root system with a fibrous root system. For each type, name a plant that provides a food in the human diet. Which type of root system is found in monocots? Which type of root system is found in dicots?

36.

What might happen to a root if the pericycle disappeared?

37.

How do dicots differ from monocots in terms of leaf structure?

38.

Describe an example of a plant with leaves that are adapted to cold temperatures.

39.

The process of bulk flow transports fluids in a plant. Describe the two main bulk flow processes.

40.

Owners and managers of plant nurseries have to plan lighting schedules for a long-day plant that will flower in February. What lighting periods will be most effective? What color of light should be chosen?

41.

What are the major benefits of gravitropism for a germinating seedling?

42.

Fruit and vegetable storage facilities are usually refrigerated and well ventilated. Why are these conditions advantageous?

43.

Stomata close in response to bacterial infection. Why is this response a mechanism of defense for the plant? Which hormone is most likely to mediate this response?

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CHAPTER OVERVIEW

8: PHOTOSYNTHESIS

The processes in all organisms—from bacteria to humans—require energy. To get this energy, many organisms access stored energy by eating, that is, by ingesting other organisms. But where does the stored energy in food originate? All of this energy can be traced back to photosynthesis.

8.1: Key Terms

8.2: Visual Connection Questions

8.3: Review Questions

8.4: Critical Thinking Questions

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8.1: KEY TERMS

absorption spectrum
range of wavelengths of electromagnetic radiation absorbed by a given substance

antenna protein
pigment molecule that directly absorbs light and transfers the energy absorbed to other pigment molecules

Calvin cycle
light-independent reactions of photosynthesis that convert carbon dioxide from the atmosphere into carbohydrates using the energy and reducing power of ATP and NADPH

carbon fixation
process of converting inorganic CO_2 gas into organic compounds

carotenoid
photosynthetic pigment (yellow-orange-red) that functions to dispose of excess energy

chemoautotroph
organism that can build organic molecules using energy derived from inorganic chemicals instead of sunlight

chlorophyll *a*
form of chlorophyll that absorbs violet-blue and red light and consequently has a bluish-green color; the only pigment molecule that performs the photochemistry by getting excited and losing an electron to the electron transport chain

chlorophyll *b*
accessory pigment that absorbs blue and red-orange light and consequently has a yellowish-green tint

chloroplast
organelle in which photosynthesis takes place

cytochrome complex
group of reversibly oxidizable and reducible proteins that forms part of the electron transport chain between photosystem II and photosystem I

electromagnetic spectrum
range of all possible frequencies of radiation

electron transport chain
group of proteins between PSII and PSI that pass energized electrons and use the energy released by the electrons to move hydrogen ions against their concentration gradient into the thylakoid lumen

granum
stack of thylakoids located inside a chloroplast

heterotroph
organism that consumes organic substances or other organisms for food

light harvesting complex
complex that passes energy from sunlight to the reaction center in each photosystem; it consists of multiple antenna proteins that contain a mixture of 300 to 400 chlorophyll *a* and *b* molecules as well as other pigments like carotenoids

light-dependent reaction
first stage of photosynthesis where certain wavelengths of the visible light are absorbed to form two energy-carrying molecules (ATP and NADPH)

light-independent reaction

second stage of photosynthesis, through which carbon dioxide is used to build carbohydrate molecules using energy from ATP and NADPH

mesophyll
middle layer of chlorophyll-rich cells in a leaf

P680
reaction center of photosystem II

P700
reaction center of photosystem I

photoact
ejection of an electron from a reaction center using the energy of an absorbed photon

photoautotroph
organism capable of producing its own organic compounds from sunlight

photon
distinct quantity or “packet” of light energy

photosystem
group of proteins, chlorophyll, and other pigments that are used in the light-dependent reactions of photosynthesis to absorb light energy and convert it into chemical energy

photosystem I
integral pigment and protein complex in thylakoid membranes that uses light energy to transport electrons from plastocyanin to $NADP^+$ (which becomes reduced to NADPH in the process)

photosystem II
integral protein and pigment complex in thylakoid membranes that transports electrons from water to the electron transport chain; oxygen is a product of PSII

pigment
molecule that is capable of absorbing certain wavelengths of light and reflecting others (which accounts for its color)

primary electron acceptor
pigment or other organic molecule in the reaction center that accepts an energized electron from the reaction center

reaction center
complex of chlorophyll molecules and other organic molecules that is assembled around a special pair of chlorophyll molecules and a primary electron acceptor; capable of undergoing oxidation and reduction

reduction
gain of electron(s) by an atom or molecule

spectrophotometer
instrument that can measure transmitted light and compute the absorption

stoma
opening that regulates gas exchange and water evaporation between leaves and the environment, typically situated on the underside of leaves

stroma
fluid-filled space surrounding the grana inside a chloroplast where the light-independent reactions of photosynthesis take place

thylakoid

disc-shaped, membrane-bound structure inside a chloroplast where the light-dependent reactions of photosynthesis take place; stacks of thylakoids are called grana

thylakoid lumen

aqueous space bound by a thylakoid membrane where protons accumulate during light-driven electron transport

wavelength

distance between consecutive points of equal position (two crests or two troughs) of a wave in a graphic representation; inversely proportional to the energy of the radiation

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8.2: VISUAL CONNECTION QUESTIONS

1.

Figure 8.6 On a hot, dry day, the guard cells of plants close their stomata to conserve water. What impact will this have on photosynthesis?

2.

Figure 8.17 What is the initial source of electrons for the chloroplast electron transport chain?

1. Water
2. Oxygen
3. Carbon dioxide
4. NADPH

3.

Figure 8.19 Which of the following statements is true?

1. In photosynthesis, oxygen, carbon dioxide, ATP, and NADPH are reactants. G3P and water are products.
2. In photosynthesis, chlorophyll, water, and carbon dioxide are reactants. G3P and oxygen are products.
3. In photosynthesis, water, carbon dioxide, ATP, and NADPH are reactants. RuBP and oxygen are products.
4. In photosynthesis, water and carbon dioxide are reactants. G3P and oxygen are products.

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8.3: REVIEW QUESTIONS

4.

Which of the following components is *not* used by both plants and cyanobacteria to carry out photosynthesis?

1. chloroplasts
2. chlorophyll
3. carbon dioxide
4. water

5.

What two main products result from photosynthesis?

1. oxygen and carbon dioxide
2. chlorophyll and oxygen
3. sugars/carbohydrates and oxygen
4. sugars/carbohydrates and carbon dioxide

6.

In which compartment of the plant cell do the light-independent reactions of photosynthesis take place?

1. thylakoid
2. stroma
3. outer membrane
4. mesophyll

7.

Which statement about thylakoids in eukaryotes is *not* correct?

1. Thylakoids are assembled into stacks.
2. Thylakoids exist as a maze of folded membranes.
3. The space surrounding thylakoids is called stroma.
4. Thylakoids contain chlorophyll.

8.

Predict the end result if a chloroplast's light-independent enzymes developed a mutation that prevented them from activating in response to light.

1. G3P accumulation
2. ATP and NADPH accumulation
3. Water accumulation
4. Carbon dioxide depletion

9.

How are the NADPH and G3P molecules made during photosynthesis similar?

1. They are both end products of photosynthesis.
2. They are both substrates for photosynthesis.
3. They are both produced from carbon dioxide.
4. They both store energy in chemical bonds.

10.

Which of the following structures is *not* a component of a photosystem?

1. ATP synthase
2. antenna molecule
3. reaction center
4. primary electron acceptor

11.

How many photons does it take to fully reduce one molecule of $NADP^+$ to NADPH?

1. 1

2. 2
3. 4
4. 8

12.

Which complex is *not* involved in the establishment of conditions for ATP synthesis?

1. photosystem I
2. ATP synthase
3. photosystem II
4. cytochrome complex

13.

From which component of the light-dependent reactions does NADPH form most directly?

1. photosystem II
2. photosystem I
3. cytochrome complex
4. ATP synthase

14.

Three of the same species of plant are each grown under a different colored light for the same amount of time. Plant A is grown under blue light, Plant B is grown under green light, and Plant C is grown under orange light. Assuming the plants use only chlorophyll *a* and chlorophyll *b* for photosynthesis, what would be the predicted order of the plants from most growth to least growth?

1. A, C, B
2. A, B, C
3. C, A, B
4. B, A, C

15.

Plants containing only chlorophyll *b* are exposed to radiation with the following wavelengths: 10nm (x-rays), 450nm (blue light), 670nm (red light), and 800nm (infrared light). Which plants harness the most energy for photosynthesis?

1. X-ray irradiated plants
2. Blue light irradiated plants
3. Red light irradiated plants
4. Infrared irradiated plants

16.

Which molecule must enter the Calvin cycle continually for the light-independent reactions to take place?

1. RuBisCO
2. RuBP
3. 3-PGA
4. CO_2

17.

Which order of molecular conversions is correct for the Calvin cycle?

1. $\mathbf{RuBP + G3P \rightarrow 3\text{-}PGA \rightarrow sugar}$
2. $\mathbf{RuBisCO \rightarrow CO_2 \rightarrow RuBP \rightarrow G3P}$
3. $\mathbf{RuBP + CO_2 \rightarrow [RuBisCO]\ 3\text{-}PGA \rightarrow G3P}$
4. $\mathbf{CO_2 \rightarrow 3\text{-}PGA \rightarrow RuBP \rightarrow G3P}$

18.

Where in eukaryotic cells does the Calvin cycle take place?

1. thylakoid membrane
2. thylakoid lumen
3. chloroplast stroma
4. granum

19.

Which statement correctly describes carbon fixation?

1. the conversion of CO_2 into an organic compound
2. the use of RuBisCO to form 3-PGA
3. the production of carbohydrate molecules from G3P
4. the formation of RuBP from G3P molecules
5. the use of ATP and NADPH to reduce CO_2

20.

If four molecules of carbon dioxide enter the Calvin cycle (four “turns” of the cycle), how many G3P molecules are produced and how many are exported?

1. 4 G3P made, 1 G3P exported
2. 4 G3P made, 2 G3P exported
3. 8 G3P made, 1 G3P exported
4. 8 G3P made, 4 G3P exported

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8.4: CRITICAL THINKING QUESTIONS

21.

What is the overall outcome of the light reactions in photosynthesis?

22.

Why are carnivores, such as lions, dependent on photosynthesis to survive?

23.

Why are energy carriers thought of as either “full” or “empty”?

24.

Describe how the grey wolf population would be impacted by a volcanic eruption that spewed a dense ash cloud that blocked sunlight in a section of Yellowstone National Park.

25.

How does the closing of the stomata limit photosynthesis?

26.

Describe the pathway of electron transfer from photosystem II to photosystem I in light-dependent reactions.

27.

What are the roles of ATP and NADPH in photosynthesis?

28.

How and why would the end products of photosynthesis be changed if a plant had a mutation that eliminated its photosystem II complex?

29.

Why is the third stage of the Calvin cycle called the regeneration stage?

30.

Which part of the light-independent reactions would be affected if a cell could not produce the enzyme RuBisCO?

31.

Why does it take three turns of the Calvin cycle to produce G3P, the initial product of photosynthesis?

32.

Imagine a sealed terrarium containing a plant and a beetle. How does each organism provide resources for the other? Could each organism survive if it was the only living thing in the terrarium? Why or why not?

33.

Compare the flow of energy with the flow of nutrients in a closed, sunny ecosystem consisting of a giraffe and a tree.

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CHAPTER OVERVIEW

9: CELLULAR RESPIRATION

Like a generating plant, plants and animals also must take in energy from the environment and convert it into a form that their cells can use. Energy enters an organism's body in one form and is converted into another form that can fuel the organism's life functions. In the process of photosynthesis, plants and other photosynthetic producers take in energy in the form of light (solar energy) and convert it into chemical energy, glucose, which stores this energy in its chemical bonds. Then, a series of metabolic pathways, collectively called cellular respiration, extracts the energy from the bonds in glucose and converts it into a form that all living things can use—both producers, such as plants, and consumers, such as animals.

9.1: Key Terms

9.2: Visual Connection Questions

9.3: Review Questions

9.4: Critical Thinking Questions

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9.1: KEY TERMS

acetyl CoA
combination of an acetyl group derived from pyruvic acid and coenzyme A, which is made from pantothenic acid (a B-group vitamin)

aerobic respiration
process in which organisms convert energy in the presence of oxygen

anaerobic
process that does not use oxygen

anaerobic cellular respiration
process in which organisms convert energy for their use in the absence of oxygen

ATP synthase
(also F1F0 ATP synthase) membrane-embedded protein complex that adds a phosphate to ADP with energy from protons diffusing through it

chemiosmosis
process in which there is a production of adenosine triphosphate (ATP) in cellular metabolism by the involvement of a proton gradient across a membrane

citric acid cycle
(also Krebs cycle) series of enzyme-catalyzed chemical reactions of central importance in all living cells for extraction of energy from carbohydrates

dephosphorylation
removal of a phosphate group from a molecule

fermentation
process of regenerating NAD^+ with either an inorganic or organic compound serving as the final electron acceptor; occurs in the absence of oxygen

GLUT protein
integral membrane protein that transports glucose

glycolysis
process of breaking glucose into two three-carbon molecules with the production of ATP and NADH

isomerase
enzyme that converts a molecule into its isomer

Krebs cycle
(also citric acid cycle) alternate name for the citric acid cycle, named after Hans Krebs, who first identified the steps in the pathway in the 1930s in pigeon flight muscles; see citric acid cycle

oxidative phosphorylation
production of ATP using the process of chemiosmosis in the presence of oxygen

phosphorylation
addition of a high-energy phosphate to a compound, usually a metabolic intermediate, a protein, or ADP

prosthetic group
(also prosthetic cofactor) molecule bound to a protein that facilitates the function of the protein

pyruvate

three-carbon sugar that can be decarboxylated and oxidized to make acetyl CoA, which enters the citric acid cycle under aerobic conditions; the end product of glycolysis

redox reaction

chemical reaction that consists of the coupling of an oxidation reaction and a reduction reaction

substrate-level phosphorylation

production of ATP from ADP using the excess energy from a chemical reaction and a phosphate group from a reactant

TCA cycle

(also citric acid cycle) alternate name for the citric acid cycle, named after the group name for citric acid, tricarboxylic acid (TCA); see citric acid cycle

ubiquinone

soluble electron transporter in the electron transport chain that connects the first or second complex to the third

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9.2: VISUAL CONNECTION QUESTIONS

1.

Figure 7.13 Dinitrophenol (DNP) is an "uncoupler" that makes the inner mitochondrial membrane "leaky" to protons. It was used until 1938 as a weight-loss drug. What effect would you expect DNP to have on the change in pH across the inner mitochondrial membrane? Why do you think this might be an effective weight-loss drug?

2.

Figure 7.14 Cyanide inhibits cytochrome c oxidase, a component of the electron transport chain. If cyanide poisoning occurs, would you expect the pH of the intermembrane space to increase or decrease? What effect would cyanide have on ATP synthesis?

3.

Figure 7.16 Tremetol, a metabolic poison found in the white snake root plant, prevents the metabolism of lactate. When cows eat this plant, tremetol is concentrated in the milk they produce. Humans who consume the milk can become seriously ill. Symptoms of this disease, which include vomiting, abdominal pain, and tremors, become worse after exercise. Why do you think this is the case?

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9.3: REVIEW QUESTIONS

4.

The energy currency used by cells is _____.

1. ATP
2. ADP
3. AMP
4. adenosine

5.

A reducing chemical reaction _____.

1. reduces the compound to a simpler form
2. adds an electron to the substrate
3. removes a hydrogen atom from the substrate
4. is a catabolic reaction

6.

During the second half of glycolysis, what occurs?

1. ATP is used up.
2. Fructose is split in two.
3. ATP is made.
4. Glucose becomes fructose.

7.

What is removed from pyruvate during its conversion into an acetyl group?

1. oxygen
2. ATP
3. B vitamin
4. carbon dioxide

8.

What do the electrons added to NAD^+ do?

1. They become part of a fermentation pathway.
2. They go to another pathway for ATP production.
3. They energize the entry of the acetyl group into the citric acid cycle.
4. They are converted to NADP.

9.

GTP or ATP is produced during the conversion of _____.

1. isocitrate into α-ketoglutarate
2. succinyl CoA into succinate
3. fumarate into malate
4. malate into oxaloacetate

10.

How many NADH molecules are produced on each turn of the citric acid cycle?

1. one
2. two
3. three
4. four

11.

What compound receives electrons from NADH?

1. FMN
2. ubiquinone

3. cytochrome c_1
4. oxygen

12.

Chemiosmosis involves _____.

1. the movement of electrons across the cell membrane
2. the movement of hydrogen atoms across a mitochondrial membrane
3. the movement of hydrogen ions across a mitochondrial membrane
4. the movement of glucose through the cell membrane

13.

Which of the following fermentation methods can occur in animal skeletal muscles?

1. lactic acid fermentation
2. alcohol fermentation
3. mixed acid fermentation
4. propionic fermentation

14.

A major connection for sugars in glycolysis is _____.

1. glucose-6-phosphate
2. fructose-1,6-bisphosphate
3. dihydroxyacetone phosphate
4. phosphoenolpyruvate

15.

Beta-oxidation is _____.

1. the breakdown of sugars
2. the assembly of sugars
3. the breakdown of fatty acids
4. the removal of amino groups from amino acids

16.

The effect of high levels of ADP is to _____ in cellular respiration.

1. increase the activity of specific enzymes
2. decrease the activity of specific enzymes
3. have no effect on the activity of specific enzymes
4. slow down the pathway

17.

The control of which enzyme exerts the most control on glycolysis?

1. hexokinase
2. phosphofructokinase
3. glucose-6-phosphatase
4. aldolase

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9.4: CRITICAL THINKING QUESTIONS

18.

Why is it beneficial for cells to use ATP rather than energy directly from the bonds of carbohydrates? What are the greatest drawbacks to harnessing energy directly from the bonds of several different compounds?

19.

Nearly all organisms on Earth carry out some form of glycolysis. How does this fact support or not support the assertion that glycolysis is one of the oldest metabolic pathways?

20.

Because they lose their mitochondria during development, red blood cells cannot perform aerobic respiration; however, they do perform glycolysis in the cytoplasm. Why do all cells need an energy source, and what would happen if glycolysis were blocked in a red blood cell?

21.

What is the primary difference between a circular pathway and a linear pathway?

22.

How do the roles of ubiquinone and cytochrome c differ from the roles of the other components of the electron transport chain?

23.

What accounts for the different number of ATP molecules that are formed through cellular respiration?

24.

What is the primary difference between fermentation and anaerobic respiration?

25.

Would you describe metabolic pathways as inherently wasteful or inherently economical? Why?

26.

How does citrate from the citric acid cycle affect glycolysis?

27.

Why might negative feedback mechanisms be more common than positive feedback mechanisms in living cells?

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CHAPTER OVERVIEW

10: CELL REPRODUCTION

10.1: Key Terms
10.2: Visual Connection Questions
10.3: Review Questions
10.4: Critical Thinking Questions

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10.1: KEY TERMS

This page is a draft and is under active development.

anaphase
stage of mitosis during which sister chromatids are separated from each other

binary fission
prokaryotic cell division process

cell cycle
ordered series of events involving cell growth and cell division that produces two new daughter cells

cell plate
structure formed during plant cell cytokinesis by Golgi vesicles, forming a temporary structure (phragmoplast) and fusing at the metaphase plate; ultimately leads to the formation of cell walls that separate the two daughter cells

cell-cycle checkpoint
mechanism that monitors the preparedness of a eukaryotic cell to advance through the various cell-cycle stages

centriole
rod-like structure constructed of microtubules at the center of each animal cell centrosome

centromere
region at which sister chromatids are bound together; a constricted area in condensed chromosomes

chromatid
single DNA molecule of two strands of duplicated DNA and associated proteins held together at the centromere

cleavage furrow
constriction formed by an actin ring during cytokinesis in animal cells that leads to cytoplasmic division

condensin
proteins that help sister chromatids coil during prophase

cyclin
one of a group of proteins that act in conjunction with cyclin-dependent kinases to help regulate the cell cycle by phosphorylating key proteins; the concentrations of cyclins fluctuate throughout the cell cycle

cyclin-dependent kinase (Cdk)
one of a group of protein kinases that helps to regulate the cell cycle when bound to cyclin; it functions to phosphorylate other proteins that are either activated or inactivated by phosphorylation

cytokinesis
division of the cytoplasm following mitosis that forms two daughter cells.

diploid
cell, nucleus, or organism containing two sets of chromosomes ($2n$)

FtsZ
tubulin-like protein component of the prokaryotic cytoskeleton that is important in prokaryotic cytokinesis (name origin: **F**ilamenting **t**emperature-**s**ensitive mutant **Z**)

G_0 phase
distinct from the G_1 phase of interphase; a cell in G_0 is not preparing to divide

G_1 phase
(also, first gap) first phase of interphase centered on cell growth during mitosis

G_2 phase
(also, second gap) third phase of interphase during which the cell undergoes final preparations for mitosis

gamete
haploid reproductive cell or sex cell (sperm, pollen grain, or egg)

gene
physical and functional unit of heredity, a sequence of DNA that codes for a protein.

genome
total genetic information of a cell or organism

haploid
cell, nucleus, or organism containing one set of chromosomes (*n*)

histone
one of several similar, highly conserved, low molecular weight, basic proteins found in the chromatin of all eukaryotic cells; associates with DNA to form nucleosomes

homologous chromosomes
chromosomes of the same morphology with genes in the same location; diploid organisms have pairs of homologous chromosomes (homologs), with each homolog derived from a different parent

interphase
period of the cell cycle leading up to mitosis; includes G_1, S, and G_2 phases (the interim period between two consecutive cell divisions)

karyokinesis
mitotic nuclear division

kinetochore
protein structure associated with the centromere of each sister chromatid that attracts and binds spindle microtubules during prometaphase

locus
position of a gene on a chromosome

metaphase
stage of mitosis during which chromosomes are aligned at the metaphase plate

metaphase plate
equatorial plane midway between the two poles of a cell where the chromosomes align during metaphase

mitosis
(also, karyokinesis) period of the cell cycle during which the duplicated chromosomes are separated into identical nuclei; includes prophase, prometaphase, metaphase, anaphase, and telophase

mitotic phase
period of the cell cycle during which duplicated chromosomes are distributed into two nuclei and cytoplasmic contents are divided; includes karyokinesis (mitosis) and cytokinesis

mitotic spindle
apparatus composed of microtubules that orchestrates the movement of chromosomes during mitosis

nucleosome
subunit of chromatin composed of a short length of DNA wrapped around a core of histone proteins

oncogene
mutated version of a normal gene involved in the positive regulation of the cell cycle

origin
(also, ORI) region of the prokaryotic chromosome where replication begins (origin of replication)

p21
cell-cycle regulatory protein that inhibits the cell cycle; its levels are controlled by p53

p53
cell-cycle regulatory protein that regulates cell growth and monitors DNA damage; it halts the progression of the cell cycle in cases of DNA damage and may induce apoptosis

prometaphase
stage of mitosis during which the nuclear membrane breaks down and mitotic spindle fibers attach to kinetochores

prophase
stage of mitosis during which chromosomes condense and the mitotic spindle begins to form

proto-oncogene
normal gene that when mutated becomes an oncogene

quiescent
refers to a cell that is performing normal cell functions and has not initiated preparations for cell division

retinoblastoma protein (Rb)
regulatory molecule that exhibits negative effects on the cell cycle by interacting with a transcription factor (E2F)

S phase
second, or synthesis, stage of interphase during which DNA replication occurs

septum
structure formed in a bacterial cell as a precursor to the separation of the cell into two daughter cells

telophase
stage of mitosis during which chromosomes arrive at opposite poles, decondense, and are surrounded by a new nuclear envelope

tumor suppressor gene
segment of DNA that codes for regulator proteins that prevent the cell from undergoing uncontrolled division

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10.2: VISUAL CONNECTION QUESTIONS

1.

Figure 10.14 Rb and other proteins that negatively regulate the cell cycle are sometimes called tumor suppressors. Why do you think the name tumor suppressor might be appropriate for these proteins?

2.

Figure 10.16 Human papillomavirus can cause cervical cancer. The virus encodes E6, a protein that binds p53. Based on this fact and what you know about p53, what effect do you think E6 binding has on p53 activity?

1. E6 activates p53
2. E6 inactivates p53
3. E6 mutates p53
4. E6 binding marks p53 for degradation

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10.3: REVIEW QUESTIONS

3.

A diploid cell has_____ the number of chromosomes as a haploid cell.

1. one-fourth
2. half
3. twice
4. four times

4.

An organism's traits are determined by the specific combination of inherited _____.

1. cells.
2. genes.
3. proteins.
4. chromatids.

5.

The first level of DNA organization in a eukaryotic cell is maintained by which molecule?

1. cohesin
2. condensin
3. chromatin
4. histone

6.

Identical copies of chromatin held together by cohesin at the centromere are called _____.

1. histones.
2. nucleosomes.
3. chromatin.
4. sister chromatids.

7.

Chromosomes are duplicated during what stage of the cell cycle?

1. G_1 phase
2. S phase
3. prophase
4. prometaphase

8.

Which of the following events does not occur during some stages of interphase?

1. DNA duplication
2. organelle duplication
3. increase in cell size
4. separation of sister chromatids

9.

The mitotic spindles arise from which cell structure?

1. centromere
2. centrosome
3. kinetochore
4. cleavage furrow

10.

Attachment of the mitotic spindle fibers to the kinetochores is a characteristic of which stage of mitosis?

1. prophase
2. prometaphase

3. metaphase
4. anaphase

11.

Unpacking of chromosomes and the formation of a new nuclear envelope is a characteristic of which stage of mitosis?

1. prometaphase
2. metaphase
3. anaphase
4. telophase

12.

Separation of the sister chromatids is a characteristic of which stage of mitosis?

1. prometaphase
2. metaphase
3. anaphase
4. telophase

13.

The chromosomes become visible under a light microscope during which stage of mitosis?

1. prophase
2. prometaphase
3. metaphase
4. anaphase

14.

The fusing of Golgi vesicles at the metaphase plate of dividing plant cells forms what structure?

1. cell plate
2. actin ring
3. cleavage furrow
4. mitotic spindle

15.

Figure 10.6 Which of the following is the correct order of events in mitosis?

1. Sister chromatids line up at the metaphase plate. The kinetochore becomes attached to the mitotic spindle. The nucleus reforms and the cell divides. Cohesin proteins break down and the sister chromatids separate.
2. The kinetochore becomes attached to the mitotic spindle. Cohesin proteins break down and the sister chromatids separate. Sister chromatids line up at the metaphase plate. The nucleus reforms and the cell divides.
3. The kinetochore becomes attached to the cohesin proteins. Sister chromatids line up at the metaphase plate. The kinetochore breaks down and the sister chromatids separate. The nucleus reforms and the cell divides.
4. The kinetochore becomes attached to the mitotic spindle. Sister chromatids line up at the metaphase plate. Cohesin proteins break down and the sister chromatids separate. The nucleus reforms and the cell divides.

16.

At which of the cell-cycle checkpoints do external forces have the greatest influence?

1. G_1 checkpoint
2. G_2 checkpoint
3. M checkpoint
4. G_0 checkpoint

17.

What is the main prerequisite for clearance at the G_2 checkpoint?

1. cell has reached a sufficient size
2. an adequate stockpile of nucleotides
3. accurate and complete DNA replication
4. proper attachment of mitotic spindle fibers to kinetochores

18.

If the M checkpoint is not cleared, what stage of mitosis will be blocked?

1. prophase
2. prometaphase
3. metaphase
4. anaphase

19.

Which protein is a positive regulator that phosphorylates other proteins when activated?

1. p53
2. retinoblastoma protein (Rb)
3. cyclin
4. cyclin-dependent kinase (Cdk)

20.

Many of the negative regulator proteins of the cell cycle were discovered in what type of cells?

1. gametes
2. cells in G_0
3. cancer cells
4. stem cells

21.

Which negative regulatory molecule can trigger cell suicide (apoptosis) if vital cell cycle events do not occur?

1. p53
2. p21
3. retinoblastoma protein (Rb)
4. cyclin-dependent kinase (Cdk)

22.

_____ are changes to the order of nucleotides in a segment of DNA that codes for a protein.

1. Proto-oncogenes
2. Tumor suppressor genes
3. Gene mutations
4. Negative regulators

23.

A gene that codes for a positive cell-cycle regulator is called a(n) _____.

1. kinase inhibitor.
2. tumor suppressor gene.
3. proto-oncogene.
4. oncogene.

24.

A mutated gene that codes for an altered version of Cdk that is active in the absence of cyclin is a(n) _____.

1. kinase inhibitor.
2. tumor suppressor gene.
3. proto-oncogene.
4. oncogene.

25.

Which molecule is a Cdk inhibitor that is controlled by p53?

1. cyclin
2. anti-kinase
3. Rb
4. p21

26.

Which eukaryotic cell-cycle event is missing in binary fission?

1. cell growth
2. DNA duplication
3. karyokinesis
4. cytokinesis

27.

FtsZ proteins direct the formation of a _____ that will eventually form the new cell walls of the daughter cells.

1. contractile ring
2. cell plate
3. cytoskeleton
4. septum

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10.4: CRITICAL THINKING QUESTIONS

28.

Compare and contrast a human somatic cell to a human gamete.

29.

What is the relationship between a genome, chromosomes, and genes?

30.

Eukaryotic chromosomes are thousands of times longer than a typical cell. Explain how chromosomes can fit inside a eukaryotic nucleus.

31.

Briefly describe the events that occur in each phase of interphase.

32.

Chemotherapy drugs such as *vincristine* (derived from Madagascar periwinkle plants) and *colchicine* (derived from autumn crocus plants) disrupt mitosis by binding to tubulin (the subunit of microtubules) and interfering with microtubule assembly and disassembly. Exactly what mitotic structure is targeted by these drugs and what effect would that have on cell division?

33.

Describe the similarities and differences between the cytokinesis mechanisms found in animal cells versus those in plant cells.

34.

List some reasons why a cell that has just completed cytokinesis might enter the G_0 phase instead of the G_1 phase.

35.

What cell-cycle events will be affected in a cell that produces mutated (non-functional) cohesin protein?

36.

Describe the general conditions that must be met at each of the three main cell-cycle checkpoints.

37.

Compare and contrast the roles of the positive cell-cycle regulators negative regulators.

38.

What steps are necessary for Cdk to become fully active?

39.

Rb is a negative regulator that blocks the cell cycle at the G_1 checkpoint until the cell achieves a requisite size. What molecular mechanism does Rb employ to halt the cell cycle?

40.

Outline the steps that lead to a cell becoming cancerous.

41.

Explain the difference between a proto-oncogene and a tumor-suppressor gene.

42.

List the regulatory mechanisms that might be lost in a cell producing faulty p53.

43.

p53 can trigger apoptosis if certain cell-cycle events fail. How does this regulatory outcome benefit a multicellular organism?

44.

Name the common components of eukaryotic cell division and binary fission.

45.

Describe how the duplicated bacterial chromosomes are distributed into new daughter cells without the direction of the mitotic spindle.

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CHAPTER OVERVIEW

11: MEIOSIS AND SEXUAL REPRODUCTION

11.1: Key Terms

11.2: Visual Connection Questions

11.3: Review Questions

11.4: Critical Thinking Questions

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11.1: KEY TERMS

alternation of generations
life-cycle type in which the diploid and haploid stages alternate

chiasmata
(singular, *chiasma*) the structure that forms at the crossover points after genetic material is exchanged

cohesin
proteins that form a complex that seals sister chromatids together at their centromeres until anaphase II of meiosis

crossover
exchange of genetic material between nonsister chromatids resulting in chromosomes that incorporate genes from both parents of the organism

fertilization
union of two haploid cells from two individual organisms

gametophyte
a multicellular haploid life-cycle stage that produces gametes

germ cells
specialized cell line that produces gametes, such as eggs or sperm

interkinesis
(also, *interphase II*) brief period of rest between meiosis I and meiosis II

life cycle
the sequence of events in the development of an organism and the production of cells that produce offspring

meiosis
a nuclear division process that results in four haploid cells

meiosis I
first round of meiotic cell division; referred to as *reduction division* because the ploidy level is reduced from diploid to haploid

meiosis II
second round of meiotic cell division following meiosis I; sister chromatids are separated into individual chromosomes, and the result is four unique haploid cells

recombination nodules
protein assemblies formed on the synaptonemal complex that mark the points of crossover events and mediate the multistep process of genetic recombination between nonsister chromatids of a homologous pair

reduction division
nuclear division that produces daughter nuclei each having one-half as many chromosome sets as the parental nucleus; meiosis I is a reduction division

somatic cell
all the cells of a multicellular organism except the gametes or reproductive cells

spore
haploid cell that can produce a haploid multicellular organism or can fuse with another spore to form a diploid cell

sporophyte
a multicellular diploid life-cycle stage that produces haploid spores by meiosis

synapsis

formation of a close association between homologous chromosomes during prophase I

synaptonemal complex

protein lattice that forms between homologous chromosomes during prophase I, supporting crossover

tetrad

two duplicated homologous chromosomes (four chromatids) bound together by chiasmata during prophase I

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11.2: VISUAL CONNECTION QUESTIONS

1.

Figure 11.10 If a mutation occurs so that a fungus is no longer able to produce a minus mating type, will it still be able to reproduce?

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11.3: REVIEW QUESTIONS

2.

Meiosis usually produces _____ daughter cells.

1. two haploid
2. two diploid
3. four haploid
4. four diploid

3.

What structure is most important in forming the tetrads?

1. centromere
2. synaptonemal complex
3. chiasma
4. kinetochore

4.

At which stage of meiosis are sister chromatids separated from each other?

1. prophase I
2. prophase II
3. anaphase I
4. anaphase II

5.

At metaphase I, homologous chromosomes are connected only at what structures?

1. chiasmata
2. recombination nodules
3. microtubules
4. kinetochores

6.

Which of the following is *not* true in regard to crossover?

1. Spindle microtubules guide the transfer of DNA across the synaptonemal complex.
2. Nonsister chromatids exchange genetic material.
3. Chiasmata are formed.
4. Recombination nodules mark the crossover point.

7.

What phase of mitotic interphase is missing from meiotic interkinesis?

1. G_0 phase
2. G_1 phase
3. S phase
4. G_2 phase

8.

The part of meiosis that is similar to mitosis is _____.

1. meiosis I
2. anaphase I
3. meiosis II
4. interkinesis

9.

If a muscle cell of a typical organism has 32 chromosomes, how many chromosomes will be in a gamete of that same organism?

1. 8
2. 16

3. 32
4. 64

10.

Which statement best describes the genetic content of the two daughter cells in prophase II of meiosis?

1. haploid with one copy of each gene
2. haploid with two copies of each gene
3. diploid with two copies of each gene
4. diploid with four copies of each gene

11.

The pea plants used in Mendel's genetic inheritance studies were diploid, with 14 chromosomes in somatic cells. Assuming no crossing over events occur, how many unique gametes could one pea plant produce?

1. 28
2. 128
3. 196
4. 16,384

12.

How do telophase I and telophase II differ during meiosis in animal cells?

1. Cells remain diploid at the end of telophase I, but are haploid at the end of telophase II.
2. Daughter cells form a cell plate to divide during telophase I, but divide by cytokinesis during telophase II.
3. Cells enter interphase after telophase I, but not after telophase II.
4. Chromosomes can remain condensed at the end of telophase I, but decondense after telophase II.

13.

What is a likely evolutionary advantage of sexual reproduction over asexual reproduction?

1. Sexual reproduction involves fewer steps.
2. There is a lower chance of using up the resources in a given environment.
3. Sexual reproduction results in variation in the offspring.
4. Sexual reproduction is more cost-effective.

14.

Which type of life cycle has both a haploid and diploid multicellular stage?

1. asexual life cycles
2. most animal life cycles
3. most fungal life cycles
4. alternation of generations

15.

What is the ploidy of the most conspicuous form of most fungi?

1. diploid
2. haploid
3. alternation of generations
4. asexual

16.

A diploid, multicellular life-cycle stage that gives rise to haploid cells by meiosis is called a _____.

1. sporophyte
2. gametophyte
3. spore
4. gamete

17.

Hydras and jellyfish both live in a freshwater lake that is slowly being acidified by the runoff from a chemical plant built upstream. Which population is predicted to be better able to cope with the changing environment?

1. jellyfish
2. hydra
3. The populations will be equally able to cope.
4. Both populations will die.

18.

Many farmers are worried about the decreasing genetic diversity of plants associated with generations of artificial selection and inbreeding. Why is limiting random sexual reproduction of food crops concerning?

1. Mutations during asexual reproduction decrease plant fitness.
2. Consumers do not trust identical-appearing produce.
3. Larger portions of the plant populations are susceptible to the same diseases.
4. Spores are not viable in an agricultural setting.

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11.4: CRITICAL THINKING QUESTIONS

19.

Describe the process that results in the formation of a tetrad.

20.

Explain how the random alignment of homologous chromosomes during metaphase I contributes to the variation in gametes produced by meiosis.

21.

What is the function of the fused kinetochore found on sister chromatids in prometaphase I?

22.

In a comparison of the stages of meiosis to the stages of mitosis, which stages are unique to meiosis and which stages have the same events in both meiosis and mitosis?

23.

Why would an individual with a mutation that prevented the formation of recombination nodules be considered less fit than other members of its species?

24.

Does crossing over occur during prophase II? From an evolutionary perspective, why is this advantageous?

25.

List and briefly describe the three processes that lead to variation in offspring with the same parents.

26.

Animals and plants both have diploid and haploid cells. How does the animal life cycle differ from the alternation of generations exhibited by plants?

27.

Explain why sexual reproduction is beneficial to a population but can be detrimental to an individual offspring.

28.

How does the role of meiosis in gamete production differ between organisms with a diploid-dominant life cycle and organisms with an alternation of generations life cycle?

29.

How do organisms with haploid-dominant life cycles ensure continued genetic diversification in offspring without using a meiotic process to make gametes?

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CHAPTER OVERVIEW

12: MENDEL'S EXPERIMENTS AND HEREDITY

Gregor Johann Mendel was a German-speaking Moravian scientist and Augustinian friar who gained posthumous fame as the founder of the modern science of genetics. Though farmers had known for centuries that crossbreeding of animals and plants could favor certain desirable traits, Mendel's experiments established many of the rules of heredity, now referred to as the laws of Mendelian inheritance.

12.1: Key Terms

12.2: Visual Connection Questions

12.3: Review Questions

12.4: Critical Thinking Questions

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12.1: KEY TERMS

allele
gene variations that arise by mutation and exist at the same relative locations on homologous chromosomes

autosomes
any of the non-sex chromosomes

blending theory of inheritance
hypothetical inheritance pattern in which parental traits are blended together in the offspring to produce an intermediate physical appearance

codominance
in a heterozygote, complete and simultaneous expression of both alleles for the same characteristic

continuous variation
inheritance pattern in which a character shows a range of trait values with small gradations rather than large gaps between them

dihybrid
result of a cross between two true-breeding parents that express different traits for two characteristics

discontinuous variation
inheritance pattern in which traits are distinct and are transmitted independently of one another

dominant
trait which confers the same physical appearance whether an individual has two copies of the trait or one copy of the dominant trait and one copy of the recessive trait

dominant lethal
inheritance pattern in which an allele is lethal both in the homozygote and the heterozygote; this allele can only be transmitted if the lethality phenotype occurs after reproductive age

epistasis
antagonistic interaction between genes such that one gene masks or interferes with the expression of another

F_1
first filial generation in a cross; the offspring of the parental generation

F_2
second filial generation produced when F_1 individuals are self-crossed or fertilized with each other

genotype
underlying genetic makeup, consisting of both physically visible and non-expressed alleles, of an organism

hemizygous
presence of only one allele for a characteristic, as in X-linkage; hemizygosity makes descriptions of dominance and recessiveness irrelevant

heterozygous
having two different alleles for a given gene on the homologous chromosome

homozygous
having two identical alleles for a given gene on the homologous chromosome

hybridization
process of mating two individuals that differ with the goal of achieving a certain characteristic in their offspring

incomplete dominance
in a heterozygote, expression of two contrasting alleles such that the individual displays an intermediate phenotype

law of dominance
in a heterozygote, one trait will conceal the presence of another trait for the same characteristic

law of independent assortment
genes do not influence each other with regard to sorting of alleles into gametes; every possible combination of alleles is equally likely to occur

law of segregation
paired unit factors (i.e., genes) segregate equally into gametes such that offspring have an equal likelihood of inheriting any combination of factors

linkage
phenomenon in which alleles that are located in close proximity to each other on the same chromosome are more likely to be inherited together

model system
species or biological system used to study a specific biological phenomenon to be applied to other different species

monohybrid
result of a cross between two true-breeding parents that express different traits for only one characteristic

P_0
parental generation in a cross

phenotype
observable traits expressed by an organism

product rule
probability of two independent events occurring simultaneously can be calculated by multiplying the individual probabilities of each event occurring alone

Punnett square
visual representation of a cross between two individuals in which the gametes of each individual are denoted along the top and side of a grid, respectively, and the possible zygotic genotypes are recombined at each box in the grid

recessive
trait that appears “latent” or non-expressed when the individual also carries a dominant trait for that same characteristic; when present as two identical copies, the recessive trait is expressed

recessive lethal
inheritance pattern in which an allele is only lethal in the homozygous form; the heterozygote may be normal or have some altered, nonlethal phenotype

reciprocal cross
paired cross in which the respective traits of the male and female in one cross become the respective traits of the female and male in the other cross

sex-linked
any gene on a sex chromosome

sum rule
probability of the occurrence of at least one of two mutually exclusive events is the sum of their individual probabilities

test cross

cross between a dominant expressing individual with an unknown genotype and a homozygous recessive individual; the offspring phenotypes indicate whether the unknown parent is heterozygous or homozygous for the dominant trait

trait

variation in the physical appearance of a heritable characteristic

X-linked

gene present on the X, but not the Y chromosome

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12.2: VISUAL CONNECTION QUESTIONS

1.

Figure 12.5 In pea plants, round peas (*R*) are dominant to wrinkled peas (*r*). You do a test cross between a pea plant with wrinkled peas (genotype *rr*) and a plant of unknown genotype that has round peas. You end up with three plants, all which have round peas. From this data, can you tell if the round pea parent plant is homozygous dominant or heterozygous? If the round pea parent plant is heterozygous, what is the probability that a random sample of 3 progeny peas will all be round?

2.

Figure 12.6 What are the genotypes of the individuals labeled 1, 2, and 3?

3.

Figure 12.12 What ratio of offspring would result from a cross between a white-eyed male and a female that is heterozygous for red eye color?

4.

Figure 12.16 In pea plants, round seed shape (R) is dominant to wrinkled seed shape (r) and yellow peas (Y) are dominant to green peas (y). What are the possible genotypes and phenotypes for a cross between RrYY and rrYy pea plants? How many squares do you need to do a Punnett square analysis of this cross?

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12.3: REVIEW QUESTIONS

5.

Mendel performed hybridizations by transferring pollen from the _____ of the male plant to the female ova.

1. anther
2. pistil
3. stigma
4. seed

6.

Which is one of the seven characteristics that Mendel observed in pea plants?

1. flower size
2. seed texture
3. leaf shape
4. stem color

7.

Imagine you are performing a cross involving seed color in garden pea plants. What F_1 offspring would you expect if you cross true-breeding parents with green seeds and yellow seeds? Yellow seed color is dominant over green.

1. 100 percent yellow-green seeds
2. 100 percent yellow seeds
3. 50 percent yellow, 50 percent green seeds
4. 25 percent green, 75 percent yellow seeds

8.

Consider a cross to investigate the pea pod texture trait, involving constricted or inflated pods. Mendel found that the traits behave according to a dominant/recessive pattern in which inflated pods were dominant. If you performed this cross and obtained 650 inflated-pod plants in the F_2 generation, approximately how many constricted-pod plants would you expect to have?

1. 600
2. 165
3. 217
4. 468

9.

A scientist pollinates a true-breeding pea plant with violet, terminal flowers with pollen from a true-breeding pea plant with white, axial flowers. Which of the following observations would most accurately describe the F_2 generation?

1. 75% violet flowers; 75% terminal flowers
2. 75% white flowers in a terminal position
3. 75% violet flowers; 75% axial flowers
4. 75% violet flowers in an axial position

10.

The observable traits expressed by an organism are described as its _____.

1. phenotype
2. genotype
3. alleles
4. zygote

11.

A recessive trait will be observed in individuals that are _____ for that trait.

1. heterozygous
2. homozygous or heterozygous
3. homozygous
4. diploid

12.

If black and white true-breeding mice are mated and the result is all gray offspring, what inheritance pattern would this be indicative of?

1. dominance
2. codominance
3. multiple alleles
4. incomplete dominance

13.

The ABO blood groups in humans are expressed as the I^A, I^B, and i alleles. The I^A allele encodes the A blood group antigen, I^B encodes B, and i encodes O. Both A and B are dominant to O. If a heterozygous blood type A parent (I^Ai) and a heterozygous blood type B parent (I^Bi) mate, one quarter of their offspring will have AB blood type (I^AI^B) in which both antigens are expressed equally. Therefore, ABO blood groups are an example of:

1. multiple alleles and incomplete dominance
2. codominance and incomplete dominance
3. incomplete dominance only
4. multiple alleles and codominance

14.

In a mating between two individuals that are heterozygous for a recessive lethal allele that is expressed *in utero*, what genotypic ratio (homozygous dominant:heterozygous:homozygous recessive) would you expect to observe in the offspring?

1. 1:2:1
2. 3:1:1
3. 1:2:0
4. 0:2:1

15.

If the allele encoding polydactyly (six fingers) is dominant why do most people have five fingers?

1. Genetic elements suppress the polydactyl gene.
2. Polydactyly is embryonic lethal.
3. The sixth finger is removed at birth.
4. The polydactyl allele is very rare in the human population.

16.

A farmer raises black and white chickens. To his surprise, when the first generation of eggs hatch all the chickens are black with white speckles throughout their feathers. What should the farmer expect when the eggs laid after interbreeding the speckled chickens hatch?

1. All the offspring will be speckled.
2. 75% of the offspring will be speckled, and 25% will be black.
3. 50% of the offspring will be speckled, 25% will be black, and 25% will be white.
4. 50% of the offspring will be black and 50% of the offspring will be white.

17.

Assuming no gene linkage, in a dihybrid cross of *AABB* x *aabb* with *AaBb* F_1 heterozygotes, what is the ratio of the F_1 gametes (*AB*, *aB*, *Ab*, *ab*) that will give rise to the F_2 offspring?

1. 1:1:1:1
2. 1:3:3:1
3. 1:2:2:1
4. 4:3:2:1

18.

The forked line and probability methods make use of what probability rule?

1. test cross
2. product rule
3. monohybrid rule
4. sum rule

19.

How many different offspring genotypes are expected in a trihybrid cross between parents heterozygous for all three traits when the traits behave in a dominant and recessive pattern? How many phenotypes?

1. 64 genotypes; 16 phenotypes
2. 16 genotypes; 64 phenotypes
3. 8 genotypes; 27 phenotypes
4. 27 genotypes; 8 phenotypes

20.

Labrador retrievers' fur color is controlled by two alleles, E and B. Any dog with the ee__ genotype develops into a yellow lab, while B_E_ dogs become black labs and bbE_ dogs become chocolate labs. This is an example of _____.

1. epistasis
2. codominance
3. incomplete dominance
4. linkage

21.

Which of the following situations does **not** follow the Law of Independent Assortment?

1. A blond person and a brown-haired person produce three offspring over time, all of who have blond hair.
2. A white cow crossed with a brown bull produces roan cattle.
3. Mating a hog with a sow produces six female piglets.
4. Men are more likely to experience hemophilia than women.

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12.4: CRITICAL THINKING QUESTIONS

22.

Describe one of the reasons why the garden pea was an excellent choice of model system for studying inheritance.

23.

How would you perform a reciprocal cross for the characteristic of stem height in the garden pea?

24.

Mendel performs a cross using a true-breeding pea plant with round, yellow seeds and a true-breeding pea plant with green, wrinkled seeds. What is the probability that offspring will have green, round seeds? Calculate the probability for the F_1 and F_2 generations.

25.

Calculate the probability of selecting a heart or a face card from a standard deck of cards. Is this outcome more or less likely than selecting a heart suit face card?

26.

The gene for flower position in pea plants exists as axial or terminal alleles. Given that axial is dominant to terminal, list all of the possible F_1 and F_2 genotypes and phenotypes from a cross involving parents that are homozygous for each trait. Express genotypes with conventional genetic abbreviations.

27.

Use a Punnett square to predict the offspring in a cross between a dwarf pea plant (homozygous recessive) and a tall pea plant (heterozygous). What is the phenotypic ratio of the offspring?

28.

Can a human male be a carrier of red-green color blindness?

29.

Why is it more efficient to perform a test cross with a homozygous recessive donor than a homozygous dominant donor? How could the same information still be found with a homozygous dominant donor?

30.

Use the probability method to calculate the genotypes and genotypic proportions of a cross between *AABBCc* and *Aabbcc* parents.

31.

Explain epistasis in terms of its Greek-language roots “standing upon.”

32.

In Section 12.3, “Laws of Inheritance,” an example of epistasis was given for the summer squash. Cross white *WwYy* heterozygotes to prove the phenotypic ratio of 12 white:3 yellow:1 green that was given in the text.

33.

People with trisomy 21 develop Down’s syndrome. What law of Mendelian inheritance is violated in this disease? What is the most likely way this occurs?

34.

A heterozygous pea plant produces violet flowers and yellow, round seeds. Describe the expected genotypes of the gametes produced by Mendelian inheritance. If all three genes are found on the same arm of one chromosome should a scientist predict that inheritance patterns will follow Mendelian genetics?

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CHAPTER OVERVIEW

13: MODERN UNDERSTANDINGS OF INHERITANCE

The gene is the physical unit of inheritance, and genes are arranged in a linear order on chromosomes. The behaviors and interactions of chromosomes during meiosis explain, at a cellular level, the patterns of inheritance that we observe in populations. Genetic disorders involving alterations in chromosome number or structure may have dramatic effects and can prevent a fertilized egg from developing altogether.

13.1: Key Terms

13.2: Visual Connection Questions

13.3: Review Questions

13.4: Critical Thinking Questions

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13.1: KEY TERMS

aneuploid
individual with an error in chromosome number; includes chromosome segment deletions and duplications

autosome
any of the non-sex chromosomes

centimorgan (cM)
(also, map unit) relative distance that corresponds to a 0,01 recombination frequency

Chromosomal Theory of Inheritance
theory proposing that chromosomes are the genes' vehicles and that their behavior during meiosis is the physical basis of the inheritance patterns that Mendel observed

chromosome inversion
detachment, 180° rotation, and chromosome arm reinsertion

euploid
individual with the appropriate number of chromosomes for their species

homologous recombination
process by which homologous chromosomes undergo reciprocal physical exchanges at their arms, also crossing over

karyogram
a karyotype's photographic image

karyotype
an individual's chromosome number and appearance; includes the size, banding patterns, and centromere position

monosomy
otherwise diploid genotype in which one chromosome is missing

nondisjunction
failure of synapsed homologs to completely separate and migrate to separate poles during the meiosis' first cell division

nonparental (recombinant) type
progeny resulting from homologous recombination that exhibits a different allele combination compared with its parents

paracentric
inversion that occurs outside the centromere

parental types
progeny that exhibits the same allelic combination as its parents

pericentric
inversion that involves the centromere

polyploid
individual with an incorrect number of chromosome sets

recombination frequency
average number of crossovers between two alleles; observed as the number of nonparental types in a progeny's population

translocation
process by which one chromosome segment dissociates and reattaches to a different, nonhomologous chromosome

trisomy
otherwise diploid genotype in which one entire chromosome duplicates

X inactivation
condensing X chromosomes into Barr bodies during embryonic development in females to compensate for the double genetic dose

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13.2: VISUAL CONNECTION QUESTIONS

1.

Figure 13.3 In a test cross for two characteristics such as the one shown here, can the predicted frequency of recombinant offspring be 60 percent? Why or why not?

2.

Figure 13.4 Which of the following statements is true?

1. Recombination of the body color and red/cinnabar eye alleles will occur more frequently than recombination of the alleles for wing length and aristae length.
2. Recombination of the body color and aristae length alleles will occur more frequently than recombination of red/brown eye alleles and the aristae length alleles.
3. Recombination of the gray/black body color and long/short aristae alleles will not occur.
4. Recombination of the red/brown eye and long/short aristae alleles will occur more frequently than recombination of the alleles for wing length and body color.

3.

Figure 13.6 Which of the following statements about nondisjunction is true?

1. Nondisjunction only results in gametes with n+1 or n–1 chromosomes.
2. Nondisjunction occurring during meiosis II results in 50 percent normal gametes.
3. Nondisjunction during meiosis I results in 50 percent normal gametes.
4. Nondisjunction always results in four different kinds of gametes.

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13.3: REVIEW QUESTIONS

4.

X-linked recessive traits in humans (or in *Drosophila*) are observed _____.

1. in more males than females
2. in more females than males
3. in males and females equally
4. in different distributions depending on the trait

5.

The first suggestion that chromosomes may physically exchange segments came from the microscopic identification of _____.

1. synapsis
2. sister chromatids
3. chiasmata
4. alleles

6.

Which recombination frequency corresponds to independent assortment and the absence of linkage?

1. 0
2. 0.25
3. 0.50
4. 0.75

7.

Which recombination frequency corresponds to perfect linkage and violates the law of independent assortment?

1. 0
2. 0.25
3. 0.50
4. 0.75

8.

Which of the following codes describes position 12 on the long arm of chromosome 13?

1. 13p12
2. 13q12
3. 12p13
4. 12q13

9.

In agriculture, polyploid crops (like coffee, strawberries, or bananas) tend to produce _____.

1. more uniformity
2. more variety
3. larger yields
4. smaller yields

10.

Assume a pericentric inversion occurred in one of two homologs prior to meiosis. The other homolog remains normal. During meiosis, what structure—if any—would these homologs assume in order to pair accurately along their lengths?

1. V formation
2. cruciform
3. loop
4. pairing would not be possible

11.

The genotype XXY corresponds to

1. Klinefelter syndrome

2. Turner syndrome
3. Triplo-X
4. Jacob syndrome

12.

Abnormalities in the number of X chromosomes tends to have milder phenotypic effects than the same abnormalities in autosomes because of _____.

1. deletions
2. nonhomologous recombination
3. synapsis
4. X inactivation

13.

By definition, a pericentric inversion includes the _____.

1. centromere
2. chiasma
3. telomere
4. synapse

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13.4: CRITICAL THINKING QUESTIONS

14.

Explain how the Chromosomal Theory of Inheritance helped to advance our understanding of genetics.

15.

Using diagrams, illustrate how nondisjunction can result in an aneuploid zygote.

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CHAPTER OVERVIEW

14: DNA STRUCTURE AND FUNCTION

Each human cell has 23 pairs of chromosomes: one set of chromosomes is inherited from the mother and the other set is inherited from the father. There is also a mitochondrial genome, inherited exclusively from the mother, which can be involved in inherited genetic disorders. On each chromosome, there are thousands of genes that are responsible for determining the genotype and phenotype of the individual. A gene is defined as a sequence of DNA that codes for a functional product. The human haploid genome contains 3 billion base pairs and has between 20,000 and 25,000 functional genes.

14.1: Key Terms

14.2: Visual Connection Questions

14.3: Review Questions

14.4: Critical Thinking Questions

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14.1: KEY TERMS

electrophoresis
technique used to separate DNA fragments according to size

helicase
during replication, this enzyme helps to open up the DNA helix by breaking the hydrogen bonds

induced mutation
mutation that results from exposure to chemicals or environmental agents

lagging strand
during replication, the strand that is replicated in short fragments and away from the replication fork

leading strand
strand that is synthesized continuously in the 5'-3' direction, which is synthesized in the direction of the replication fork

ligase
enzyme that catalyzes the formation of a phosphodiester linkage between the 3' OH and 5' phosphate ends of the DNA

mismatch repair
type of repair mechanism in which mismatched bases are removed after replication

mutation
variation in the nucleotide sequence of a genome

nucleotide excision repair
type of DNA repair mechanism in which the wrong base, along with a few nucleotides upstream or downstream, are removed

Okazaki fragment
DNA fragment that is synthesized in short stretches on the lagging strand

point mutation
mutation that affects a single base

primase
enzyme that synthesizes the RNA primer; the primer is needed for DNA pol to start synthesis of a new DNA strand

primer
short stretch of nucleotides that is required to initiate replication; in the case of replication, the primer has RNA nucleotides

proofreading
function of DNA pol in which it reads the newly added base before adding the next one

replication fork
Y-shaped structure formed during initiation of replication

silent mutation
mutation that is not expressed

single-strand binding protein
during replication, protein that binds to the single-stranded DNA; this helps in keeping the two strands of DNA apart so that they may serve as templates

sliding clamp
ring-shaped protein that holds the DNA pol on the DNA strand

spontaneous mutation
mutation that takes place in the cells as a result of chemical reactions taking place naturally without exposure to any external agent

telomerase
enzyme that contains a catalytic part and an inbuilt RNA template; it functions to maintain telomeres at chromosome ends

telomere
DNA at the end of linear chromosomes

topoisomerase
enzyme that prevents overwinding of DNA when DNA replication is taking place

transformation
process in which external DNA is taken up by a cell

transition substitution
when a purine is replaced with a purine or a pyrimidine is replaced with another pyrimidine

transversion substitution
when a purine is replaced by a pyrimidine or a pyrimidine is replaced by a purine

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14.2: VISUAL CONNECTION QUESTIONS

1.

Figure 14.10 In eukaryotic cells, DNA and RNA synthesis occur in a separate compartment from protein synthesis. In prokaryotic cells, both processes occur together. What advantages might there be to separating the processes? What advantages might there be to having them occur together?

2.

Figure 14.14 You isolate a cell strain in which the joining of Okazaki fragments is impaired and suspect that a mutation has occurred in an enzyme found at the replication fork. Which enzyme is most likely to be mutated?

3.

Figure 14.21 A frameshift mutation that results in the insertion of three nucleotides is often less deleterious than a mutation that results in the insertion of one nucleotide. Why?

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14.3: REVIEW QUESTIONS

4.

If DNA of a particular species was analyzed and it was found that it contains 27 percent A, what would be the percentage of C?

1. 27 percent
2. 30 percent
3. 23 percent
4. 54 percent

5.

The experiments by Hershey and Chase helped confirm that DNA was the hereditary material on the basis of the finding that:

1. radioactive phage were found in the pellet
2. radioactive cells were found in the supernatant
3. radioactive sulfur was found inside the cell
4. radioactive phosphorus was found in the cell

6.

Bacterial transformation is a major concern in many medical settings. Why might health care providers be concerned?

1. Pathogenic bacteria could introduce disease-causing genes in non-pathogenic bacteria.
2. Antibiotic resistance genes could be introduced to new bacteria to create “superbugs.”
3. Bacteriophages could spread DNA encoding toxins to new bacteria.
4. All of the above.

7.

DNA double helix does not have which of the following?

1. antiparallel configuration
2. complementary base pairing
3. major and minor grooves
4. uracil

8.

In eukaryotes, what is the DNA wrapped around?

1. single-stranded binding proteins
2. sliding clamp
3. polymerase
4. histones

9.

Meselson and Stahl's experiments proved that DNA replicates by which mode?

1. conservative
2. semi-conservative
3. dispersive
4. none of the above

10.

If the sequence of the 5'-3' strand is AATGCTAC, then the complementary sequence has the following sequence:

1. 3'-AATGCTAC-5'
2. 3'-CATCGTAA-5'
3. 3'-TTACGATG-5'
4. 3'-GTAGCATT-5'

11.

How did Meselson and Stahl support Watson and Crick’s double-helix model?

1. They demonstrated that each strand serves as a template for synthesizing a new strand of DNA.
2. They showed that the DNA strands break and recombine without losing genetic material.

3. They proved that DNA maintains a double-helix structure while undergoing semi-conservative replication.
4. They demonstrated that conservative replication maintains the complementary base pairing of each DNA helix.

12.

Which of the following components is not involved during the formation of the replication fork?

1. single-strand binding proteins
2. helicase
3. origin of replication
4. ligase

13.

Which of the following does the enzyme primase synthesize?

1. DNA primer
2. RNA primer
3. Okazaki fragments
4. phosphodiester linkage

14.

In which direction does DNA replication take place?

1. 5'-3'
2. 3'-5'
3. 5'
4. 3'

15.

A scientist randomly mutates the DNA of a bacterium. She then sequences the bacterium's daughter cells, and finds that the daughters have many errors in their replicated DNA. The parent bacterium likely acquired a mutation in which enzyme?

1. DNA ligase
2. DNA pol II
3. Primase
4. DNA pol I

16.

The ends of the linear chromosomes are maintained by

1. helicase
2. primase
3. DNA pol
4. telomerase

17.

Which of the following is not a true statement comparing prokaryotic and eukaryotic DNA replication?

1. Both eukaryotic and prokaryotic DNA polymerases build off RNA primers made by primase.
2. Eukaryotic DNA replication requires multiple replication forks, while prokaryotic replication uses a single origin to rapidly replicate the entire genome.
3. DNA replication always occurs in the nucleus.
4. Eukaryotic DNA replication involves more polymerases than prokaryotic replication.

18.

During proofreading, which of the following enzymes reads the DNA?

1. primase
2. topoisomerase
3. DNA pol
4. helicase

19.

The initial mechanism for repairing nucleotide errors in DNA is _____.

1. mismatch repair
2. DNA polymerase proofreading
3. nucleotide excision repair
4. thymine dimers

20.

A scientist creates fruit fly larvae with a mutation that eliminates the exonuclease function of DNA pol. Which prediction about the mutational load in the adult fruit flies is most likely to be correct?

1. The adults with the DNA pol mutation will have significantly more mutations than average.
2. The adults with the DNA pol mutation will have slightly more mutations than average.
3. The adults with the DNA pol mutation will have the same number of mutations as average.
4. The adults with the DNA pol mutation will have fewer mutations than average.

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14.4: CRITICAL THINKING QUESTIONS

21.

Explain Griffith's transformation experiments. What did he conclude from them?

22.

Why were radioactive sulfur and phosphorous used to label bacteriophage in Hershey and Chase's experiments?

23.

When Chargaff was performing his experiments, the tetranucleotide hypothesis, which stated that DNA was composed of GACT nucleotide repeats, was the most widely accepted view of DNA's composition. How did Chargaff disprove this hypothesis?

24.

Provide a brief summary of the Sanger sequencing method.

25.

Describe the structure and complementary base pairing of DNA.

26.

Prokaryotes have a single circular chromosome while eukaryotes have linear chromosomes. Describe one advantage and one disadvantage to the eukaryotic genome packaging compared to the prokaryotes.

27.

How did the scientific community learn that DNA replication takes place in a semi-conservative fashion?

28.

Imagine the Meselson and Stahl experiments had supported conservative replication instead of semi-conservative replication. What results would you predict to observe after two rounds of replication? Be specific regarding percent distributions of DNA incorporating ^{15}N and ^{14}N in the gradient.

29.

DNA replication is bidirectional and discontinuous; explain your understanding of those concepts.

30.

What are Okazaki fragments and how they are formed?

31.

If the rate of replication in a particular prokaryote is 900 nucleotides per second, how long would it take 1.2 million base pair genomes to make two copies?

32.

Explain the events taking place at the replication fork. If the gene for helicase is mutated, what part of replication will be affected?

33.

What is the role of a primer in DNA replication? What would happen if you forgot to add a primer in a tube containing the reaction mix for a DNA sequencing reaction?

34.

Quinolone antibiotics treat bacterial infections by blocking the activity of topoisomerase. Why does this treatment work? Explain what occurs at the molecular level.

35.

How do the linear chromosomes in eukaryotes ensure that its ends are replicated completely?

36.

What is the consequence of mutation of a mismatch repair enzyme? How will this affect the function of a gene?

37.

An adult with a history of tanning has his genome sequenced. The beginning of a protein-coding region of his DNA reads ATGGGGATATGGCAT. If the protein-coding region of a healthy adult reads ATGGGGATATGAGCAT, identify the site and type of mutation.

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CHAPTER OVERVIEW

15: GENES AND PROTEINS

Since the rediscovery of Mendel’s work in 1900, the definition of the gene has progressed from an abstract unit of heredity to a tangible molecular entity capable of replication, expression, and mutation. Genes are composed of DNA and are linearly arranged on chromosomes. Genes specify the sequences of amino acids, which are the building blocks of proteins. In turn, proteins are responsible for orchestrating nearly every function of the cell. Both genes and the proteins they encode are absolutely essential to life as we know it.

15.1: Key Terms

15.2: Visual Connection Questions

15.3: Review Questions

15.4: Critical Thinking Questions

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15.1: KEY TERMS

7-methylguanosine cap
modification added to the 5' end of pre-mRNAs to protect mRNA from degradation and assist translation

aminoacyl tRNA synthetase
enzyme that “charges” tRNA molecules by catalyzing a bond between the tRNA and a corresponding amino acid

anticodon
three-nucleotide sequence in a tRNA molecule that corresponds to an mRNA codon

CAAT box
(GGCCAATCT) essential eukaryotic promoter sequence involved in binding transcription factors

central dogma
states that genes specify the sequence of mRNAs, which in turn specify the sequence of proteins

codon
three consecutive nucleotides in mRNA that specify the insertion of an amino acid or the release of a polypeptide chain during translation

colinear
in terms of RNA and protein, three “units” of RNA (nucleotides) specify one “unit” of protein (amino acid) in a consecutive fashion

consensus
DNA sequence that is used by many species to perform the same or similar functions

core enzyme
prokaryotic RNA polymerase consisting of α, α, β, and β' but missing σ; this complex performs elongation

degeneracy
(of the genetic code) describes that a given amino acid can be encoded by more than one nucleotide triplet; the code is degenerate, but not ambiguous

downstream
nucleotides following the initiation site in the direction of mRNA transcription; in general, sequences that are toward the 3' end relative to a site on the mRNA

exon
sequence present in protein-coding mRNA after completion of pre-mRNA splicing

FACT
complex that “facilitates chromatin transcription” by disassembling nucleosomes ahead of a transcribing RNA polymerase II and reassembling them after the polymerase passes by

GC-rich box
(GGCG) nonessential eukaryotic promoter sequence that binds cellular factors to increase the efficiency of transcription; may be present several times in a promoter

hairpin
structure of RNA when it folds back on itself and forms intramolecular hydrogen bonds between complementary nucleotides

holoenzyme
prokaryotic RNA polymerase consisting of α, α, β, β', and σ; this complex is responsible for transcription initiation

initiation site

nucleotide from which mRNA synthesis proceeds in the 5' to 3' direction; denoted with a “+1”

initiator tRNA

in prokaryotes, called $tRNA_f^{Met}$; in eukaryotes, called $tRNA_i$; a tRNA that interacts with a start codon, binds directly to the ribosome P site, and links to a special methionine to begin a polypeptide chain

intron

non–protein-coding intervening sequences that are spliced from mRNA during processing

Kozak’s rules

determines the correct initiation AUG in a eukaryotic mRNA; the following consensus sequence must appear around the AUG: 5’-GCC(**purine**)CCAUG**G**-3’; the bolded bases are most important

nonsense codon

one of the three mRNA codons that specifies termination of translation

nontemplate strand

strand of DNA that is not used to transcribe mRNA; this strand is identical to the mRNA except that T nucleotides in the DNA are replaced by U nucleotides in the mRNA

Octamer box

(ATTTGCAT) nonessential eukaryotic promoter sequence that binds cellular factors to increase the efficiency of transcription; may be present several times in a promoter

peptidyl transferase

RNA-based enzyme that is integrated into the 50S ribosomal subunit and catalyzes the formation of peptide bonds

plasmid

extrachromosomal, covalently closed, circular DNA molecule that may only contain one or a few genes; common in prokaryotes

poly-A tail

modification added to the 3' end of pre-mRNAs to protect mRNA from degradation and assist mRNA export from the nucleus

polysome

mRNA molecule simultaneously being translated by many ribosomes all going in the same direction

preinitiation complex

cluster of transcription factors and other proteins that recruit RNA polymerase II for transcription of a DNA template

promoter

DNA sequence to which RNA polymerase and associated factors bind and initiate transcription

reading frame

sequence of triplet codons in mRNA that specify a particular protein; a ribosome shift of one or two nucleotides in either direction completely abolishes synthesis of that protein

rho-dependent termination

in prokaryotes, termination of transcription by an interaction between RNA polymerase and the rho protein at a run of G nucleotides on the DNA template

rho-independent

termination sequence-dependent termination of prokaryotic mRNA synthesis; caused by hairpin formation in the mRNA that stalls the polymerase

RNA editing

direct alteration of one or more nucleotides in an mRNA that has already been synthesized

Shine-Dalgarno sequence
(AGGAGG); initiates prokaryotic translation by interacting with rRNA molecules comprising the 30S ribosome

signal sequence
short tail of amino acids that directs a protein to a specific cellular compartment

small nuclear RNA
molecules synthesized by RNA polymerase III that have a variety of functions, including splicing pre-mRNAs and regulating transcription factors

splicing
process of removing introns and reconnecting exons in a pre-mRNA

start codon
AUG (or rarely, GUG) on an mRNA from which translation begins; always specifies methionine

TATA box
conserved promoter sequence in eukaryotes and prokaryotes that helps to establish the initiation site for transcription

template strand
strand of DNA that specifies the complementary mRNA molecule

transcription bubble
region of locally unwound DNA that allows for transcription of mRNA

upstream
nucleotides preceding the initiation site; in general, sequences toward the 5' end relative to a site on the mRNA

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15.2: VISUAL CONNECTION QUESTIONS

1.

Figure 15.11 A scientist splices a eukaryotic promoter in front of a bacterial gene and inserts the gene in a bacterial chromosome. Would you expect the bacteria to transcribe the gene?

2.

Figure 15.13 Errors in splicing are implicated in cancers and other human diseases. What kinds of mutations might lead to splicing errors? Think of different possible outcomes if splicing errors occur.

3.

Figure 15.18 Many antibiotics inhibit bacterial protein synthesis. For example, tetracycline blocks the A site on the bacterial ribosome, and chloramphenicol blocks peptidyl transfer. What specific effect would you expect each of these antibiotics to have on protein synthesis?

Tetracycline would directly affect:

1. tRNA binding to the ribosome
2. ribosome assembly
3. growth of the protein chain

Chloramphenicol would directly affect

1. tRNA binding to the ribosome
2. ribosome assembly
3. growth of the protein chain

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15.3: REVIEW QUESTIONS

4.

The AUC and AUA codons in mRNA both specify isoleucine. What feature of the genetic code explains this?

1. complementarity
2. nonsense codons
3. universality
4. degeneracy

5.

How many nucleotides are in 12 mRNA codons?

1. 12
2. 24
3. 36
4. 48

6.

Which event contradicts the central dogma of molecular biology?

1. Poly-A polymerase enzymes process mRNA in the nucleus.
2. Endonuclease enzymes splice out and repair damaged DNA.
3. Scientists use reverse transcriptase enzymes to make DNA from RNA.
4. Codons specifying amino acids are degenerate and universal.

7.

Which subunit of the *E. coli* polymerase confers specificity to transcription?

1. α
2. β
3. β'
4. σ

8.

The -10 and -35 regions of prokaryotic promoters are called consensus sequences because _____.

1. they are identical in all bacterial species
2. they are similar in all bacterial species
3. they exist in all organisms
4. they have the same function in all organisms

9.

Three different bacteria species have the following consensus sequences upstream of a conserved gene.

	Species A	Species B	Species C
-10	TAATAAT	TTTAAT	TATATT
-35	TTGACA	TTGGCC	TTGAAA

Table 15.2

Order the bacteria from most to least efficient initiation of gene transcription.

1. A > B > C
2. B > C > A
3. C > B > A
4. A > C > B

10.

Which feature of promoters can be found in both prokaryotes and eukaryotes?

1. GC box
2. TATA box

3. octamer box
4. -10 and -35 sequences

11.

What transcripts will be most affected by low levels of α-amanitin?

1. 18S and 28S rRNAs
2. pre-mRNAs
3. 5S rRNAs and tRNAs
4. other small nuclear RNAs

12.

How do enhancers and promoters differ?

1. Enhancers bind transcription factors to silence gene expression, while promoters activate transcription.
2. Enhancers increase the efficiency of gene expression, but are not essential for transcription. Promoter recognition is essential to transcription initiation.
3. Promoters bind transcription factors to increase the efficiency of transcription. Enhancers bind RNA polymerases to initiate transcription.
4. There is no difference. Both are transcription factor-binding sequences in DNA.

13.

Which pre-mRNA processing step is important for initiating translation?

1. poly-A tail
2. RNA editing
3. splicing
4. 7-methylguanosine cap

14.

What processing step enhances the stability of pre-tRNAs and pre-rRNAs?

1. methylation
2. nucleotide modification
3. cleavage
4. splicing

15.

A scientist identifies a pre-mRNA with the following structure.



What is the predicted size of the corresponding mature mRNA in base pairs (bp), excluding the 5’ cap and 3’ poly-A tail?

1. 220bp
2. 295bp
3. 140bp
4. 435bp

16.

The RNA components of ribosomes are synthesized in the _____.

1. cytoplasm
2. nucleus
3. nucleolus
4. endoplasmic reticulum

17.

In any given species, there are at least how many types of aminoacyl tRNA synthetases?

1. 20
2. 40
3. 100
4. 200

18.

A scientist introduces a mutation that makes the 60S ribosomal subunit nonfunctional in a human cell line. What would be the predicted effect on translation?

1. Translation stalls after the initiation AUG codon is identified.
2. The ribosome cannot catalyze the formation of peptide bonds between the tRNAs in the A and P sites.
3. The ribosome cannot interact with mRNAs.
4. tRNAs cannot exit the E site of the ribosome.

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15.4: CRITICAL THINKING QUESTIONS

19.

Imagine if there were 200 commonly occurring amino acids instead of 20. Given what you know about the genetic code, what would be the shortest possible codon length? Explain.

20.

Discuss how degeneracy of the genetic code makes cells more robust to mutations.

21.

A scientist sequencing mRNA identifies the following strand: CUAUGUGUCGUAACAGCCGAUGACCCG

What is the sequence of the amino acid chain this mRNA makes when it is translated?

22.

If mRNA is complementary to the DNA template strand and the DNA template strand is complementary to the DNA nontemplate strand, then why are base sequences of mRNA and the DNA nontemplate strand not identical? Could they ever be?

23.

In your own words, describe the difference between rho-dependent and rho-independent termination of transcription in prokaryotes.

24.

A fragment of bacterial DNA reads:

3’ –TACCTATAATCTCAATTGATAGAAGCACTCTAC– 5’

Assuming that this fragment is the template strand, what is the sequence of mRNA that would be transcribed? (Hint: Be sure to identify the initiation site.)

25.

A scientist observes that a cell has an RNA polymerase deficiency that prevents it from making proteins. Describe three additional observations that would together support the conclusion that a defect in RNA polymerase I activity, and not problems with the other polymerases, causes the defect.

26.

Chronic lymphocytic leukemia patients often harbor nonsense mutations in their spliceosome machinery. Describe how this mutation of the spliceosome would change the final location and sequence of a pre-mRNA.

27.

Transcribe and translate the following DNA sequence (nontemplate strand): 5'-ATGGCCGGTTATTAAGCA-3'

28.

Explain how single nucleotide changes can have vastly different effects on protein function.

29.

A normal mRNA that reads 5’ – UGCCAUGGUAAUAACACAUGAGGCCUGAAC– 3’ has an insertion mutation that changes the sequence to 5’ -UGCCAUGG**U**UUAAUAACACAUGAGGCCUGAAC– 3’. Translate the original mRNA and the mutated mRNA, and explain how insertion mutations can have dramatic effects on proteins. (Hint: Be sure to find the initiation site.)

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CHAPTER OVERVIEW

16: GENE EXPRESSION

Whereas each cell shares the same genome and DNA sequence, each cell does not turn on, or express, the same set of genes. Each cell type needs a different set of proteins to perform its function. Therefore, only a small subset of proteins is expressed in a cell. For the proteins to be expressed, the DNA must be transcribed into RNA and the RNA must be translated into protein. In a given cell type, not all genes encoded in the DNA are transcribed into RNA or translated into protein because specific cells in our body have specific functions. Specialized proteins that make up the eye (iris, lens, and cornea) are only expressed in the eye, whereas the specialized proteins in the heart (pacemaker cells, heart muscle, and valves) are only expressed in the heart. At any given time, only a subset of all of the genes encoded by our DNA are expressed and translated into proteins. The expression of specific genes is a highly regulated process with many levels and stages of control. This complexity ensures the proper expression in the proper cell at the proper time.

16.1: Key Terms
16.2: Visual Connection Questions
16.3: Review Questions
16.4: Critical Thinking Questions

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16.1: KEY TERMS

3' UTR
3' untranslated region; region just downstream of the protein-coding region in an RNA molecule that is not translated

5' cap
a methylated guanosine triphosphate (GTP) molecule that is attached to the 5' end of a messenger RNA to protect the end from degradation

5' UTR
5' untranslated region; region just upstream of the protein-coding region in an RNA molecule that is not translated

activator
protein that binds to prokaryotic operators to increase transcription

catabolite activator protein (CAP)
protein that complexes with cAMP to bind to the promoter sequences of operons which control sugar processing when glucose is not available

***cis*-acting element**
transcription factor binding sites within the promoter that regulate the transcription of a gene adjacent to it

Dicer
enzyme that chops the pre-miRNA into the mature form of the miRNA

DNA methylation
epigenetic modification that leads to gene silencing; a process involving adding a methyl group to the DNA molecule

enhancer
segment of DNA that is upstream, downstream, perhaps thousands of nucleotides away, or on another chromosome that influence the transcription of a specific gene

epigenetic
heritable changes that do not involve changes in the DNA sequence

eukaryotic initiation factor-2 (eIF-2)
protein that binds first to an mRNA to initiate translation

gene expression
processes that control the turning on or turning off of a gene

guanine diphosphate (GDP)
molecule that is left after the energy is used to start translation

guanine triphosphate (GTP)
energy-providing molecule that binds to eIF-2 and is needed for translation

histone acetylation
epigenetic modification that leads to gene expression; a process involving adding or removing an acetyl functional group

inducible operon
operon that can be activated or repressed depending on cellular needs and the surrounding environment

initiation complex
protein complex containing eIF-2 that starts translation

***lac* operon**

operon in prokaryotic cells that encodes genes required for processing and intake of lactose

large 60S ribosomal subunit
second, larger ribosomal subunit that binds to the RNA to translate it into protein

microRNA (miRNA)
small RNA molecules (approximately 21 nucleotides in length) that bind to RNA molecules to degrade them

myc
oncogene that causes cancer in many cancer cells

negative regulator
protein that prevents transcription

operator
region of DNA outside of the promoter region that binds activators or repressors that control gene expression in prokaryotic cells

operon
collection of genes involved in a pathway that are transcribed together as a single mRNA in prokaryotic cells

poly-A tail
a series of adenine nucleotides that are attached to the 3' end of an mRNA to protect the end from degradation

positive regulator
protein that increases transcription

post-transcriptional
control of gene expression after the RNA molecule has been created but before it is translated into protein

post-translational
control of gene expression after a protein has been created

proteasome
organelle that degrades proteins

repressor
protein that binds to the operator of prokaryotic genes to prevent transcription

RISC
protein complex that binds along with the miRNA to the RNA to degrade it

RNA stability
how long an RNA molecule will remain intact in the cytoplasm

RNA-binding protein (RBP)
protein that binds to the 3' or 5' UTR to increase or decrease the RNA stability

small 40S ribosomal subunit
ribosomal subunit that binds to the RNA to translate it into protein

***trans*-acting element**
transcription factor binding site found outside the promoter or on another chromosome that influences the transcription of a particular gene

transcription factor
protein that binds to the DNA at the promoter or enhancer region and that influences transcription of a gene

transcription factor binding site

sequence of DNA to which a transcription factor binds

transcriptional start site

site at which transcription begins

***trp* operon**

series of genes necessary to synthesize tryptophan in prokaryotic cells

tryptophan

amino acid that can be synthesized by prokaryotic cells when necessary

untranslated region

segment of the RNA molecule that is not translated into protein. These regions lie before (upstream or 5') and after (downstream or 3') the protein-coding region

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16.2: VISUAL CONNECTION QUESTIONS

1.

Figure 16.6 In *E. coli*, the *trp* operon is on by default, while the *lac* operon is off. Why do you think that this is the case?

2.

Figure 16.8 In females, one of the two X chromosomes is inactivated during embryonic development because of epigenetic changes to the chromatin. What impact do you think these changes would have on nucleosome packing?

3.

Figure 16.14 An increase in phosphorylation levels of eIF-2 has been observed in patients with neurodegenerative diseases such as Alzheimer's, Parkinson's, and Huntington's. What impact do you think this might have on protein synthesis?

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16.3: REVIEW QUESTIONS

4.

Control of gene expression in eukaryotic cells occurs at which level(s)?

1. only the transcriptional level
2. epigenetic and transcriptional levels
3. epigenetic, transcriptional, and translational levels
4. epigenetic, transcriptional, post-transcriptional, translational, and post-translational levels

5.

Post-translational control refers to:

1. regulation of gene expression after transcription
2. regulation of gene expression after translation
3. control of epigenetic activation
4. period between transcription and translation

6.

How does the regulation of gene expression support continued evolution of more complex organisms?

1. Cells can become specialized within a multicellular organism.
2. Organisms can conserve energy and resources.
3. Cells grow larger to accommodate protein production.
4. Both A and B.

7.

If glucose is absent, but so is lactose, the *lac* operon will be _____.

1. activated
2. repressed
3. activated, but only partially
4. mutated

8.

Prokaryotic cells lack a nucleus. Therefore, the genes in prokaryotic cells are:

1. all expressed, all of the time
2. transcribed and translated almost simultaneously
3. transcriptionally controlled because translation begins before transcription ends
4. b and c are both true

9.

The *ara* operon is an inducible operon that controls the breakdown of the sugar arabinose. When arabinose is present in a bacterium it binds to the protein AraC, and the complex binds to the initiator site to promote transcription. In this scenario, AraC is a(n) _____.

1. activator
2. inducer
3. repressor
4. operator

10.

What are epigenetic modifications?

1. the addition of reversible changes to histone proteins and DNA
2. the removal of nucleosomes from the DNA
3. the addition of more nucleosomes to the DNA
4. mutation of the DNA sequence

11.

Which of the following are true of epigenetic changes?

1. allow DNA to be transcribed

2. move histones to open or close a chromosomal region
3. are temporary
4. all of the above

12.

The binding of _____ is required for transcription to start.

1. a protein
2. DNA polymerase
3. RNA polymerase
4. a transcription factor

13.

What will result from the binding of a transcription factor to an enhancer region?

1. decreased transcription of an adjacent gene
2. increased transcription of a distant gene
3. alteration of the translation of an adjacent gene
4. initiation of the recruitment of RNA polymerase

14.

A scientist compares the promoter regions of two genes. Gene A's core promoter plus proximal promoter elements encompasses 70bp. Gene B's core promoter plus proximal promoter elements encompasses 250bp. Which of the scientist's hypotheses is most likely to be correct?

1. More transcripts will be made from Gene B.
2. Transcription of Gene A involves fewer transcription factors.
3. Enhancers control Gene B's transcription.
4. Transcription of Gene A is more controlled than transcription of Gene B.

15.

Which of the following are involved in post-transcriptional control?

1. control of RNA splicing
2. control of RNA shuttling
3. control of RNA stability
4. all of the above

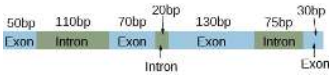
16.

Binding of an RNA binding protein will _____ the stability of the RNA molecule.

1. increase
2. decrease
3. neither increase nor decrease
4. either increase or decrease

17.

An unprocessed pre-mRNA has the following structure.



Which of the following is not a possible size (in bp) of the mature mRNA?

1. 205bp
2. 180bp
3. 150bp
4. 100bp

18.

Alternative splicing has been estimated to occur in more than 95% of multi-exon genes. Which of the following is not an evolutionary advantage of alternative splicing?

1. Alternative splicing increases diversity without increasing genome size.
2. Different gene isoforms can be expressed in different tissues.

3. Alternative splicing creates shorter mRNA transcripts.
4. Different gene isoforms can be expressed during different stages of development.

19.

Post-translational modifications of proteins can affect which of the following?

1. protein function
2. transcriptional regulation
3. chromatin modification
4. all of the above

20.

A scientist mutates eIF-2 to eliminate its GTP hydrolysis capability. How would this mutated form of eIF-2 alter translation?

1. Initiation factors would not be able to bind to mRNA.
2. The large ribosomal subunit would not be able to interact with mRNA transcripts.
3. tRNAi-Met would not scan mRNA transcripts for the start codon.
4. eIF-2 would not be able to interact with the small ribosomal subunit.

21.

Cancer causing genes are called _____.

1. transformation genes
2. tumor suppressor genes
3. oncogenes
4. mutated genes

22.

Targeted therapies are used in patients with a set gene expression pattern. A targeted therapy that prevents the activation of the estrogen receptor in breast cancer would be beneficial to which type of patient?

1. patients who express the EGFR receptor in normal cells
2. patients with a mutation that inactivates the estrogen receptor
3. patients with lots of the estrogen receptor expressed in their tumor
4. patients that have no estrogen receptor expressed in their tumor

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16.4: CRITICAL THINKING QUESTIONS

23.

Name two differences between prokaryotic and eukaryotic cells and how these differences benefit multicellular organisms.

24.

Describe how controlling gene expression will alter the overall protein levels in the cell.

25.

Describe how transcription in prokaryotic cells can be altered by external stimulation such as excess lactose in the environment.

26.

What is the difference between a repressible and an inducible operon?

27.

In cancer cells, alteration to epigenetic modifications turns off genes that are normally expressed. Hypothetically, how could you reverse this process to turn these genes back on?

28.

A scientific study demonstrated that rat mothering behavior impacts the stress response in their pups. Rats that were born and grew up with attentive mothers showed low activation of stress-response genes later in life, while rats with inattentive mothers had high activation of stress-response genes in the same situation. An additional study that swapped the pups at birth (i.e., rats born to inattentive mothers grew up with attentive mothers and vice versa) showed the same positive effect of attentive mothering. How do genetics and/or epigenetics explain the results of this study?

29.

Some autoimmune diseases show a positive correlation with dramatically decreased expression of histone deacetylase 9 (HDAC9, an enzyme that removes acetyl groups from histones). Why would the decreased expression of HDAC9 cause immune cells to produce inflammatory genes at inappropriate times?

30.

A mutation within the promoter region can alter transcription of a gene. Describe how this can happen.

31.

What could happen if a cell had too much of an activating transcription factor present?

32.

A scientist identifies a potential transcription regulation site 300bp downstream of a gene and hypothesizes that it is a repressor. What experiment (with results) could he perform to support this hypothesis?

33.

Describe how RBPs can prevent miRNAs from degrading an RNA molecule.

34.

How can external stimuli alter post-transcriptional control of gene expression?

35.

Protein modification can alter gene expression in many ways. Describe how phosphorylation of proteins can alter gene expression.

36.

Alternative forms of a protein can be beneficial or harmful to a cell. What do you think would happen if too much of an alternative protein bound to the 3' UTR of an RNA and caused it to degrade?

37.

Changes in epigenetic modifications alter the accessibility and transcription of DNA. Describe how environmental stimuli, such as ultraviolet light exposure, could modify gene expression.

38.

A scientist discovers a virus encoding a Protein X that degrades a subunit of the eIF4F complex. Knowing that this virus transcribes its own mRNAs in the cytoplasm of human cells, why would Protein X be an effective virulence factor?

39.

New drugs are being developed that decrease DNA methylation and prevent the removal of acetyl groups from histone proteins. Explain how these drugs could affect gene expression to help kill tumor cells.

40

10.
How can understanding the gene expression pattern in a cancer cell tell you something about that specific form of cancer?

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CHAPTER OVERVIEW

17: BIOTECHNOLOGY AND GENOMICS

17.1: Key Terms

17.2: Visual Connection Questions

17.3: Review Questions

17.4: Critical Thinking Questions

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17.1: KEY TERMS

antibiotic resistance
ability of an organism to be unaffected by an antibiotic's actions

biomarker
individual protein that is uniquely produced in a diseased state

biotechnology
use of biological agents for technological advancement

cDNA library
collection of cloned cDNA sequences

cellular cloning
production of identical cell populations by binary fission

chain termination method
method of DNA sequencing using labeled dideoxynucleotides to terminate DNA replication; it is also called the dideoxy method or the Sanger method

clone
exact replica

contig
larger sequence of DNA assembled from overlapping shorter sequences

cytogenetic mapping
technique that uses a microscope to create a map from stained chromosomes

deoxynucleotide
individual DNA monomer (single unit)

dideoxynucleotide
individual DNA monomer that is missing a hydroxyl group (–OH)

DNA microarray
method to detect gene expression by analyzing many DNA fragments that are fixed to a glass slide or a silicon chip to identify active genes and identify sequences

expressed sequence tag (EST)
short STS that is identified with cDNA

false negative
incorrect test result that should have been positive

foreign DNA
DNA that belongs to a different species or DNA that is artificially synthesized

gel electrophoresis
technique used to separate molecules on the basis of size using electric charge

gene targeting
method for altering the sequence of a specific gene by introducing the modified version on a vector

gene therapy

technique used to cure inheritable diseases by replacing mutant genes with good genes

genetic diagnosis
diagnosis of the potential for disease development by analyzing disease-causing genes

genetic engineering
alteration of the genetic makeup of an organism

genetic map
outline of genes and their location on a chromosome

genetic marker
gene or sequence on a chromosome with a known location that is associated with a specific trait

genetic recombination
DNA exchange between homologous chromosome pairs

genetic testing
process of testing for the presence of disease-causing genes

genetically modified organism (GMO)
organism whose genome has been artificially changed

genome annotation
process of attaching biological information to gene sequences

genome mapping
process of finding the location of genes on each chromosome

genomic library
collection of cloned DNA which represents all of the sequences and fragments from a genome

genomics
study of entire genomes including the complete set of genes, their nucleotide sequence and organization, and their interactions within a species and with other species

host DNA
DNA that is present in the genome of the organism of interest

linkage analysis
procedure that analyzes recombining genes to determine if they are linked

lysis buffer
solution to break the cell membrane and release cell contents

metabolome
complete set of metabolites which are related to an organism's genetic makeup

metabolomics
study of small molecule metabolites in an organism

metagenomics
study of multiple species' collective genomes that grow and interact in an environmental niche

microsatellite polymorphism
variation between individuals in the sequence and number of microsatellite DNA repeats

model organism

species that researchers study and use as a model to understand the biological processes in other species represented by the model organism

molecular cloning
cloning of DNA fragments

multiple cloning site (MCS)
site that multiple restriction endonucleases can recognize

next-generation sequencing
group of automated techniques for rapid DNA sequencing

Northern blotting
transfer of RNA from a gel to a nylon membrane

pharmacogenomics
study of drug interactions with the genome or proteome; also called toxicogenomics

physical map
representation of the physical distance between genes or genetic markers

polygenic
phenotypic characteristic caused by two or more genes

polymerase chain reaction (PCR)
technique to amplify DNA

probe
small DNA fragment to determine if the complementary sequence is present in a DNA sample

protease
enzyme that breaks down proteins

protein signature
set of uniquely expressed proteins in the diseased state

proteome
entire set of proteins that cell type produces

proteomics
study of proteomes' function

pure culture
growth of a single cell type in the laboratory

radiation hybrid mapping
information obtained by fragmenting the chromosome with x-rays

recombinant DNA
combining DNA fragments that molecular cloning generates that do not exist in nature; also a chimeric molecule

recombinant protein
a gene's protein product derived by molecular cloning

reproductive cloning
entire organism cloning

restriction endonuclease

enzyme that can recognize and cleave specific DNA sequences

restriction fragment length polymorphism (RFLP)
variation between individuals in the length of DNA fragments, which restriction endonucleases generate

reverse genetics
method of determining the gene's function by starting with the gene itself instead of starting with the gene product

reverse transcriptase PCR (RT-PCR)
PCR technique that involves converting RNA to DNA by reverse transcriptase

ribonuclease
enzyme that breaks down RNA

sequence mapping
mapping information obtained after DNA sequencing

shotgun sequencing
method used to sequence multiple DNA fragments to generate the sequence of a large piece of DNA

single nucleotide polymorphism (SNP)
variation between individuals in a single nucleotide

Southern blotting
DNA transfer from a gel to a nylon membrane

systems biology
study of whole biological systems (genomes and proteomes) based on interactions within the system

Ti plasmid
plasmid system derived from *Agrobacterium tumefaciens* that scientists have used to introduce foreign DNA into plant cells

transgenic
organism that receives DNA from a different species

variable number of tandem repeats (VNTRs)
variation in the number of tandem repeats between individuals in the population

whole-genome sequencing
process that determines an entire genome's DNA sequence

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17.2: VISUAL CONNECTION QUESTIONS

1.

Figure 17.7 You are working in a molecular biology lab and, unbeknownst to you, your lab partner left the foreign genomic DNA that you are planning to clone on the lab bench overnight instead of storing it in the freezer. As a result, it was degraded by nucleases, but still used in the experiment. The plasmid, on the other hand, is fine. What results would you expect from your molecular cloning experiment?

1. There will be no colonies on the bacterial plate.
2. There will be blue colonies only.
3. There will be blue and white colonies.
4. The will be white colonies only.

2.

Figure 17.8 Do you think Dolly was a Finn-Dorset or a Scottish Blackface sheep?

3.

Figure 17.15 In 2011, the United States Preventative Services Task Force recommended against using the PSA test to screen healthy people for prostate cancer. Their recommendation is based on evidence that screening does not reduce the risk of death from prostate cancer. Prostate cancer often develops very slowly and does not cause problems, while the cancer treatment can have severe side effects. The *PCA3* test is more accurate, but screening may still result in people who would not have been harmed by the cancer itself suffering side effects from treatment. What do you think? Should healthy people be screened for prostate cancer using the *PCA3* or PSA test? Should people in general be screened to find out if they have a genetic risk for cancer or other diseases?

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17.3: REVIEW QUESTIONS

4.

GMOs are created by _____.

1. generating genomic DNA fragments with restriction endonucleases
2. introducing recombinant DNA into an organism by any means
3. overexpressing proteins in *E. coli*
4. all of the above

5.

Gene therapy can be used to introduce foreign DNA into cells _____.

1. for molecular cloning
2. by PCR
3. of tissues to cure inheritable disease
4. all of the above

6.

Insulin produced by molecular cloning:

1. is of pig origin
2. is a recombinant protein
3. is made by the human pancreas
4. is recombinant DNA

7.

Bt toxin is considered to be _____.

1. a gene for modifying insect DNA
2. an organic insecticide produced by bacteria
3. useful for humans to fight against insects
4. a recombinant protein

8.

The Flavr Savr Tomato:

1. is a variety of vine-ripened tomato in the supermarket
2. was created to have better flavor and shelf-life
3. does not undergo soft rot
4. all of the above

9.

ESTs are _____.

1. generated after a cDNA library is made
2. unique sequences in the genome
3. useful for mapping using sequence information
4. all of the above

10.

Linkage analysis _____.

1. is used to create a physical map
2. is based on the natural recombination process
3. requires radiation hybrid mapping
4. involves breaking and rejoining of DNA artificially

11.

Genetic recombination occurs by which process?

1. independent assortment
2. crossing over

3. chromosome segregation
4. sister chromatids

12.

Individual genetic maps in a given species are:

1. genetically similar
2. genetically identical
3. genetically dissimilar
4. not useful in species analysis

13.

Information obtained by microscopic analysis of stained chromosomes is used in:

1. radiation hybrid mapping
2. sequence mapping
3. RFLP mapping
4. cytogenetic mapping

14.

The chain termination method of sequencing:

1. uses labeled ddNTPs
2. uses only dideoxynucleotides
3. uses only deoxynucleotides
4. uses labeled dNTPs

15.

Whole-genome sequencing can be used for advances in:

1. the medical field
2. agriculture
3. biofuels
4. all of the above

16.

Sequencing an individual person’s genome

1. is currently possible
2. could lead to legal issues regarding discrimination and privacy
3. could help make informed choices about medical treatment
4. all of the above

17.

What is the most challenging issue facing genome sequencing?

1. the inability to develop fast and accurate sequencing techniques
2. the ethics of using information from genomes at the individual level
3. the availability and stability of DNA
4. all of the above

18.

Genomics can be used in agriculture to:

1. generate new hybrid strains
2. improve disease resistance
3. improve yield
4. all of the above

19.

Genomics can be used on a personal level to:

1. decrease transplant rejection
2. predict genetic diseases that a person may have inherited

3. determine the risks of genetic diseases for an individual’s children
4. all of the above

20.

What is a biomarker?

1. the color coding of different genes
2. a protein that is uniquely produced in a diseased state
3. a molecule in the genome or proteome
4. a marker that is genetically inherited

21.

A protein signature is:

1. the path followed by a protein after it is synthesized in the nucleus
2. the path followed by a protein in the cytoplasm
3. a protein expressed on the cell surface
4. a unique set of proteins present in a diseased state

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17.4: CRITICAL THINKING QUESTIONS

22.

Describe the process of Southern blotting.

23.

A researcher wants to study cancer cells from a patient with breast cancer. Is cloning the cancer cells an option?

24.

How would a scientist introduce a gene for herbicide resistance into a plant?

25.

If you had a chance to get your genome sequenced, what are some questions you might be able to have answered about yourself?

26.

Why is so much effort being poured into genome mapping applications?

27.

How could a genetic map of the human genome help find a cure for cancer?

28.

Explain why metagenomics is probably the most revolutionary application of genomics.

29.

How can genomics be used to predict disease risk and treatment options?

30.

How has proteomics been used in cancer detection and treatment?

31.

What is personalized medicine?

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CHAPTER OVERVIEW

18: EVOLUTION AND THE ORIGIN OF SPECIES

The theory of evolution is the unifying theory of biology, meaning it is the framework within which biologists ask questions about the living world. Its power is that it provides direction for predictions about living things that are borne out in experiment after experiment. The Ukrainian-born American geneticist Theodosius Dobzhansky famously wrote that “nothing makes sense in biology except in the light of evolution." He meant that the tenet that all life has evolved and diversified from a common ancestor is the foundation from which we approach all questions in biology.

18.1: Key Terms

18.2: Visual Connection Questions

18.3: Review Questions

18.4: Critical Thinking Questions

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18.1: KEY TERMS

adaptation
heritable trait or behavior in an organism that aids in its survival and reproduction in its present environment

adaptive radiation
speciation when one species radiates to form several other species

allopatric speciation
speciation that occurs via geographic separation

allopolyploid
polyploidy formed between two related, but separate species

aneuploidy
condition of a cell having an extra chromosome or missing a chromosome for its species

autopolyploid
polyploidy formed within a single species

behavioral isolation
type of reproductive isolation that occurs when a specific behavior or lack of one prevents reproduction from taking place

convergent evolution
process by which groups of organisms independently evolve to similar forms

dispersal
allopatric speciation that occurs when a few members of a species move to a new geographical area

divergent evolution
process by which groups of organisms evolve in diverse directions from a common point

gametic barrier
prezygotic barrier occurring when closely related individuals of different species mate, but differences in their gamete cells (eggs and sperm) prevent fertilization from taking place

gradual speciation model
model that shows how species diverge gradually over time in small steps

habitat isolation
reproductive isolation resulting when species' populations move or are moved to a new habitat, taking up residence in a place that no longer overlaps with the same species' other populations

homologous structures
parallel structures in diverse organisms that have a common ancestor

hybrid
offspring of two closely related individuals, not of the same species

hybrid zone
area where two closely related species continue to interact and reproduce, forming hybrids

natural selection
reproduction of individuals with favorable genetic traits that survive environmental change because of those traits, leading to evolutionary change

postzygotic barrier

reproductive isolation mechanism that occurs after zygote formation

prezygotic barrier
reproductive isolation mechanism that occurs before zygote formation

punctuated equilibrium
model for rapid speciation that can occur when an event causes a small portion of a population to be cut off from the rest of the population

reinforcement
continued speciation divergence between two related species due to low fitness of hybrids between them

reproductive isolation
situation that occurs when a species is reproductively independent from other species; behavior, location, or reproductive barriers may cause this to happen

speciation
formation of a new species

species
group of populations that interbreed and produce fertile offspring

sympatric speciation
speciation that occurs in the same geographic space

temporal isolation
differences in breeding schedules that can act as a form of prezygotic barrier leading to reproductive isolation

variation
genetic differences among individuals in a population

vestigial structure
physical structure present in an organism but that has no apparent function and appears to be from a functional structure in a distant ancestor

vicariance
allopatric speciation that occurs when something in the environment separates organisms of the same species into separate groups

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18.2: VISUAL CONNECTION QUESTIONS

1.

Figure 18.14 Which is most likely to survive, offspring with $2n+1$ chromosomes or offspring with $2n-1$ chromosomes?

2.

Figure 18.22 If two species eat a different diet but one of the food sources is eliminated and both species are forced to eat the same foods, what change in the hybrid zone is most likely to occur?

3.

Figure 18.23 Which of the following statements is false?

1. Punctuated equilibrium is most likely to occur in a small population that experiences a rapid change in its environment.
2. Punctuated equilibrium is most likely to occur in a large population that lives in a stable climate.
3. Gradual speciation is most likely to occur in species that live in a stable climate.
4. Gradual speciation and punctuated equilibrium both result in the evolution of new species.

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18.3: REVIEW QUESTIONS

4.

Which scientific concept did Charles Darwin and Alfred Wallace independently discover?

1. mutation
2. natural selection
3. overbreeding
4. sexual reproduction

5.

Which of the following situations will lead to natural selection?

1. The seeds of two plants land near each other and one grows larger than the other.
2. Two types of fish eat the same kind of food, and one is better able to gather food than the other.
3. Male lions compete for the right to mate with females, with only one possible winner.
4. all of the above

6.

Which description is an example of a phenotype?

1. A certain duck has a blue beak.
2. A mutation occurred to a flower.
3. Most cheetahs live solitary lives.
4. both a and c

7.

Which situation is most likely an example of convergent evolution?

1. Squid and humans have eyes similar in structure.
2. Worms and snakes both move without legs.
3. Some bats and birds have wings that allow them to fly.
4. all of the above

8.

Which situation would most likely lead to allopatric speciation?

1. Flood causes the formation of a new lake.
2. A storm causes several large trees to fall down.
3. A mutation causes a new trait to develop.
4. An injury causes an organism to seek out a new food source.

9.

What is the main difference between dispersal and vicariance?

1. One leads to allopatric speciation, whereas the other leads to sympatric speciation.
2. One involves the movement of the organism, and the other involves a change in the environment.
3. One depends on a genetic mutation occurring, and the other does not.
4. One involves closely related organisms, and the other involves only individuals of the same species.

10.

Which variable increases the likelihood of allopatric speciation taking place more quickly?

1. lower rate of mutation
2. longer distance between divided groups
3. increased instances of hybrid formation
4. equivalent numbers of individuals in each population

11.

What is the main difference between autopolyploid and allopolyploid?

1. the number of chromosomes
2. the functionality of the chromosomes

3. the source of the extra chromosomes
4. the number of mutations in the extra chromosomes

12.

Which reproductive combination produces hybrids?

1. when individuals of the same species in different geographical areas reproduce
2. when any two individuals sharing the same habitat reproduce
3. when members of closely related species reproduce
4. when offspring of the same parents reproduce

13.

Which condition is the basis for a species to be reproductively isolated from other members?

1. It does not share its habitat with related species.
2. It does not exist out of a single habitat.
3. It does not exchange genetic information with other species.
4. It does not undergo evolutionary changes for a significant period of time.

14.

Which situation is *not* an example of a prezygotic barrier?

1. Two species of turtles breed at different times of the year.
2. Two species of flowers attract different pollinators.
3. Two species of birds display different mating dances.
4. Two species of insects produce infertile offspring.

15.

Which term is used to describe the continued divergence of species based on the low fitness of hybrid offspring?

1. reinforcement
2. fusion
3. stability
4. punctuated equilibrium

16.

Which components of speciation would be least likely to be a part of punctuated equilibrium?

1. a division of populations
2. a change in environmental conditions
3. ongoing gene flow among all individuals
4. a large number of mutations taking place at once

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18.4: CRITICAL THINKING QUESTIONS

17.

If a person scatters a handful of garden pea plant seeds in one area, how would natural selection work in this situation?

18.

Why do scientists consider vestigial structures evidence for evolution?

19.

How does the scientific meaning of “theory” differ from the common vernacular meaning?

20.

Explain why the statement that a monkey is more evolved than a mouse is incorrect.

21.

Why do island chains provide ideal conditions for adaptive radiation to occur?

22.

Two species of fish had recently undergone sympatric speciation. The males of each species had a different coloring through which the females could identify and choose a partner from her own species. After some time, pollution made the lake so cloudy that it was hard for females to distinguish colors. What might take place in this situation?

23.

Why can polyploidy individuals lead to speciation fairly quickly?

24.

What do both rate of speciation models have in common?

25.

Describe a situation where hybrid reproduction would cause two species to fuse into one.

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CHAPTER OVERVIEW

19: THE EVOLUTION OF POPULATIONS

Natural selection is one of the most dominant evolutionary forces. Natural selection acts to promote traits and behaviors that increase an organism's chances of survival and reproduction, while eliminating those traits and behaviors that are to the organism's detriment. But natural selection can only, as its name implies, select—it cannot create. The introduction of novel traits and behaviors falls on the shoulders of another evolutionary force—mutation. Mutation and other sources of variation among individuals, as well as the evolutionary forces that act upon them, alter populations and species. This combination of processes has led to the world of life we see today.

19.1: Key Terms

19.2: Visual Connection Questions

19.3: Review Questions

19.4: Critical Thinking Questions

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19.1: KEY TERMS

adaptive evolution
increase in frequency of beneficial alleles and decrease in deleterious alleles due to selection

allele frequency
(also, gene frequency) rate at which a specific allele appears within a population

assortative mating
when individuals tend to mate with those who are phenotypically similar to themselves

bottleneck effect
magnification of genetic drift as a result of natural events or catastrophes

cline
gradual geographic variation across an ecological gradient

directional selection
selection that favors phenotypes at one end of the spectrum of existing variation

diversifying selection
selection that favors two or more distinct phenotypes

evolutionary fitness
(also, Darwinian fitness) individual's ability to survive and reproduce

founder effect
event that initiates an allele frequency change in part of the population, which is not typical of the original population

frequency-dependent selection
selection that favors phenotypes that are either common (positive frequency-dependent selection) or rare (negative frequency-dependent selection)

gene flow
flow of alleles in and out of a population due to the individual or gamete migration

gene pool
all the alleles that the individuals in the population carry

genetic drift
effect of chance on a population's gene pool

genetic structure
distribution of the different possible genotypes in a population

genetic variance
diversity of alleles and genotypes in a population

geographical variation
differences in the phenotypic variation between populations that are separated geographically

good genes hypothesis
theory of sexual selection that argues individuals develop impressive ornaments to show off their efficient metabolism or ability to fight disease

handicap principle

theory of sexual selection that argues only the fittest individuals can afford costly traits

heritability
fraction of population variation that can be attributed to its genetic variance

honest signal
trait that gives a truthful impression of an individual's fitness

inbreeding
mating of closely related individuals

inbreeding depression
increase in abnormalities and disease in inbreeding populations

macroevolution
broader scale evolutionary changes that scientists see over paleontological time

microevolution
changes in a population's genetic structure

modern synthesis
overarching evolutionary paradigm that took shape by the 1940s and scientists generally accept today

nonrandom mating
changes in a population's gene pool due to mate choice or other forces that cause individuals to mate with certain phenotypes more than others

population genetics
study of how selective forces change the allele frequencies in a population over time

population variation
distribution of phenotypes in a population

relative fitness
individual's ability to survive and reproduce relative to the rest of the population

selective pressure
environmental factor that causes one phenotype to be better than another

sexual dimorphism
phenotypic difference between a population's males and females

stabilizing selection
selection that favors average phenotypes

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19.2: VISUAL CONNECTION QUESTIONS

1.

Figure 19.2 In plants, violet flower color (V) is dominant over white (v). If p = .8 and q = 0.2 in a population of 500 plants, how many individuals would you expect to be homozygous dominant (VV), heterozygous (Vv), and homozygous recessive (vv)? How many plants would you expect to have violet flowers, and how many would have white flowers?

2.

Figure 19.4 Do you think genetic drift would happen more quickly on an island or on the mainland?

3.

Figure 19.8 In recent years, factories have become cleaner, and less soot is released into the environment. What impact do you think this has had on the distribution of moth color in the population?

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19.3: REVIEW QUESTIONS

4.

What is the difference between micro- and macroevolution?

1. Microevolution describes the evolution of small organisms, such as insects, while macroevolution describes the evolution of large organisms, like people and elephants.
2. Microevolution describes the evolution of microscopic entities, such as molecules and proteins, while macroevolution describes the evolution of whole organisms.
3. Microevolution describes the evolution of organisms in populations, while macroevolution describes the evolution of species over long periods of time.
4. Microevolution describes the evolution of organisms over their lifetimes, while macroevolution describes the evolution of organisms over multiple generations.

5.

Population genetics is the study of:

1. how selective forces change the allele frequencies in a population over time
2. the genetic basis of population-wide traits
3. whether traits have a genetic basis
4. the degree of inbreeding in a population

6.

Which of the following populations is not in Hardy-Weinberg equilibrium?

1. a population with 12 homozygous recessive individuals (yy), 8 homozygous dominant individuals (YY), and 4 heterozygous individuals (Yy)
2. a population in which the allele frequencies do not change over time
3. $p^2 + 2pq + q^2 = 1$
4. a population undergoing natural selection

7.

One of the original Amish colonies rose from a ship of colonists that came from Europe. The ship's captain, who had polydactyly, a rare dominant trait, was one of the original colonists. Today, we see a much higher frequency of polydactyly in the Amish population. This is an example of:

1. natural selection
2. genetic drift
3. founder effect
4. b and c

8.

When male lions reach sexual maturity, they leave their group in search of a new pride. This can alter the allele frequencies of the population through which of the following mechanisms?

1. natural selection
2. genetic drift
3. gene flow
4. random mating

9.

Which of the following evolutionary forces can introduce new genetic variation into a population?

1. natural selection and genetic drift
2. mutation and gene flow
3. natural selection and nonrandom mating
4. mutation and genetic drift

10.

What is assortative mating?

1. when individuals mate with those who are similar to themselves

2. when individuals mate with those who are dissimilar to themselves
3. when individuals mate with those who are the most fit in the population
4. when individuals mate with those who are least fit in the population

11.

When closely related individuals mate with each other, or inbreed, the offspring are often not as fit as the offspring of two unrelated individuals. Why?

1. Close relatives are genetically incompatible.
2. The DNA of close relatives reacts negatively in the offspring.
3. Inbreeding can bring together rare, deleterious mutations that lead to harmful phenotypes.
4. Inbreeding causes normally silent alleles to be expressed.

12.

What is a cline?

1. the slope of a mountain where a population lives
2. the degree to which a mutation helps an individual survive
3. the number of individuals in the population
4. gradual geographic variation across an ecological gradient

13.

Which type of selection results in greater genetic variance in a population?

1. stabilizing selection
2. directional selection
3. diversifying selection
4. positive frequency-dependent selection

14.

When males and females of a population look or act differently, it is referred to as _____.

1. sexual dimorphism
2. sexual selection
3. diversifying selection
4. a cline

15.

The good genes hypothesis is a theory that explains what?

1. why more fit individuals are more likely to have more offspring
2. why alleles that confer beneficial traits or behaviors are selected for by natural selection
3. why some deleterious mutations are maintained in the population
4. why individuals of one sex develop impressive ornamental traits

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19.4: CRITICAL THINKING QUESTIONS

16.

Solve for the genetic structure of a population with 12 homozygous recessive individuals (yy), 8 homozygous dominant individuals (YY), and 4 heterozygous individuals (Yy).

17.

Explain the Hardy-Weinberg principle of equilibrium theory.

18.

Imagine you are trying to test whether a population of flowers is undergoing evolution. You suspect there is selection pressure on the color of the flower: bees seem to cluster around the red flowers more often than the blue flowers. In a separate experiment, you discover blue flower color is dominant to red flower color. In a field, you count 600 blue flowers and 200 red flowers. What would you expect the genetic structure of the flowers to be?

19.

Describe a situation in which a population would undergo the bottleneck effect and explain what impact that would have on the population's gene pool.

20.

Describe natural selection and give an example of natural selection at work in a population.

21.

Explain what a cline is and provide examples.

22.

Give an example of a trait that may have evolved as a result of the handicap principle and explain your reasoning.

23.

List the ways in which evolution can affect population variation and describe how they influence allele frequencies.

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CHAPTER OVERVIEW

20: PHYLOGENIES AND THE HISTORY OF LIFE

By following pathways of similarities and changes—both visible and genetic—scientists seek to map the evolutionary past of how life developed from single-celled organisms to the tremendous collection of creatures that have germinated, crawled, floated, swam, flown, and walked on this planet.

20.1: Key Terms

20.2: Visual Connection Questions

20.3: Review Questions

20.4: Critical Thinking Questions

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20.1: KEY TERMS

analogy
(also, homoplasy) characteristic that is similar between organisms by convergent evolution, not due to the same evolutionary path

basal taxon
branch on a phylogenetic tree that has not diverged significantly from the root ancestor

binomial nomenclature
system of two-part scientific names for an organism, which includes genus and species names

branch point
node on a phylogenetic tree where a single lineage splits into distinct new ones

cladistics
system to organize homologous traits to describe phylogenies

class
division of phylum in the taxonomic classification system

eukaryote-first hypothesis
proposal that prokaryotes evolved from eukaryotes

family
division of order in the taxonomic classification system

gene transfer agent (GTA)
bacteriophage-like particle that transfers random genomic segments from one species of prokaryote to another

genome fusion
fusion of two prokaryotic genomes, presumably by endosymbiosis

genus
division of family in the taxonomic classification system; the first part of the binomial scientific name

homology
similarity in characteristics resulting from a shared ancestry

horizontal gene transfer (HGT)
(also, lateral gene transfer) transfer of genes between unrelated species

kingdom
domain division in the taxonomic classification system

maximum parsimony
applying the simplest, most obvious way with the least number of steps

mitochondria-first hypothesis
proposal that prokaryotes acquired a mitochondrion first, followed by nuclear development

molecular systematics
technique using molecular evidence to identify phylogenetic relationships

monophyletic group
(also, clade) organisms that share a single ancestor

nucleus-first hypothesis

proposal that prokaryotes acquired a nucleus first, and then the mitochondrion

order
class division in the taxonomic classification system

phylogenetic tree
diagram that reflects the evolutionary relationships among organisms or groups of organisms

phylogeny
evolutionary history and relationship of an organism or group of organisms

phylum
(plural: phyla) kingdom division in the taxonomic classification system

polytomy
branch on a phylogenetic tree with more than two groups or taxa

ring of life
phylogenetic model where all three domains of life evolved from a pool of primitive prokaryotes

rooted
single ancestral lineage on a phylogenetic tree to which all organisms represented in the diagram relate

shared ancestral character
describes a characteristic on a phylogenetic tree that all organisms on the tree share

shared derived character
describes a characteristic on a phylogenetic tree that only a certain clade of organisms share

sister taxa
two lineages that diverged from the same branch point

systematics
field of organizing and classifying organisms based on evolutionary relationships

taxon
(plural: taxa) single level in the taxonomic classification system

taxonomy
science of classifying organisms

web of life
phylogenetic model that attempts to incorporate the effects of horizontal gene transfer on evolution

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20.2: VISUAL CONNECTION QUESTIONS

1.

Figure 20.6 At what levels are cats and dogs part of the same group?

2.

Figure 20.10 Which animals in this figure belong to a clade that includes animals with hair? Which evolved first, hair or the amniotic egg?

3.

Figure 20.11 What is the largest clade in this diagram?

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20.3: REVIEW QUESTIONS

4.

What is used to determine phylogeny?

1. mutations
2. DNA
3. evolutionary history
4. organisms on earth

5.

What do scientists in the field of systematics accomplish?

1. discover new fossil sites
2. organize and classify organisms
3. name new species
4. communicate among field biologists

6.

Which statement about the taxonomic classification system is correct?

1. There are more domains than kingdoms.
2. Kingdoms are the top category of classification.
3. Classes are divisions of orders.
4. Subspecies are the most specific category of classification.

7.

On a phylogenetic tree, which term refers to lineages that diverged from the same place?

1. sister taxa
2. basal taxa
3. rooted taxa
4. dichotomous taxa

8.

Which statement about analogies is correct?

1. They occur only as errors.
2. They are synonymous with homologous traits.
3. They are derived by similar environmental constraints.
4. They are a form of mutation.

9.

What do scientists use to apply cladistics?

1. homologous traits
2. homoplasies
3. analogous traits
4. monophyletic groups

10.

What is true about organisms that are a part of the same clade?

1. They all share the same basic characteristics.
2. They evolved from a shared ancestor.
3. They usually fall into the same classification taxa.
4. They have identical phylogenies.

11.

Why do scientists apply the concept of maximum parsimony?

1. to decipher accurate phylogenies
2. to eliminate analogous traits

3. to identify mutations in DNA codes
4. to locate homoplasies

12.

The transfer of genes by a mechanism not involving reproduction is called:

1. meiosis
2. web of life
3. horizontal gene transfer
4. gene fusion

13.

Particles that transfer genetic material from one species to another, especially in marine prokaryotes:

1. horizontal gene transfer
2. lateral gene transfer
3. genome fusion device
4. gene transfer agents

14.

What does the trunk of the classic phylogenetic tree represent?

1. single common ancestor
2. pool of ancestral organisms
3. new species
4. old species

15.

Which phylogenetic model proposes that all three domains of life evolved from a pool of primitive prokaryotes?

1. tree of life
2. web of life
3. ring of life
4. network model

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20.4: CRITICAL THINKING QUESTIONS

16.

How does a phylogenetic tree relate to the passing of time?

17.

Some organisms that appear very closely related on a phylogenetic tree may not actually be closely related. Why is this?

18.

List the different levels of the taxonomic classification system.

19.

Dolphins and fish have similar body shapes. Is this feature more likely a homologous or analogous trait?

20.

Why is it so important for scientists to distinguish between homologous and analogous characteristics before building phylogenetic trees?

21.

Describe maximum parsimony.

22.

Compare three different ways that eukaryotic cells may have evolved.

23.

Describe how aphids acquired the ability to change color.

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CHAPTER OVERVIEW

21: VIRUSES

Viruses are acellular, parasitic entities that are not classified within any kingdom. Viruses are not cells and cannot divide. They infect a host cell and use the host's replication processes to produce identical progeny virus particles. Viruses infect organisms as diverse as bacteria, plants, and animals and exist in a netherworld between a living organism and a nonliving entity. Living things grow, metabolize, and reproduce. Viruses replicate, but to do so, they are entirely dependent on their host cells.

21.1: Key Terms

21.2: Visual Connection Questions

21.3: Review Questions

21.4: Critical Thinking Questions

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21.1: KEY TERMS

acellular
lacking cells

acute disease
disease where the symptoms rise and fall within a short period of time

asymptomatic disease
disease where there are no symptoms and the individual is unaware of being infected unless lab tests are performed

attenuation
weakening of a virus during vaccine development

AZT
anti-HIV drug that inhibits the viral enzyme reverse transcriptase

back mutation
when a live virus vaccine reverts back to it disease-causing phenotype

bacteriophage
virus that infects bacteria

budding
method of exit from the cell used in certain animal viruses, where virions leave the cell individually by capturing a piece of the host plasma membrane

capsid
protein coating of the viral core

capsomere
protein subunit that makes up the capsid

cell necrosis
cell death

chronic infection
describes when the virus persists in the body for a long period of time

cytopathic
causing cell damage

envelope
lipid bilayer that encircles some viruses

fusion
method of entry by some enveloped viruses, where the viral envelope fuses with the plasma membrane of the host cell

gall
appearance of a plant tumor

gene therapy
treatment of genetic disease by adding genes, using viruses to carry the new genes inside the cell

group I virus
virus with a dsDNA genome

group II virus
virus with an ssDNA genome

group III virus
virus with a dsRNA genome

group IV virus
virus with an ssRNA genome with positive polarity

group V virus
virus with an ssRNA genome with negative polarity

group VI virus
virus with an ssRNA genome converted into dsDNA by reverse transcriptase

group VII virus
virus with a single-stranded mRNA converted into dsDNA for genome replication

horizontal transmission
transmission of a disease between unrelated individuals

hyperplasia
abnormally high cell growth and division

hypoplasia
abnormally low cell growth and division

intermittent symptom
symptom that occurs periodically

latency
virus that remains in the body for a long period of time but only causes intermittent symptoms

lysis
bursting of a cell

lysogenic cycle
type of virus replication in which the viral genome is incorporated into the genome of the host cell

lytic cycle
type of virus replication in which virions are released through lysis, or bursting, of the cell

matrix protein
envelope protein that stabilizes the envelope and often plays a role in the assembly of progeny virions

negative polarity
ssRNA viruses with genomes complementary to their mRNA

oncogenic virus
virus that has the ability to cause cancer

oncolytic virus
virus engineered to specifically infect and kill cancer cells

pathogen
agent with the ability to cause disease

permissive
cell type that is able to support productive replication of a virus

phage therapy
treatment of bacterial diseases using bacteriophages specific to a particular bacterium

positive polarity
ssRNA virus with a genome that contains the same base sequences and codons found in their mRNA

prion
infectious particle that consists of proteins that replicate without DNA or RNA

productive
viral infection that leads to the production of new virions

prophage
phage DNA that is incorporated into the host cell genome

PrP^{c}
normal prion protein

PrP^{sc}
infectious form of a prion protein

replicative intermediate
dsRNA intermediate made in the process of copying genomic RNA

reverse transcriptase
enzyme found in Baltimore groups VI and VII that converts single-stranded RNA into double-stranded DNA

vaccine
weakened solution of virus components, viruses, or other agents that produce an immune response

vertical transmission
transmission of disease from parent to offspring

viral receptor
glycoprotein used to attach a virus to host cells via molecules on the cell

virion
individual virus particle outside a host cell

viroid
plant pathogen that produces only a single, specific RNA

virus core
contains the virus genome

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21.2: VISUAL CONNECTION QUESTIONS

1.

Figure 21.5 Which of the following statements about virus structure is true?

1. All viruses are encased in a viral membrane.
2. The capsomere is made up of small protein subunits called capsids.
3. DNA is the genetic material in all viruses.
4. Glycoproteins help the virus attach to the host cell.

2.

Figure 21.8 Influenza virus is packaged in a viral envelope that fuses with the plasma membrane. This way, the virus can exit the host cell without killing it. What advantage does the virus gain by keeping the host cell alive?

3.

Figure 21.10 Which of the following statements is false?

1. In the lytic cycle, new phages are produced and released into the environment.
2. In the lysogenic cycle, phage DNA is incorporated into the host genome.
3. An environmental stressor can cause the phage to initiate the lysogenic cycle.
4. Cell lysis only occurs in the lytic cycle.

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21.3: REVIEW QUESTIONS

4.

Which statement is true?

1. A virion contains DNA and RNA.
2. Viruses are acellular.
3. Viruses replicate outside of the cell.
4. Most viruses are easily visualized with a light microscope.

5.

The viral _____ play(s) a role in attaching a virion to the host cell.

1. core
2. capsid
3. envelope
4. both b and c

6.

Viruses_____.

1. all have a round shape
2. cannot have a long shape
3. do not maintain any shape
4. vary in shape

7.

The observation that the bacteria genus *Chlamydia* contains species that can only survive as intracellular parasites supports which viral origin hypothesis?

1. Progressive
2. Regressive
3. Self-replicating
4. Virus-first

8.

A scientist discovers a new virus with a linear, RNA genome surrounded by a helical capsid. The virus is most likely a member of which family based on structure classification?

1. Rabies virus
2. Herpesviruses
3. Retroviruses
4. Influenza viruses

9.

Which statement is *not* true of viral replication?

1. A lysogenic cycle kills the host cell.
2. There are six basic steps in the viral replication cycle.
3. Viral replication does not affect host cell function.
4. Newly released virions can infect adjacent cells.

10.

Which statement is true of viral replication?

1. In the process of apoptosis, the cell survives.
2. During attachment, the virus attaches at specific sites on the cell surface.
3. The viral capsid helps the host cell produce more copies of the viral genome.
4. mRNA works outside of the host cell to produce enzymes and proteins.

11.

Which statement is true of reverse transcriptase?

1. It is a nucleic acid

1. It is a nucleic acid.
2. It infects cells.
3. It transcribes RNA to make DNA.
4. It is a lipid.

12.

Oncogenic virus cores can be_____.

1. RNA
2. DNA
3. neither RNA nor DNA
4. either RNA or DNA

13.

Which is true of DNA viruses?

1. They use the host cell's machinery to produce new copies of their genome.
2. They all have envelopes.
3. They are the only kind of viruses that can cause cancer.
4. They are not important plant pathogens.

14.

A bacteriophage can infect _____.

1. the lungs
2. viruses
3. prions
4. bacteria

15.

People with the CCR5Δ32 mutation of a T-cell surface protein can be exposed to some strains of HIV-1 without becoming sick. What step of the virus life cycle is likely to be inhibited with this mutation?

1. Release
2. Reverse transcription
3. Uncoating
4. Attachment

16.

An apple grower notices that several of his apple trees with fungi growing on their trunks have developed necrotic ring spots, while other trees in the orchard that lack fungi appear healthy. What is the most likely conclusion the farmer can make about the virus infecting his apple trees?

1. The apple trees were infected by horizontal transmission.
2. The fungi carry disease.
3. The fungi attract disease-carrying insects.
4. The apple trees were infected by vertical transmission.

17.

Which of the following is NOT used to treat active viral disease?

1. Vaccines
2. Antiviral drugs
3. Antibiotics
4. Phage therapy

18.

Vaccines_____.

1. are similar to viroids
2. are only needed once
3. kill viruses
4. stimulate an immune response

19.

A patient presents at the clinic with an acute viral infection. Assays that analyze the viral life cycle classify the virus into Group V with a segmented genome. Which virus is the most likely diagnosis for the patient?

1. Rabies virus
2. Picornavirus
3. HIV-1
4. Influenza A virus

20.

Which of the following is not associated with prions?

1. Replicating shapes
2. Mad cow disease
3. DNA
4. Toxic proteins

21.

Which statement is true of viroids?

1. They are single-stranded RNA particles.
2. They reproduce only outside of the cell.
3. They produce proteins.
4. They affect both plants and animals.

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21.4: CRITICAL THINKING QUESTIONS

22.

The first electron micrograph of a virus (tobacco mosaic virus) was produced in 1939. Before that time, how did scientists know that viruses existed if they could not see them? (Hint: Early scientists called viruses “filterable agents.”)

23.

Varicella-zoster virus is a double-stranded DNA virus that causes chickenpox. How does its genome structure provide an evolutionary advantage over a single-stranded DNA virus?

24.

Classify the Rabies virus (a rhabdovirus family member) and HIV-1 with both the Baltimore and genomic structure systems. Compare your results. What conclusions can be made about these two different methods?

25.

Why can’t dogs catch the measles?

26.

One of the first and most important targets for drugs to fight infection with HIV (a retrovirus) is the reverse transcriptase enzyme. Why?

27.

In this section, you were introduced to different types of viruses and viral diseases. Briefly discuss the most interesting or surprising thing you learned about viruses.

28.

Although plant viruses cannot infect humans, what are some of the ways in which they affect humans?

29.

A bacteriophage with a lytic life cycle develops a mutation that allows it to now also go through the lysogenic cycle. How would this provide an evolutionary advantage over the other bacteriophages that can only spread through lytic cycles?

30.

Why is immunization after being bitten by a rabid animal so effective and why aren’t people vaccinated for rabies like dogs and cats are?

31.

The vaccine Gardasil that targets human papilloma virus (HPV), the etiological agent of genital warts, was developed after the anti-HPV medication podofilox. Why would doctors still want a vaccine created after anti-viral medications were available?

32.

Prions are responsible for variant Creutzfeldt-Jakob Disease, which has resulted in over 100 human deaths in Great Britain during the last 10 years. How do humans contract this disease?

33.

How are viroids like viruses?

34.

A botanist notices that a tomato plant looks diseased. How could the botanist confirm that the agent causing disease is a viroid, and not a virus?

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CHAPTER OVERVIEW

22: PROKARYOTES - BACTERIA AND ARCHAEA

22.1: Key Terms

22.2: Visual Connection Questions

22.3: Review Questions

22.4: Critical Thinking Questions

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22.1: KEY TERMS

acidophile
organism with optimal growth pH of three or below

alkaliphile
organism with optimal growth pH of nine or above

ammonification
process by which ammonia is released during the decomposition of nitrogen-containing organic compounds

anaerobic
refers to organisms that grow without oxygen

anoxic
without oxygen

antibiotic
biological substance that, in low concentration, is antagonistic to the growth of prokaryotes

biofilm
microbial community that is held together by a gummy-textured matrix

biological nitrogen fixation
conversion of atmospheric nitrogen into ammonia exclusively carried out by prokaryotes

bioremediation
use of microbial metabolism to remove pollutants

biotechnology
any technological application that uses living organisms, biological systems, or their derivatives to produce or modify other products

Black Death
devastating pandemic that is believed to have been an outbreak of bubonic plague caused by the bacterium *Yersinia pestis*

botulism
disease produced by the toxin of the anaerobic bacterium *Clostridium botulinum*

CA-MRSA
MRSA acquired in the community rather than in a hospital

capsule
external structure that enables a prokaryote to attach to surfaces and protects it from dehydration

chemotroph
organism that obtains energy from chemical compounds

conjugation
process by which prokaryotes move DNA from one individual to another using a pilus

cyanobacteria
bacteria that evolved from early phototrophs and oxygenated the atmosphere; also known as blue-green algae

decomposer
organism that carries out the decomposition of dead organisms

denitrification

transformation of nitrate from soil to gaseous nitrogen compounds such as N_2O, NO, and N_2

emerging disease
disease making an initial appearance in a population or that is increasing in incidence or geographic range

endemic disease
disease that is constantly present, usually at low incidence, in a population

epidemic
disease that occurs in an unusually high number of individuals in a population at the same time

extremophile
organism that grows under extreme or harsh conditions

foodborne disease
any illness resulting from the consumption of contaminated food, or of the pathogenic bacteria, viruses, or other parasites that contaminate food

Gram negative
bacterium whose cell wall contains little peptidoglycan but has an outer membrane

Gram positive
bacterium that contains mainly peptidoglycan in its cell walls

halophile
organism that require a salt concentration of at least 0.2 M

hydrothermal vent
fissure in Earth's surface that releases geothermally heated water

hyperthermophile
organism that grows at temperatures between 80–122 °C

microbial mat
multi-layered sheet of prokaryotes that may include bacteria and archaea

MRSA
(methicillin-resistant *Staphylococcus aureus*) very dangerous *Staphylococcus aureus* strain resistant to multiple antibiotics

nitrification
conversion of ammonium into nitrite and nitrate in soils

nitrogen fixation
process by which gaseous nitrogen is transformed, or "fixed" into more readily available forms such as ammonia

nodule
novel structure on the roots of certain plants (legumes) that results from the symbiotic interaction between the plant and soil bacteria, and is the site of nitrogen fixation

nutrient
essential substances for growth, such as carbon and nitrogen

osmophile
organism that grows in a high sugar concentration

pandemic
widespread, usually worldwide, epidemic disease

peptidoglycan
material composed of polysaccharide chains cross-linked to unusual peptides

phototroph
organism that is able to make its own food by converting solar energy to chemical energy

pilus
surface appendage of some prokaryotes used for attachment to surfaces including other prokaryotes

pseudopeptidoglycan
component of archaea cell walls that is similar to peptidoglycan in morphology but contains different sugars

psychrophile
organism that grows at temperatures of -15 °C or lower

radioresistant
organism that grows in high levels of radiation

resuscitation
process by which prokaryotes that are in the VBNC state return to viability

S-layer
surface-layer protein present on the outside of cell walls of archaea and bacteria

serotype
strain of bacterium that carries a set of similar antigens on its cell surface, often many in a bacterial species

stromatolite
layered sedimentary structure formed by precipitation of minerals by prokaryotes in microbial mats

teichoic acid
polymer associated with the cell wall of Gram-positive bacteria

thermophile
organism that lives at temperatures between 60–80 °C

transduction
process by which a bacteriophage moves DNA from one prokaryote to another

transformation
process by which a prokaryote takes in DNA found in its environment that is shed by other prokaryotes

viable-but-non-culturable (VBNC) state
survival mechanism of bacteria facing environmental stress conditions

zoonosis
disease that primarily infects animals that is transmitted to humans

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22.2: VISUAL CONNECTION QUESTIONS

1.

Figure 22.8 Compared to free-floating bacteria, bacteria in biofilms often show increased resistance to antibiotics and detergents. Why do you think this might be the case?

2.

Figure 22.16 Which of the following statements is true?

1. Gram-positive bacteria have a single cell wall anchored to the cell membrane by lipoteichoic acid.
2. Porins allow entry of substances into both Gram-positive and Gram-negative bacteria.
3. The cell wall of Gram-negative bacteria is thick, and the cell wall of Gram-positive bacteria is thin.
4. Gram-negative bacteria have a cell wall made of peptidoglycan, whereas Gram-positive bacteria have a cell wall made of lipoteichoic acid.

3.

Figure 22.19 Which of the following statements about the nitrogen cycle is false?

1. Nitrogen fixing bacteria exist on the root nodules of legumes and in the soil.
2. Denitrifying bacteria convert nitrates (NO_3^-) into nitrogen gas (N_2).
3. Ammonification is the process by which ammonium ion (NH_4^+) is released from decomposing organic compounds.
4. Nitrification is the process by which nitrites (NO_2^-) are converted to ammonium ion (NH_4^+).

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22.3: REVIEW QUESTIONS

4.

The first forms of life on Earth were thought to be_____.

1. single-celled plants
2. prokaryotes
3. insects
4. large animals such as dinosaurs

5.

Microbial mats _____.

1. are the earliest forms of life on Earth
2. obtained their energy and food from hydrothermal vents
3. are multi-layered sheets of prokaryotes including mostly bacteria but also archaea
4. all of the above

6.

The first organisms that oxygenated the atmosphere were

1. cyanobacteria
2. phototrophic organisms
3. anaerobic organisms
4. all of the above

7.

Halophiles are organisms that require_____.

1. a salt concentration of at least 0.2 M
2. high sugar concentration
3. the addition of halogens
4. all of the above

8.

Many of the first prokaryotes to be cultured in a scientific lab were human or animal pathogens. Why would these species be more readily cultured than non-pathogenic prokaryotes?

1. Pathogenic prokaryotes are hardier than non-pathogenic prokaryotes.
2. Non-pathogenic prokaryotes require more supplements in their growth media.
3. Most of the necessary culture conditions could be inferred for pathogenic prokaryotes.
4. Pathogenic bacteria can grow as free bacteria, but non-pathogenic bacteria only grow as parts of large colonies.

9.

The presence of a membrane-enclosed nucleus is a characteristic of _____.

1. prokaryotic cells
2. eukaryotic cells
3. all cells
4. viruses

10.

Which of the following consist of prokaryotic cells?

1. bacteria and fungi
2. archaea and fungi
3. protists and animals
4. bacteria and archaea

11.

The cell wall is _____.

1. interior to the cell membrane

2. exterior to the cell membrane
3. a part of the cell membrane
4. interior or exterior, depending on the particular cell

12.

Organisms most likely to be found in extreme environments are _____.

1. fungi
2. bacteria
3. viruses
4. archaea

13.

Prokaryotes stain as Gram-positive or Gram-negative because of differences in the cell _____.

1. wall
2. cytoplasm
3. nucleus
4. chromosome

14.

Pseudopeptidoglycan is a characteristic of the walls of _____.

1. eukaryotic cells
2. bacterial prokaryotic cells
3. archaean prokaryotic cells
4. bacterial and archaean prokaryotic cells

15.

The lipopolysaccharide layer (LPS) is a characteristic of the wall of _____.

1. archaean cells
2. Gram-negative bacteria
3. bacterial prokaryotic cells
4. eukaryotic cells

16.

Which of the following elements is *not* a micronutrient?

1. boron
2. calcium
3. chromium
4. manganese

17.

Prokaryotes that obtain their energy from chemical compounds are called _____.

1. phototrophs
2. auxotrophs
3. chemotrophs
4. lithotrophs

18.

Ammonification is the process by which _____.

1. ammonia is released during the decomposition of nitrogen-containing organic compounds
2. ammonium is converted to nitrite and nitrate in soils
3. nitrate from soil is transformed to gaseous nitrogen compounds such as NO, N_2O, and N_2
4. gaseous nitrogen is fixed to yield ammonia

19.

Plants use carbon dioxide from the air and are therefore called _____.

1. consumers

2. producers
3. decomposer
4. carbon fixers

20.

Cyanobacteria harness energy from the sun through photosynthesis, and oxidize water to provide electrons for energy generation. Thus, we classify cyanobacteria as _____.

1. photolithotrophs
2. photoautotrophs
3. chemolithoautotrophs
4. chemo-organotrophs

21.

A disease that is constantly present in a population is called _____.

1. pandemic
2. epidemic
3. endemic
4. re-emerging

22.

Which of the statements about biofilms is correct?

1. Biofilms are considered responsible for diseases such as cystic fibrosis.
2. Biofilms produce dental plaque, and colonize catheters and prostheses.
3. Biofilms colonize open wounds and burned tissue.
4. All statements are correct.

23.

Which of these statements is true?

1. An antibiotic is any substance produced by an organism that is antagonistic to the growth of prokaryotes.
2. An antibiotic is any substance produced by a prokaryote that is antagonistic to the growth of other viruses.
3. An antibiotic is any substance produced by a prokaryote that is antagonistic to the growth of eukaryotic cells.
4. An antibiotic is any substance produced by a prokaryote that prevents growth of the same prokaryote.

24.

A person in England arrives at a medical clinic with a fever and swollen lymph nodes shortly after returning from a visit to New Mexico. For which bacteria should the doctor test the patient?

1. *Salmonella enterica*
2. *Borrelia burgdorferi*
3. *Clostridium botulinum*
4. *Yersinia pestis*

25.

MRSA has emerged as a serious infectious disease, with the first case of methicillin-resistant S. *aureus* being detected in 1961. Why are medical professionals so concerned when antibiotics exist that can kill MRSA?

1. MRSA can transfer methicillin-resistance to other bacteria.
2. Patients are not treated with correct antibiotics rapidly enough to prevent serious illness.
3. MRSA could acquire additional antibiotic resistance genes from other bacteria to become a “super bug.”
4. All of the above.

26.

Which of these occurs through symbiotic nitrogen fixation?

1. The plant benefits from using an endless source of nitrogen.
2. The soil benefits from being naturally fertilized.
3. Bacteria benefit from using photosynthates from the plant.
4. All of the above occur.

27.

Synthetic compounds found in an organism but not normally produced or expected to be present in that organism are called _____.

1. pesticides
2. bioremediators
3. recalcitrant compounds
4. xenobiotics

28.

Bioremediation includes _____.

1. the use of prokaryotes that can fix nitrogen
2. the use of prokaryotes to clean up pollutants
3. the use of prokaryotes as natural fertilizers
4. All of the above

29.

In addition to providing yogurt with its unique flavor and texture, lactic acid-producing bacteria also provide which additional benefit during food production?

1. Providing xenobiotics
2. Lowering the pH to kill pathogenic bacteria
3. Pasteurizing milk products
4. Breaking down lactose for lactose-intolerant individuals

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22.4: CRITICAL THINKING QUESTIONS

30.

Describe briefly how you would detect the presence of a non-culturable prokaryote in an environmental sample.

31.

Why do scientists believe that the first organisms on Earth were extremophiles?

32.

A new bacterial species is discovered and classified as an endolith, an extremophile that lives inside rock. If the bacteria were discovered in the permafrost of Antarctica, describe two extremophile features the bacteria must possess.

33.

Mention three differences between bacteria and archaea.

34.

Explain the statement that both types, bacteria and archaea, have the same basic structures, but built from different chemical components.

35.

A scientist isolates a new species of prokaryote. They note that the specimen is a bacillus with a lipid bilayer and cell wall that stains positive for peptidoglycan. Its circular chromosome replicates from a single origin of replication. Is the specimen most likely an Archaea, a Gram-positive bacterium, or a Gram-negative bacterium? How do you know?

36.

Think about the conditions (temperature, light, pressure, and organic and inorganic materials) that you may find in a deep-sea hydrothermal vent. What type of prokaryotes, in terms of their metabolic needs (autotrophs, phototrophs, chemotrophs, etc.), would you expect to find there?

37.

Farmers continually rotate the crops grown in different fields to maintain nutrients in the soil. How would planting soybeans in a field the year after the field was used to grow carrots help maintain nitrogen in the soil?

38.

Imagine a region of soil became contaminated, killing bacteria that decompose dead plants and animals. How would this effect the carbon cycle in the area? Be specific in stating where carbon would accumulate in the cycle.

39.

Explain the reason why the imprudent and excessive use of antibiotics has resulted in a major global problem.

40.

Researchers have discovered that washing spinach with water several times does not prevent foodborne diseases due to *E. coli*. How can you explain this fact?

41.

Your friend believes that prokaryotes are always detrimental and pathogenic. How would you explain to them that they are wrong?

42.

Many people use antimicrobial soap to kill bacteria on their hands. However, overuse may actually increase the risk of infection. How could this occur?

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CHAPTER OVERVIEW

23: PROTISTS

Most protists are microscopic, unicellular organisms that are abundant in soil, freshwater, brackish, and marine environments. They are also common in the digestive tracts of animals and in the vascular tissues of plants.

23.1: Key Terms

23.2: Visual Connection Questions

23.3: Review Questions

23.4: Critical Thinking Questions

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23.1: KEY TERMS

biological carbon pump
process by which inorganic carbon is fixed by photosynthetic species that then die and fall to the sea floor where they cannot be reached by saprobes and their carbon dioxide consumption cannot be returned to the atmosphere

bioluminescence
generation and emission of light by an organism, as in dinoflagellates

contractile vacuole
vesicle that fills with water (as it enters the cell by osmosis) and then contracts to squeeze water from the cell; an osmoregulatory vesicle

cytoplasmic streaming
movement of cytoplasm into an extended pseudopod such that the entire cell is transported to the site of the pseudopod

endosymbiosis
engulfment of one cell within another such that the engulfed cell survives, and both cells benefit; the process responsible for the evolution of mitochondria and chloroplasts in eukaryotes

endosymbiotic theory
theory that states that eukaryotes may have been a product of one cell engulfing another, one living within another, and evolving over time until the separate cells were no longer recognizable as such

hydrogenosome
organelle carried by parabasalids (Excavata) that functions anaerobically and outputs hydrogen gas as a byproduct; likely evolved from mitochondria

kinetoplast
mass of DNA carried within the single, oversized mitochondrion, characteristic of kinetoplastids (phylum: Euglenozoa)

mitosome
nonfunctional organelle carried in the cells of diplomonads (Excavata) that likely evolved from a mitochondrion

mixotroph
organism that can obtain nutrition by autotrophic or heterotrophic means, usually facultatively

pellicle
outer cell covering composed of interlocking protein strips that function like a flexible coat of armor, preventing cells from being torn or pierced without compromising their range of motion

phagolysosome
cellular body formed by the union of a phagosome containing the ingested particle with a lysosome that contains hydrolytic enzymes

plankton
diverse group of mostly microscopic organisms that drift in marine and freshwater systems and serve as a food source for larger aquatic organisms

plastid
one of a group of related organelles in plant cells that are involved in the storage of starches, fats, proteins, and pigments

raphe
slit in the silica shell of diatoms through which the protist secretes a stream of mucopolysaccharides for locomotion and attachment to substrates

test
porous shell of a foram that is built from various organic materials and typically hardened with calcium carbonate

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23.2: VISUAL CONNECTION QUESTIONS

1.

Figure 23.5 What evidence is there that mitochondria were incorporated into the ancestral eukaryotic cell before chloroplasts?

2.

Figure 23.25 Which of the following statements about *Paramecium* sexual reproduction is false?

1. The macronuclei are derived from micronuclei.
2. Both mitosis and meiosis occur during sexual reproduction.
3. The conjugate pair swaps macronuclei.
4. Each parent produces four daughter cells.

3.

Figure 23.28 Which of the following statements about the *Laminaria* life cycle is false?

1. 1*n* zoospores form in the sporangia.
2. The sporophyte is the *2n* plant.
3. The gametophyte is diploid.
4. Both the gametophyte and sporophyte stages are multicellular.

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23.3: REVIEW QUESTIONS

4.

What event is thought to have contributed to the evolution of eukaryotes?

1. global warming
2. glaciation
3. volcanic activity
4. oxygenation of the atmosphere

5.

Which characteristic is shared by prokaryotes and eukaryotes?

1. cytoskeleton
2. nuclear envelope
3. DNA-based genome
4. mitochondria

6.

Mitochondria most likely evolved by _____.

1. a photosynthetic cyanobacterium
2. cytoskeletal elements
3. endosymbiosis
4. membrane proliferation

7.

Which of these protists is believed to have evolved following a secondary endosymbiosis?

1. green algae
2. cyanobacteria
3. red algae
4. chlorarachniophytes

8.

In 2016, scientists published the genome of *Monocercomonoides*, and demonstrated that this organism has no detectable mitochondrial genes. However, its genome was arranged in linear chromosomes wrapped around histones which are contained within the nucleus. *Monocercomonoides* is therefore a(n) _____.

1. Bacteria
2. Archea
3. Eukaryote
4. Endosymbiont

9.

Which of the following observations about a bacterium would distinguish it from the last eukaryotic common ancestor?

1. A double-stranded DNA genome
2. Lack of a membrane-bound structure surrounding the genome
3. Fatty acids in the lipid bilayer of the plasma membrane
4. Enclosed by a cell wall

10.

Protists that have a pellicle are surrounded by _____.

1. silica dioxide
2. calcium carbonate
3. carbohydrates
4. proteins

11.

Protists with the capabilities to perform photosynthesis and to absorb nutrients from dead organisms are called _____.

1. photoautotrophs

1. photoautotrophs
2. mixotrophs
3. saprobes
4. heterotrophs

12.

Which of these locomotor organs would likely be the shortest?

1. a flagellum
2. a cilium
3. an extended pseudopod
4. a pellicle

13.

Alternation of generations describes which of the following?

1. The haploid form can be multicellular; the diploid form is unicellular.
2. The haploid form is unicellular; the diploid form can be multicellular.
3. Both the haploid and diploid forms can be multicellular.
4. Neither the haploid nor the diploid forms can be multicellular.

14.

The amoeba *E. histolytica* is a pathogen that forms liver abscesses in infected individuals. Its metabolic classification is most likely _____.

1. Anaerobic heterotroph
2. Mixotroph
3. Aerobic phototroph
4. Phagocytic autotroph

15.

Which protist group exhibits mitochondrial remnants with reduced functionality?

1. slime molds
2. diatoms
3. parabasalids
4. dinoflagellates

16.

Conjugation between two *Paramecia* produces _____ total daughter cells.

1. 2
2. 4
3. 8
4. 16

17.

What is the function of the raphe in diatoms?

1. locomotion
2. defense
3. capturing food
4. photosynthesis

18.

What genus of protists appears to contradict the statement that unicellularity restricts cell size?

1. *Dictyostelium*
2. *Ulva*
3. *Plasmodium*
4. *Caulerpa*

19.

A marine biologist analyzing water samples notices a protist with a calcium carbonate shell that moves by pseudopodia extension. The protist is likely to be closely related to which species?

1. *Fuligo septica* (Dog Vomit slime mold)
2. *Circogonia icosahedra* (Radiolarian)
3. *Euglena viridis*
4. *Ammonia tepida*

20.

An example of carbon fixation is _____.

1. photosynthesis
2. decomposition
3. phagocytosis
4. parasitism

21.

Which parasitic protist evades the host immune system by altering its surface proteins with each generation?

1. *Paramecium caudatum*
2. *Trypanosoma brucei*
3. *Plasmodium falciparum*
4. *Phytophthora infestans*

22.

Which of the following is **not** a way that protists contribute to the food web?

1. They fix carbon into organic molecules.
2. They occupy the apex producer niche.
3. They enter symbiotic relationships with animals.
4. They recycle nutrients back into the carbon and nitrogen cycles.

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23.4: CRITICAL THINKING QUESTIONS

23.

Describe the hypothesized steps in the origin of eukaryotic cells.

24.

Some aspects of eukaryotes are more similar to Archaea, while other aspects of eukaryotic cell composition appear more closely related to Bacteria. Explain how endosymbiosis could resolve this paradox.

25.

Explain in your own words why sexual reproduction can be useful if a protist's environment changes.

26.

Giardia lamblia is a cyst-forming protist parasite that causes diarrhea if ingested. Given this information, against what type(s) of environments might *G. lamblia* cysts be particularly resistant?

27.

Explain how the definition of protists ensures that the kingdom Protista includes a wide diversity of cellular structures. Provide an example of two different structures that perform the same function for their respective protist.

28.

The chlorophyte (green algae) genera *Ulva* and *Caulerpa* both have macroscopic leaf-like and stem-like structures, but only *Ulva* species are considered truly multicellular. Explain why.

29.

Why might a light-sensing eyespot be ineffective for an obligate saprobe? Suggest an alternative organ for a saprobic protist.

30.

Opisthokonta includes animals and fungi, as well as protists. Describe the key feature of this phylum, and an example of how an organism in each kingdom uses this feature.

31.

Describe two ways in which paramecium differs from the projected traits of the last eukaryotic common ancestor.

32.

How does killing *Anopheles* mosquitoes affect the *Plasmodium* protists?

33.

Without treatment, why does African sleeping sickness invariably lead to death?

34.

Describe how increasing stress to the ocean would affect a food chain containing zooxanthellae, corals, parrotfish, and sharks.

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CHAPTER OVERVIEW

24: FUNGI

The kingdom Fungi includes an enormous variety of living organisms collectively referred to as Eucomycota, or true Fungi. While scientists have identified about 100,000 species of fungi, this is only a fraction of the 1.5 million species of fungus likely present on Earth. Edible mushrooms, yeasts, black mold, and the producer of the antibiotic penicillin, *Penicillium notatum*, are all members of the kingdom Fungi, which belongs to the domain Eukarya.

24.1: Key Terms

24.2: Visual Connection Questions

24.3: Review Questions

24.4: Critical Thinking Questions

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24.1: KEY TERMS

arbuscular mycorrhiza
mycorrhizal association in which the fungal hyphae enter the root cells and form extensive networks

Arbuscular mycorrhizae
mycorrhizae commonly involving Glomeromycetes in which the fungal hyphae penetrate the cell walls of the plant root cells (but not the cell membranes)

ascocarp
fruiting body of ascomycetes

Ascomycota
(also, sac fungi) phylum of fungi that store spores in a sac called ascus

basidiocarp
fruiting body that protrudes from the ground and bears the basidia

Basidiomycota
(also, club fungi) phylum of fungi that produce club-shaped structures (basidia) that contain spores

basidium
club-shaped fruiting body of basidiomycetes

Chytridiomycota
(also, chytrids) primitive phylum of fungi that live in water and produce gametes with flagella

coenocytic hypha
single hypha that lacks septa and contains many nuclei

commensalism
symbiotic relationship in which one member benefits while the other member is not affected

Deuteromycota
former form phylum of fungi that do not have a known sexual reproductive cycle (presently members of two phyla: Ascomycota and Basidiomycota)

ectomycorrhiza
mycorrhizal fungi that surround the roots with a mantle and have a Hartig net that extends into the roots between cells

Ectomycorrhizae
mycorrhizae in which the fungal hyphae do not penetrate the root cells of the plant

facultative anaerobes
organisms that can perform both aerobic and anaerobic respiration and can survive in oxygen-rich and oxygen-poor environment

Glomeromycota
phylum of fungi that form symbiotic relationships with the roots of trees

haustoria
modified hyphae on many parasitic fungi that penetrate the tissues of their hosts, release digestive enzymes, and/or absorb nutrients from the host

heterothallic
describes when only one mating type is present in an individual mycelium

homothallic

describes when both mating types are present in mycelium

hypha
fungal filament composed of one or more cells

karyogamy
fusion of nuclei

lichen
close association of a fungus with a photosynthetic alga or bacterium that benefits both partners

mold
tangle of visible mycelia with a fuzzy appearance

mycelium
mass of fungal hyphae

mycetismus
ingestion of toxins in poisonous mushrooms

mycology
scientific study of fungi

mycorrhiza
mutualistic association between fungi and vascular plant roots

mycorrhizae
a mutualistic relationship between a plant and a fungus. Mycorrhizae are connections between fungal hyphae, which provide soil minerals to the plant, and plant roots, which provide carbohydrates to the fungus

mycosis
fungal infection

mycotoxicosis
poisoning by a fungal toxin released in food

obligate aerobes
organisms, such as humans, that must perform aerobic respiration to survive

obligate anaerobes
organisms that only perform anaerobic respiration and often cannot survive in the presence of oxygen

parasitism
symbiotic relationship in which one member of the association benefits at the expense of the other

plasmogamy
fusion of cytoplasm

saprobe
organism that derives nutrients from decaying organic matter; also saprophyte

septa
cell wall division between hyphae

soredia
clusters of algal cells and mycelia that allow lichens to propagate

sporangium

reproductive sac that contains spores

spore
a haploid cell that can undergo mitosis to form a multicellular, haploid individual

thallus
vegetative body of a fungus

yeast
general term used to describe unicellular fungi

Zygomycota
(also, conjugated fungi) phylum of fungi that form a zygote contained in a zygospore

zygospore
structure with thick cell wall that contains the zygote in zygomycetes

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24.2: VISUAL CONNECTION QUESTIONS

1.

Figure 24.14 Which of the following statements is true?

1. A dikaryotic ascus that forms in the ascocarp undergoes karyogamy, meiosis, and mitosis to form eight ascospores.
2. A diploid ascus that forms in the ascocarp undergoes karyogamy, meiosis, and mitosis to form eight ascospores.
3. A haploid zygote that forms in the ascocarp undergoes karyogamy, meiosis, and mitosis to form eight ascospores.
4. A dikaryotic ascus that forms in the ascocarp undergoes plasmogamy, meiosis, and mitosis to form eight ascospores.

2.

Figure 24.17 Which of the following statements is true?

1. A basidium is the fruiting body of a mushroom-producing fungus, and it forms four basidiocarps.
2. The result of the plasmogamy step is four basidiospores.
3. Karyogamy results directly in the formation of mycelia.
4. A basidiocarp is the fruiting body of a mushroom-producing fungus.

3.

Figure 24.21 If symbiotic fungi are absent from the soil, what impact do you think this would have on plant growth?

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24.3: REVIEW QUESTIONS

4.

Which polysaccharide is usually found in the cell wall of fungi?

1. starch
2. glycogen
3. chitin
4. cellulose

5.

Which of these organelles is not found in a fungal cell?

1. chloroplast
2. nucleus
3. mitochondrion
4. Golgi apparatus

6.

The wall dividing individual cells in a fungal filament is called a

1. thallus
2. hypha
3. mycelium
4. septum

7.

During sexual reproduction, a homothallic mycelium contains

1. all septated hyphae
2. all haploid nuclei
3. both mating types
4. none of the above

8.

The life cycles of perfect fungi are most similar to which other organism?

1. Hydra that undergo asexual budding
2. Diploid-dominant pea plants
3. Haploid-dominant green algae
4. Bacteria undergoing binary fission

9.

The most primitive phylum of fungi is the _____.

1. Chytridiomycota
2. Zygomycota
3. Glomeromycota
4. Ascomycota

10.

Members of which phylum produce a club-shaped structure that contains spores?

1. Chytridiomycota
2. Basidiomycota
3. Glomeromycota
4. Ascomycota

11.

Members of which phylum establish a successful symbiotic relationship with the roots of trees?

1. Ascomycota
2. Deuteromycota

3. Basidiomycota
4. Glomeromycota

12.

The fungi that do not reproduce sexually used to be classified as _____.

1. Ascomycota
2. Deuteromycota
3. Basidiomycota
4. Glomeromycota

13.

A scientist discovers a new species of fungus that introduces genetic diversity during reproduction by creating a diploid zygote. This new species cannot belong to which modern phylum of fungi?

1. Zygomycota
2. Glomeromycota
3. Chytridiomycota
4. Deuteromycota

14.

What term describes the close association of a fungus with the root of a tree?

1. a rhizoid
2. a lichen
3. a mycorrhiza
4. an endophyte

15.

Why are fungi important decomposers?

1. They produce many spores.
2. They can grow in many different environments.
3. They produce mycelia.
4. They recycle carbon and inorganic minerals by the process of decomposition.

16.

Consider an ecosystem where all the fungi not involved in mycorrhizae are eliminated. How would this affect nitrogen intake by plants?

1. Nitrogen intake would increase.
2. Nitrogen intake would not change.
3. Nitrogen intake would decrease.
4. Nitrogen intake would stop.

17.

A fungus that climbs up a tree reaching higher elevation to release its spores in the wind and does not receive any nutrients from the tree or contribute to the tree's welfare is described as a _____.

1. commensal
2. mutualist
3. parasite
4. pathogen

18.

A fungal infection that affects nails and skin is classified as _____.

1. systemic mycosis
2. mycetismus
3. superficial mycosis
4. mycotoxicosis

19.

The targets for anti-fungal drugs are much more limited than antibiotics or anti-viral medications. Why?

1. There are more bacteria and viruses than fungi.
2. Fungi can only be targeted during sexual reproduction, while bacteria and viruses can be targeted at any point in their lifespan.
3. Fungi cause topical infections, while viruses and bacteria cause systemic infections.
4. Human cells are much more similar to fungi cells than bacteria or viruses.

20.

Yeast is a facultative anaerobe. This means that alcohol fermentation takes place only if:

1. the temperature is close to 37°C
2. the atmosphere does not contain oxygen
3. sugar is provided to the cells
4. light is provided to the cells

21.

The advantage of yeast cells over bacterial cells to express human proteins is that:

1. yeast cells grow faster
2. yeast cells are easier to manipulate genetically
3. yeast cells are eukaryotic and modify proteins similarly to human cells
4. yeast cells are easily lysed to purify the proteins

22.

Why are fungal insecticides an attractive alternative to chemical pesticides for growing food crops?

1. Human consumption of fungal insecticides would not make a person sick, but ingestion of chemical pesticides can be harmful to humans.
2. A single fungal insecticide would kill a wider variety of insects than a chemical pesticide.
3. Fungal insecticides can eliminate both harmful insects and plant pathogens, while chemical pesticides only kill insects.
4. Fungal insecticides will decompose dying plants, enhancing the nitrogen content of the soil, while chemical pesticides are not decomposers.

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24.4: CRITICAL THINKING QUESTIONS

23.

What are the evolutionary advantages for an organism to reproduce both asexually and sexually?

24.

Compare plants, animals, and fungi, considering these components: cell wall, chloroplasts, plasma membrane, food source, and polysaccharide storage. Be sure to indicate fungi's similarities and differences to plants and animals.

25.

Why is the large surface area of the mycelium essential for nutrient acquisition by fungi?

26.

What is the advantage for a basidiomycete to produce a showy and fleshy fruiting body?

27.

For each of the four groups of perfect fungi (Chytridiomycota, Zygomycota, Ascomycota, and Basidiomycota), compare the body structure and features, and provide an example.

28.

Why does protection from light actually benefit the photosynthetic partner in lichens?

29.

Ambrosia bark beetles carry *Ambrosiella* fungal spores to trees, then bore holes and lay their eggs with the fungus. When the new larvae hatch, they eat the fungus that has germinated in the holes. Describe how this relationship can be classified as mutualistic.

30.

Ecologists often attempt to introduce new plants to restore degraded land. In an arid climate, scientists recommend introducing plants with arbuscular mycorrhizae. How would the mycorrhizae increase the plants' survival compared to plants without mycorrhizae?

31.

Why can superficial mycoses in humans lead to bacterial infections?

32.

Explain how the Red Queen Hypothesis describes the continuously evolving relationship between red grapes and *Botrytis cinerea*.

33.

Historically, artisanal breads were produced by capturing wild yeasts from the air. Prior to the development of modern yeast strains, the production of artisanal breads was long and laborious because many batches of dough ended up being discarded. Can you explain this fact?

34.

How would treating an area of a forest with a broad-spectrum fungicide alter the carbon and nitrogen cycles in the area?

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CHAPTER OVERVIEW

25: SEEDLESS PLANTS

Seedless plants reproduce and spread through spores, but do not flower or seed to replicate.

25.1: Key Terms

25.2: Visual Connection Questions

25.3: Review Questions

25.4: Critical Thinking Questions

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25.1: KEY TERMS

adventitious
describes an organ that grows in an unusual place, such as a roots growing from the side of a stem

antheridium
male gametangium

archegonium
female gametangium

capsule
case of the sporangium in mosses

charophyte
other term for green algae; considered the closest relative of land plants

club mosses
earliest group of seedless vascular plants

diplontic
diploid stage is the dominant stage

embryophyte
other name for land plant; embryo is protected and nourished by the sporophyte

extant
still-living species

extinct
no-longer-existing species

fern
seedless vascular plant that produces large fronds; the most advanced group of seedless vascular plants

gametangium
structure on the gametophyte in which gametes are produced

gemma
(plural, gemmae) leaf fragment that spreads for asexual reproduction

haplodiplodontic
haploid and diploid stages alternate

haplontic
haploid stage is the dominant stage

heterosporous
produces two types of spores

homosporous
produces one type of spore

hornworts
group of non-vascular plants in which stomata appear

horsetail

seedless vascular plant characterized by joints

lignin
complex polymer impermeable to water

liverworts
most primitive group of the non-vascular plants

lycophyte
club moss

megaphyll
larger leaves with a pattern of branching veins

megaspore
female spore

microphyll
small size and simple vascular system with a single unbranched vein

microspore
male spore

mosses
group of bryophytes in which a primitive conductive system appears

non-vascular plant
plant that lacks vascular tissue, which is formed of specialized cells for the transport of water and nutrients

peat moss
Sphagnum

peristome
tissue that surrounds the opening of the capsule and allows periodic release of spores

phloem
tissue responsible for transport of sugars, proteins, and other solutes

protonema
tangle of single-celled filaments that forms from the haploid spore

rhizoids
thin filaments that anchor the plant to the substrate

seedless vascular plant
plant that does not produce seeds

seta
stalk that supports the capsule in mosses

sporocyte
diploid cell that produces spores by meiosis

sporophyll
leaf modified structurally to bear sporangia

sporopollenin
tough polymer surrounding the spore

streptophytes
group that includes green algae and land plants

strobili
cone-like structures that contain the sporangia

tracheophyte
vascular plant

vascular plant
plant containing a network of cells that conducts water and solutes through the organism

vein
bundle of vascular tissue made of xylem and phloem

whisk fern
seedless vascular plant that lost roots and leaves by reduction

xylem
tissue responsible for long-distance transport of water and nutrients

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25.2: VISUAL CONNECTION QUESTIONS

1.

Figure 25.6 Which of the following statements about plant divisions is false?

1. Lycophytes and pterophytes are seedless vascular plants.
2. All vascular plants produce seeds.
3. All non-vascular embryophytes are bryophytes.
4. Seed plants include angiosperms and gymnosperms.

2.

Figure 25.14 Which of the following statements about the moss life cycle is false?

1. The mature gametophyte is haploid.
2. The sporophyte produces haploid spores.
3. The calyptra buds to form a mature gametophyte.
4. The zygote is housed in the venter.

3.

Figure 25.24 Which of the following statements about the fern life cycle is false?

1. Sporangia produce haploid spores.
2. The sporophyte grows from a gametophyte.
3. The sporophyte is diploid and the gametophyte is haploid.
4. Sporangia form on the underside of the gametophyte.

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25.3: REVIEW QUESTIONS

4.

The land plants are probably descendants of which of these groups?

1. green algae
2. red algae
3. brown algae
4. angiosperms

5.

Alternation of generations means that plants produce:

1. only haploid multicellular organisms
2. only diploid multicellular organisms
3. only diploid multicellular organisms with single-celled haploid gametes
4. both haploid and diploid multicellular organisms

6.

Which of the following traits of land plants allows them to grow in height?

1. alternation of generations
2. waxy cuticle
3. tracheids
4. sporopollenin

7.

How does a haplontic plant population maintain genetic diversity?

1. Zygotes are produced by random fusion.
2. Gametes are created through meiosis.
3. Diploid spores undergo independent assortment during mitosis.
4. The zygote undergoes meiosis to generate a haploid sporophyte.

8.

What characteristic of Charales would enable them to survive a dry spell?

1. sperm with flagella
2. phragmoplasts
3. sporopollenin
4. chlorophyll *a*

9.

Which one of these characteristics is present in land plants and not in Charales?

1. alternation of generations
2. flagellated sperm
3. phragmoplasts
4. plasmodesmata

10.

A scientist sequences the genome of *Chara*, red algae, and a tomato plant. What result would support the conclusion that Charophytes should be included in the *Plantae* kingdom?

1. The *Chara* genome is more similar to the red algae than the tomato plant.
2. All three genomes are distinctly different.
3. The *Chara* genome is more similar to the tomato plant genome than the red algae genome.
4. The tomato plant genome is distinct from the red algae genome.

11.

Which of the following features does not support the inclusion of Charophytes in the *Plantae* kingdom?

1. Charophyte chloroplasts contain chlorophyll a and b.

2. Charophyte plant cell walls contain plasmodesmata to allow transfer between cells within multicellular organisms.
3. Charophytes do not exhibit growth throughout the entire plant body.
4. Charophytes are multicellular organisms that lack vascular tissue.

12.

Which of the following structures is not found in bryophytes?

1. a cellulose cell wall
2. chloroplast
3. sporangium
4. root

13.

Stomata appear in which group of plants?

1. Charales
2. liverworts
3. hornworts
4. mosses

14.

The chromosome complement in a moss protonema is:

1. 1*n*
2. 2*n*
3. 3*n*
4. varies with the size of the protonema

15.

Why do mosses grow well in the Arctic tundra?

1. They grow better at cold temperatures.
2. They do not require moisture.
3. They do not have true roots and can grow on hard surfaces.
4. There are no herbivores in the tundra.

16.

A botanist travels to an area that has experienced a long, severe drought. While examining the bryophytes in the area, they notice that many are in the same life-cycle stage. Which life-cycle stage *should* be the most common?

1. zygote
2. gametophyte
3. sporophyte
4. archegonium

17.

Microphylls are characteristic of which types of plants?

1. mosses
2. liverworts
3. club mosses
4. ferns

18.

A plant in the understory of a forest displays a segmented stem and slender leaves arranged in a whorl. It is probably a _____.

1. club moss
2. whisk fern
3. fern
4. horsetail

19.

The following structures are found on the underside of fern leaves and contain sporangia:

1. sori
2. rhizomes
3. megaphylls
4. microphylls

20.

The dominant organism in fern is the _____.

1. sperm
2. spore
3. gamete
4. sporophyte

21.

What seedless plant is a renewable source of energy?

1. club moss
2. horsetail
3. sphagnum moss
4. fern

22.

How do mosses contribute to returning nitrogen to the soil?

1. Mosses fix nitrogen from the air.
2. Mosses harbor cyanobacteria that fix nitrogen.
3. Mosses die and return nitrogen to the soil.
4. Mosses decompose rocks and release nitrogen.

23.

The production of megaphylls by many different species of plants is an example of _____.

1. parallel evolution
2. analogy
3. divergent evolution
4. homology

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25.4: CRITICAL THINKING QUESTIONS

24.

Why did land plants lose some of the accessory pigments present in brown and red algae?

25.

What is the difference between extant and extinct?

26.

Describe at least two challenges that cactuses had to overcome that cattails did not.

27.

Describe a minimum of two ways that plants changed the land environment to support the emergence of land animals.

28.

To an alga, what is the main advantage of producing drought-resistant structures?

29.

In areas where it rains often, mosses grow on roofs. How do mosses survive on roofs without soil?

30.

What are the three classes of bryophytes?

31.

Describe two adaptations that are present in mosses, but not hornworts or liverworts, which reflect steps of evolution toward land plants.

32.

Bryophytes form a monophyletic group that transitions between green algae and vascular plants. Describe at least one similarity and one difference between bryophyte reproduction and green algae reproduction.

33.

How did the development of a vascular system contribute to the increase in size of plants?

34.

Which plant is considered the most advanced seedless vascular plant and why?

35.

Ferns are simultaneously involved in promoting rock weathering, while preventing soil erosion. Explain how a single plant can perform both these functions, and how these functions are beneficial to its ecosystem.

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CHAPTER OVERVIEW

26: SEED PLANTS

Seed plants, such as palms, have broken free from the need to rely on water for their reproductive needs. They play an integral role in all aspects of life on the planet, shaping the physical terrain, influencing the climate, and maintaining life as we know it.

26.1: Key Terms

26.2: Visual Connection Questions

26.3: Review Questions

26.4: Critical Thinking Questions

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26.1: KEY TERMS

anther
sac-like structure at the tip of the stamen in which pollen grains are produced

Anthophyta
phylum to which angiosperms belong

barcoding
molecular biology technique in which one or more short gene sequences taken from a well-characterized portion of the genome is used to identify a species

basal angiosperms
a group of plants that probably branched off before the separation of monocots and eudicots

calyx
whorl of sepals

carpel
single unit of the pistil

conifer
dominant phylum of gymnosperms with the greatest variety of trees

corolla
collection of petals

cotyledon
primitive leaf that develops in the zygote; monocots have one cotyledon, and dicots have two cotyledons

crop
cultivated plant

cycad
gymnosperm that grows in tropical climates and resembles a palm tree; member of the phylum Cycadophyta

dicot
(also, eudicot) related group of angiosperms whose embryos possess two cotyledons

dioecious
describes a species in which the male and female reproductive organs are carried on separate specimens

filament
thin stalk that links the anther to the base of the flower

flower
branches specialized for reproduction found in some seed-bearing plants, containing either specialized male or female organs or both male and female organs

fruit
thickened tissue derived from ovary wall that protects the embryo after fertilization and facilitates seed dispersal

ginkgophyte
gymnosperm with one extant species, the *Ginkgo biloba*: a tree with fan-shaped leaves

gnetophyte

gymnosperm shrub with varied morphological features that produces vessel elements in its woody tissues; the phylum includes the genera *Ephedra*, *Gnetum*, and *Welwitschia*

gymnosperm
seed plant with naked seeds (seeds exposed on modified leaves or in cones)

gynoecium
(also, carpel) structure that constitutes the female reproductive organ

heirloom seed
seed from a plant that was grown historically, but has not been used in modern agriculture on a large scale

herbaceous
grass-like plant noticeable by the absence of woody tissue

herbivory
consumption of plants by insects and other animals

integument
layer of sporophyte tissue that surrounds the megasporangium, and later, the embryo

megasporocyte
megaspore mother cell; larger spore that germinates into a female gametophyte in a heterosporous plant

microsporocyte
smaller spore that produces a male gametophyte in a heterosporous plant

monocot
related group of angiosperms that produce embryos with one cotyledon and pollen with a single ridge

monoecious
describes a species in which the male and female reproductive organs are on the same plant

nectar
liquid rich in sugars produced by flowers to attract animal pollinators

ovary
chamber that contains and protects the ovule or female megasporangium

ovulate cone
cone containing two ovules per scale

ovule
female gametophyte

perianth
part of the plant consisting of the calyx (sepals) and corolla (petals)

petal
modified leaf interior to the sepals; colorful petals attract animal pollinators

pistil
fused group of carpels

pollen grain
structure containing the male gametophyte of the plant

pollen tube

extension from the pollen grain that delivers sperm to the egg cell

pollination
transfer of pollen from the anther to the stigma

progymnosperm
transitional group of plants that resembled conifers because they produced wood, yet still reproduced like ferns

seed
structure containing the embryo, storage tissue, and protective coat

sepal
modified leaf that encloses the bud; outermost structure of a flower

spermatophyte
seed plant; from the Greek *sperm* (seed) and *phyte* (plant)

stamen
structure that contains the male reproductive organs

stigma
uppermost structure of the carpel where pollen is deposited

strobilus
plant structure with a tight arrangement of sporophylls around a central stalk, as seen in cones or flowers; the male strobilus produces pollen, and the female strobilus produces eggs

style
long, thin structure that links the stigma to the ovary

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26.2: VISUAL CONNECTION QUESTIONS

1.

Figure 26.8 At what stage does the diploid zygote form?

1. when the female cone begins to bud from the tree
2. at fertilization
3. when the seeds drop from the tree
4. when the pollen tube begins to grow

2.

Figure 26.15 If a flower lacked a megasporangium, what type of gamete would not form? If the flower lacked a microsporangium, what type of gamete would not form?

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26.3: REVIEW QUESTIONS

3.

Seed plants are _____.

1. all homosporous
2. mostly homosporous with some heterosporous
3. mostly heterosporous with some homosporous
4. all heterosporous

4.

Besides the seed, what other major structure diminishes a plant's reliance on water for reproduction?

1. flower
2. fruit
3. pollen
4. spore

5.

In which of the following geological periods would gymnosperms dominate the landscape?

1. Carboniferous
2. Permian
3. Triassic
4. Eocene (present)

6.

Which of the following structures widens the geographic range of a species and is an agent of dispersal?

1. seed
2. flower
3. leaf
4. root

7.

Which of the following traits characterizes gymnosperms?

1. The plants carry exposed seeds on modified leaves.
2. Reproductive structures are located in a flower.
3. After fertilization, the ovary thickens and forms a fruit.
4. The gametophyte is the longest phase of the life cycle.

8.

Megasporocytes will eventually produce which of the following?

1. pollen grain
2. sporophytes
3. male gametophytes
4. female gametophytes

9.

What is the ploidy of the following structures: gametophyte, seed, spore, sporophyte?

1. $1n$, $1n$, $2n$, $2n$
2. $1n$, $2n$, $1n$, $2n$
3. $2n$, $1n$, $2n$, $1n$
4. $2n$, $2n$, $1n$, $1n$

10.

In the northern forests of Siberia, a tall tree is most likely a:

1. conifer
2. cycad

3. *Ginkgo biloba*
4. gnetophyte

11.

Which of the following structures in a flower is not directly involved in reproduction?

1. the style
2. the stamen
3. the sepal
4. the anther

12.

Pollen grains develop in which structure?

1. the anther
2. the stigma
3. the filament
4. the carpel

13.

In the course of double fertilization, one sperm cell fuses with the egg and the second one fuses with _____.

1. the synergids
2. the polar nuclei of the center cell
3. the egg as well
4. the antipodal cells

14.

Corn develops from a seedling with a single cotyledon, displays parallel veins on its leaves, and produces monosulcate pollen. It is most likely:

1. a gymnosperm
2. a monocot
3. a eudicot
4. a basal angiosperm

15.

Which of the following plant structures is not a defense against herbivory?

1. thorns
2. spines
3. nectar
4. alkaloids

16.

White and sweet-smelling flowers with abundant nectar are probably pollinated by

1. bees and butterflies
2. flies
3. birds
4. wind

17.

Abundant and powdery pollen produced by small, indistinct flowers is probably transported by:

1. bees and butterflies
2. flies
3. birds
4. wind

18.

Plants are a source of _____.

1. food

2. fuel
3. medicine
4. all of the above

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26.4: CRITICAL THINKING QUESTIONS

19.

The Cretaceous Period was marked by the increase in number and variety of angiosperms. Insects also diversified enormously during the same period. Can you propose the reason or reasons that could foster coevolution?

20.

What role did the adaptations of seed and pollen play in the development and expansion of seed plants?

21.

The Mediterranean landscape along the sea shore is dotted with pines and cypresses. The weather is not cold, and the trees grow at sea level. What evolutionary adaptation of conifers makes them suitable to the Mediterranean climate?

22.

What are the four modern-day phyla of gymnosperms?

23.

Some cycads are considered endangered species and their trade is severely restricted. Customs officials stop suspected smugglers who claim that the plants in their possession are palm trees, not cycads. How would a botanist distinguish between the two types of plants?

24.

What are the two structures that allow angiosperms to be the dominant form of plant life in most terrestrial ecosystems?

25.

Biosynthesis of nectar and nutrient-rich pollen is energetically very expensive for a plant. Yet, plants funnel large amounts of energy into animal pollination. What are the evolutionary advantages that offset the cost of attracting animal pollinators?

26.

What is biodiversity and why is it important to an ecosystem?

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CHAPTER OVERVIEW

27: INTRODUCTION TO ANIMAL DIVERSITY

27.1: Key Terms

27.2: Visual Connection Questions

27.3: Review Questions

27.4: Critical Thinking Questions

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27.1: KEY TERMS

acoelomate
animal without a body cavity

bilateral symmetry
type of symmetry in which there is only one plane of symmetry, so the left and right halves of an animal are mirror images

blastopore
opening into the archenteron that forms during gastrulation

blastula
16–32 cell stage of development of an animal embryo

body plan
morphology or defining shape of an organism

Cambrian explosion
time during the Cambrian period (542–488 million years ago) when most of the animal phyla in existence today evolved

cleavage
cell divisions subdividing a fertilized egg (zygote) to form a multicellular embryo

coelom
lined body cavity

Cryogenian period
geologic period (850–630 million years ago) characterized by a very cold global climate

determinate cleavage
cleavage pattern in which developmental fate of each blastomere is tightly defined

deuterostome
blastopore develops into the anus, with the second opening developing into the mouth

diploblast
animal that develops from two germ layers

Ecdysozoa
clade of protostomes that exhibit exoskeletal molting (ecdysis)

Ediacaran period
geological period (630–542 million years ago) when the oldest definite multicellular organisms with tissues evolved

enterocoely
mesoderm of deuterostomes develops as pouches that are pinched off from endodermal tissue, cavity contained within the pouches becomes coelom

eucoelomate
animal with a body cavity completely lined with mesodermal tissue

Eumetazoa
group of animals with true differentiated tissues

gastrula
stage of animal development characterized by the formation of the digestive cavity

germ layer
collection of cells formed during embryogenesis that will give rise to future body tissues, more pronounced in vertebrate embryogenesis

Hox gene
(also, homeobox gene) master control gene that can turn on or off large numbers of other genes during embryogenesis

indeterminate cleavage
cleavage pattern in which individual blastomeres have the character of "stem cells," and are not yet predetermined to develop into specific cell types

Lophotrochozoa
clade of protostomes that exhibit a trochophore larvae stage or a lophophore feeding structure

mass extinction
event or environmental condition that wipes out the majority of species within a relatively short geological time period

Metazoa
group containing all animals

organogenesis
formation of organs in animal embryogenesis

Parazoa
group of animals without true differentiated tissues

protostome
blastopore develops into the mouth of protostomes, with the second opening developing into the anus

pseudocoelomate
animal with a body cavity located between the mesoderm and endoderm

radial cleavage
cleavage axes are parallel or perpendicular to the polar axis, resulting in the alignment of cells between the two poles

radial symmetry
type of symmetry with multiple planes of symmetry, with body parts (rays) arranged around a central disk

schizocoely
during development of protostomes, a solid mass of mesoderm splits apart and forms the hollow opening of the coelom

spiral cleavage
cells of one pole of the embryo are rotated or misaligned with respect to the cells of the opposite pole

triploblast
animal that develops from three germ layers

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27.2: VISUAL CONNECTION QUESTIONS

1.

Figure 27.5 If a *Hox 13* gene in a mouse was replaced with a *Hox 1* gene, how might this alter animal development?

2.

Figure 27.6 Which of the following statements is false?

1. Eumetazoans have specialized tissues and parazoans don’t.
2. Lophotrochozoa and Ecdysozoa are both Bilataria.
3. Acoela and Cnidaria both possess radial symmetry.
4. Arthropods are more closely related to nematodes than they are to annelids.

3.

Figure 27.9 Which of the following statements about diploblasts and triploblasts is false?

1. Animals that display radial symmetry are diploblasts.
2. Animals that display bilateral symmetry are triploblasts.
3. The endoderm gives rise to the lining of the digestive tract and the respiratory tract.
4. The mesoderm gives rise to the central nervous system.

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27.3: REVIEW QUESTIONS

4.

Which of the following is not a feature common to *most* animals?

1. development into a fixed body plan
2. asexual reproduction
3. specialized tissues
4. heterotrophic nutrient sourcing

5.

During embryonic development, unique cell layers develop into specific groups of tissues or organs during a stage called _____.

1. the blastula stage
2. the germ layer stage
3. the gastrula stage
4. the organogenesis stage

6.

Which of the following phenotypes would most likely be the result of a *Hox* gene mutation?

1. abnormal body length or height
2. two different eye colors
3. the contraction of a genetic illness
4. two fewer appendages than normal

7.

Which of the following organisms is most likely to be a diploblast?

1. sea star
2. shrimp
3. jellyfish
4. insect

8.

Which of the following is not possible?

1. radially symmetrical diploblast
2. diploblastic eucoelomate
3. protostomic coelomate
4. bilaterally symmetrical deuterostome

9.

An animal whose development is marked by radial cleavage and enterocoely is _____.

1. a deuterostome
2. an annelid or mollusk
3. either an acoelomate or eucoelomate
4. none of the above

10.

Consulting the modern phylogenetic tree of animals, which of the following would not constitute a clade?

1. deuterostomes
2. lophotrochozoans
3. Parazoa
4. Bilateria

11.

Which of the following is thought to be the most closely related to the common animal ancestor?

1. fungal cells
2. protist cells

3. plant cells
4. bacterial cells

12.

As with the emergence of the Acoelomorpha phylum, it is common for ____ data to misplace animals in close relation to other species, whereas ____ data often reveals a different and more accurate evolutionary relationship.

1. molecular : morphological
2. molecular : fossil record
3. fossil record : morphological
4. morphological : molecular

13.

Which of the following periods is the earliest during which animals may have appeared?

1. Ordovician period
2. Cambrian period
3. Ediacaran period
4. Cryogenian period

14.

What type of data is primarily used to determine the existence and appearance of early animal species?

1. molecular data
2. fossil data
3. morphological data
4. embryological development data

15.

The time between 542–488 million years ago marks which period?

1. Cambrian period
2. Silurian period
3. Ediacaran period
4. Devonian period

16.

Until recent discoveries suggested otherwise, animals existing before the Cambrian period were believed to be:

1. small and ocean-dwelling
2. small and nonmotile
3. small and soft-bodied
4. small and radially symmetrical or asymmetrical

17.

Plant life first appeared on land during which of the following periods?

1. Cambrian period
2. Ordovician period
3. Silurian period
4. Devonian period

18.

Approximately how many mass extinction events occurred throughout the evolutionary history of animals?

1. 3
2. 4
3. 5
4. more than 5

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27.4: CRITICAL THINKING QUESTIONS

19.

Why might the evolution of specialized tissues be important for animal function and complexity?

20.

Describe and give examples of how humans display all of the features common to the animal kingdom.

21.

How have *Hox* genes contributed to the diversity of animal body plans?

22.

Using the following terms, explain what classifications and groups humans fall into, from the most general to the most specific: symmetry, germ layers, coelom, cleavage, embryological development.

23.

Explain some of the advantages brought about through the evolution of bilateral symmetry and coelom formation.

24.

Describe at least two major changes to the animal phylogenetic tree that have come about due to molecular or genetic findings.

25.

How is it that morphological data alone might lead scientists to group animals into erroneous evolutionary relationships?

26.

Briefly describe at least two theories that attempt to explain the cause of the Cambrian explosion.

27.

How is it that most, if not all, of the extant animal phyla today evolved during the Cambrian period if so many massive extinction events have taken place since then?

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CHAPTER OVERVIEW

28: INVERTEBRATES

Invertebrate animals are those without a cranium and defined vertebral column or spine. In addition to lacking a spine, most invertebrates also lack an endoskeleton. A large number of invertebrates are aquatic animals, and scientific research suggests that many of the world's species are aquatic invertebrates that have not yet been documented.

28.1: Key Terms

28.2: Visual Connection Questions

28.3: Review Questions

28.4: Critical Thinking Questions

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28.1: KEY TERMS

amoebocyte
sponge cell with multiple functions, including nutrient delivery, egg formation, sperm delivery, and cell differentiation

Annelida
phylum of vermiform animals with metamerism

archenteron
primitive gut cavity within the gastrula that opens outward via the blastopore

Arthropoda
phylum of animals with jointed appendages

biramous
referring to two branches per appendage

captacula
tentacle-like projection that is present in tusks shells to catch prey

cephalothorax
fused head and thorax in some species

chelicera
modified first pair of appendages in subphylum Chelicerata

choanocyte
(also, collar cell) sponge cell that functions to generate a water current and to trap and ingest food particles via phagocytosis

Chordata
phylum of animals distinguished by their possession of a notochord, a dorsal, hollow nerve cord, an endostyle, pharyngeal slits, and a post-anal tail at some point in their development

clitellum
specialized band of fused segments, which aids in reproduction

Cnidaria
phylum of animals that are diploblastic and have radial symmetry

cnidocyte
specialized stinging cell found in Cnidaria

conispiral
shell shape coiled around a horizontal axis

corona
wheel-like structure on the anterior portion of the rotifer that contains cilia and moves food and water toward the mouth

ctenidium
specialized gill structure in mollusks

cuticle (animal)
the tough, external layer possessed by members of the invertebrate class Ecdysozoa that is periodically molted and replaced

cypris
larval stage in the early development of crustaceans

Echinodermata
phylum of deuterostomes with spiny skin; exclusively marine organisms

enterocoelom
coelom formed by fusion of coelomic pouches budded from the endodermal lining of the archenteron

epidermis
outer layer (from ectoderm) that lines the outside of the animal

extracellular digestion
food is taken into the gastrovascular cavity, enzymes are secreted into the cavity, and the cells lining the cavity absorb nutrients

gastrodermis
inner layer (from endoderm) that lines the digestive cavity

gastrovascular cavity
opening that serves as both a mouth and an anus, which is termed an incomplete digestive system

gemmule
structure produced by asexual reproduction in freshwater sponges where the morphology is inverted

hemocoel
internal body cavity seen in arthropods

hermaphrodite
referring to an animal where both male and female gonads are present in the same individual

invertebrata
(also, invertebrates) category of animals that do not possess a cranium or vertebral column

madreporite
pore for regulating entry and exit of water into the water vascular system

mantle
(also, pallium) specialized epidermis that encloses all visceral organs and secretes shells

mastax
jawed pharynx unique to the rotifers

medusa
free-floating cnidarian body plan with mouth on underside and tentacles hanging down from a bell

mesoglea
non-living, gel-like matrix present between ectoderm and endoderm in cnidarians

mesohyl
collagen-like gel containing suspended cells that perform various functions in the sponge

metamerism
series of body structures that are similar internally and externally, such as segments

Mollusca
phylum of protostomes with soft bodies and no segmentation

nacre
calcareous secretion produced by bivalves to line the inner side of shells as well as to coat intruding particulate matter

nauplius
larval stage in the early development of crustaceans

nematocyst
harpoon-like organelle within cnidocyte with pointed projectile and poison to stun and entangle prey

Nematoda
phylum of worm-like animals that are triploblastic, pseudocoelomates that can be free-living or parasitic

Nemertea
phylum of dorsoventrally flattened protostomes known as ribbon worms

osculum
large opening in the sponge's body through which water leaves

ostium
pore present on the sponge's body through which water enters

oviger
additional pair of appendages present on some arthropods between the chelicerae and pedipalps

parapodium
fleshy, flat, appendage that protrudes in pairs from each segment of polychaetes

pedipalp
second pair of appendages in Chelicerata

pilidium
larval form found in some nemertine species

pinacocyte
epithelial-like cell that forms the outermost layer of sponges and encloses a jelly-like substance called mesohyl

planospiral
shell shape coiled around a vertical axis

planuliform
larval form found in phylum Nemertea

polymorphic
possessing multiple body plans within the lifecycle of a group of organisms

polyp
stalk-like sessile life form of a cnidarians with mouth and tentacles facing upward, usually sessile but may be able to glide along surface

Porifera
phylum of animals with no true tissues, but a porous body with rudimentary endoskeleton

radula
tongue-like organ with chitinous ornamentation

rhynchocoel
cavity present above the mouth that houses the proboscis

schizocoelom
coelom formed by groups of cells that split from the endodermal layer

sclerocyte
cell that secretes silica spicules into the mesohyl

seta/chaeta

chitinous projection from the cuticle

siphon
tubular structure that serves as an inlet for water into the mantle cavity

spicule
structure made of silica or calcium carbonate that provides structural support for sponges

spongocoel
central cavity within the body of some sponges

trochophore
first of the two larval stages in mollusks

uniramous
referring to one branch per appendage

veliger
second of the two larval stages in mollusks

water vascular system
system in echinoderms where water is the circulatory fluid

zoea
larval stage in the early development of crustaceans

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28.2: VISUAL CONNECTION QUESTIONS

1.

Figure 28.3 Which of the following statements is false?

1. Choanocytes have flagella that propel water through the body.
2. Pinacocytes can transform into any cell type.
3. Lophocytes secrete collagen.
4. Porocytes control the flow of water through pores in the sponge body.

2.

Figure 28.21 Which of the following statements about the anatomy of a mollusk is false?

1. Mollusks have a radula for grinding food.
2. A digestive gland is connected to the stomach.
3. The tissue beneath the shell is called the mantle.
4. The digestive system includes a gizzard, a stomach, a digestive gland, and the intestine.

3.

Figure 28.45 Which of the following statements about insects is false?

1. Insects have both dorsal and ventral blood vessels.
2. Insects have spiracles, openings that allow air to enter into the tracheal system.
3. The trachea is part of the digestive system.
4. Most insects have a well-developed digestive system with a mouth, crop, and intestine.

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28.3: REVIEW QUESTIONS

4.

Mesohyl contains:

1. a polysaccharide gel and dead cells.
2. a collagen-like gel and suspended cells for various functions.
3. spicules composed of silica or calcium carbonate.
4. multiple pores.

5.

The large central opening in the parazoan body is called the:

1. gemmule.
2. spicule.
3. ostia.
4. osculum.

6.

Most sponge body plans are slight variations on a simple tube-within-a-tube design. Which of the following is a key limitation of sponge body plans?

1. Sponges lack the specialized cell types needed to produce more complex body plans.
2. The reliance on osmosis/diffusion requires a design that maximizes the surface area to volume ratio of the sponge.
3. Choanocytes must be protected from the hostile exterior environment.
4. Spongin cannot support heavy bodies.

7.

Cnidocytes are found in _____.

1. phylum Porifera
2. phylum Nemertea
3. phylum Nematoda
4. phylum Cnidaria

8.

Cubozoans are _____.

1. polyps
2. medusoids
3. polymorphs
4. sponges

9.

While collecting specimens, a marine biologist finds a sessile Cnidarian. The medusas that bud from it swim by contracting a ring of muscle in their bells. To which class does this specimen belong?

1. Class Hydrozoa
2. Class Cubozoa
3. Class Scyphozoa
4. Class Anthozoa

10.

Which group of flatworms are primarily ectoparasites of fish?

1. monogeneans
2. trematodes
3. cestodes
4. turbellarians

11.

The rhynchocoel is a _____.

1. circulatory system

1. circulatory system
2. fluid-filled cavity
3. primitive excretory system
4. proboscis

12.

Annelids have (a):

1. pseudocoelom.
2. true coelom.
3. no coelom.
4. none of the above

13.

A mantle and mantle cavity are present in:

1. phylum Echinodermata.
2. phylum Adversoidea.
3. phylum Mollusca.
4. phylum Nemertea.

14.

How does segmentation enhance annelid locomotion?

1. Segmentation creates repeating body structures so the entire organism functions in synchrony.
2. Segmentation allows specialization of different body regions.
3. Neural segmentation allows annelids to localize sensations.
4. Muscle contractions can be localized to specific regions of the body to coordinate movement.

15.

The embryonic development in nematodes can have up to _____ larval stages.

1. one
2. two
3. three
4. four

16.

The nematode cuticle contains _____.

1. glucose
2. skin cells
3. chitin
4. nerve cells

17.

Crustaceans are _____.

1. ecdysozoans
2. nematodes
3. arachnids
4. parazoans

18.

Flies are_____.

1. chelicerates
2. hexapods
3. arachnids
4. crustaceans

19.

Which of the following is **not** a key advantage provided by the exoskeleton of terrestrial arthropods?

1. Prevents dessication

2. Protects internal tissue
3. Provides mechanical support
4. Grows with the arthropod throughout its life

20.

Echinoderms have _____.

1. triangular symmetry
2. radial symmetry
3. hexagonal symmetry
4. pentaradial symmetry

21.

The circulatory fluid in echinoderms is _____.

1. blood
2. mesohyl
3. water
4. saline

22.

Which of the following features does not distinguish humans as a member of phylum Chordata?

1. Human embryos undergo indeterminate cleavage.
2. A spinal cord runs along an adult human’s dorsal side.
3. Human embryos exhibit pharyngeal arches and gill slits.
4. The human coccyx forms from an embryonic tail.

23.

The sister taxon of the Chordata is the _____.

1. Mollusca
2. Arthropoda
3. Ambulacraria
4. Rotifera

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28.4: CRITICAL THINKING QUESTIONS

24.

Describe the different cell types and their functions in sponges.

25.

Describe the feeding mechanism of sponges and identify how it is different from other animals.

26.

Explain the function of nematocysts in cnidarians.

27.

Compare the structural differences between Porifera and Cnidaria.

28.

Compare the differences in sexual reproduction between Porifera and Cubozoans. How does the difference in fertilization provide an evolutionary advantage to the Cubozoans?

29.

How does the tapeworm body plan support widespread dissemination of the parasite?

30.

Describe the morphology and anatomy of mollusks.

31.

What are the anatomical differences between nemertines and mollusks?

32.

How does a change in the circulatory system organization support the body designs in cephalopods compared to other mollusks?

33.

Enumerate features of *Caenorhabditis elegans* that make it a valuable model system for biologists.

34.

What are the different ways in which nematodes can reproduce?

35.

Why are tardigrades essential to recolonizing habits following destruction or mass extinction?

36.

Describe the various superclasses that phylum Arthropoda can be divided into.

37.

Compare and contrast the segmentation seen in phylum Annelida with that seen in phylum Arthropoda.

38.

How do terrestrial arthropods of the subphylum Hexapoda impact the world’s food supply? Provide at least two positive and two negative effects.

39.

Describe the different classes of echinoderms using examples.

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CHAPTER OVERVIEW

29: VERTEBRATES

Vertebrates are among the most recognizable organisms of the animal kingdom. More than 62,000 vertebrate species have been identified. The vertebrate species now living represent only a small portion of the vertebrates that have existed. The best-known extinct vertebrates are the dinosaurs, a unique group of reptiles, which reached sizes not seen before or after in terrestrial animals. They were the dominant terrestrial animals for 150 million years, until they died out in a mass extinction near the end of the Cretaceous period. Although it is not known with certainty what caused their extinction, a great deal is known about the anatomy of the dinosaurs, given the preservation of skeletal elements in the fossil record.

29.1: Key Terms

29.2: Visual Connection Questions

29.3: Review Questions

29.4: Critical Thinking Questions

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29.1: KEY TERMS

Acanthostega
one of the earliest known tetrapods

Actinopterygii
ray-finned fishes

allantois
membrane of the egg that stores nitrogenous wastes produced by the embryo; also facilitates respiration

amnion
membrane of the egg that protects the embryo from mechanical shock and prevents dehydration

amniote
animal that produces a terrestrially adapted egg protected by amniotic membranes

Amphibia
frogs, salamanders, and caecilians

ampulla of Lorenzini
sensory organ that allows sharks to detect electromagnetic fields produced by living things

anapsid
animal having no temporal fenestrae in the cranium

anthropoid
monkeys, apes, and humans

Anura
frogs

apocrine gland
scent gland that secretes substances that are used for chemical communication

Apoda
caecilians

Archaeopteryx
transition species from dinosaur to bird from the Jurassic period

archosaur
modern crocodilian or bird, or an extinct pterosaur or dinosaur

Australopithecus
genus of hominins that evolved in eastern Africa approximately four million years ago

brachiation
movement through trees branches via suspension from the arms

brumation
period of much reduced metabolism and torpor that occurs in any ectotherm in cold weather

caecilian
legless amphibian that belongs to the clade Apoda

Casineria

one of the oldest known amniotes; had both amphibian and reptilian characteristics

Catarrhini
clade of Old World monkeys

Cephalochordata
chordate clade whose members possess a notochord, dorsal hollow nerve cord, pharyngeal slits, and a post-anal tail in the adult stage

Chondrichthyes
jawed fish with paired fins and a skeleton made of cartilage

Chordata
phylum of animals distinguished by their possession of a notochord, a dorsal hollow nerve cord, pharyngeal slits, and a post-anal tail at some point during their development

chorion
membrane of the egg that surrounds the embryo and yolk sac

contour feather
feather that creates an aerodynamic surface for efficient flight

Craniata
clade composed of chordates that possess a cranium; includes Vertebrata together with hagfishes

cranium
bony, cartilaginous, or fibrous structure surrounding the brain, jaw, and facial bones

Crocodilia
crocodiles and alligators

cutaneous respiration
gas exchange through the skin

dentary
single bone that comprises the lower jaw of mammals

diapsid
animal having two temporal fenestrae in the cranium

diphyodont
refers to the possession of two sets of teeth in a lifetime

dorsal hollow nerve cord
hollow, tubular structure derived from ectoderm, which is located dorsal to the notochord in chordates

down feather
feather specialized for insulation

eccrine gland
sweat gland

Enantiornithes
dominant bird group during the Cretaceous period

eutherian mammal
mammal that possesses a complex placenta, which connects a fetus to the mother; sometimes called placental mammals

flight feather

feather specialized for flight

frog
tail-less amphibian that belongs to the clade Anura

furcula
wishbone formed by the fusing of the clavicles

gnathostome
jawed fish

Gorilla
genus of gorillas

hagfish
eel-like jawless fish that live on the ocean floor and are scavengers

heterodont tooth
different types of teeth that are modified for different purposes

hominin
species that are more closely related to humans than chimpanzees

hominoid
pertaining to great apes and humans

Homo
genus of humans

Homo sapiens sapiens
anatomically modern humans

Hylobatidae
family of gibbons

Hylonomus
one of the earliest reptiles

lamprey
jawless fish characterized by a toothed, funnel-like, sucking mouth

lancelet
member of Cephalochordata; named for its blade-like shape

lateral line
sense organ that runs the length of a fish's body; used to detect vibration in the water

lepidosaur
modern lizards, snakes, and tuataras

mammal
one of the groups of endothermic vertebrates that possesses hair and mammary glands

mammary gland
in female mammals, a gland that produces milk for newborns

marsupial

one of the groups of mammals that includes the kangaroo, koala, bandicoot, Tasmanian devil, and several other species; young develop within a pouch

monotreme
egg-laying mammal

Myxini
hagfishes

Neognathae
birds other than the Paleognathae

Neornithes
modern birds

notochord
flexible, rod-shaped support structure that is found in the embryonic stage of all chordates and in the adult stage of some chordates

Ornithorhynchidae
clade that includes the duck-billed platypus

Osteichthyes
bony fish

ostracoderm
one of the earliest jawless fish covered in bone

Paleognathae
ratites; flightless birds, including ostriches and emus

Pan
genus of chimpanzees and bonobos

Petromyzontidae
clade of lampreys

pharyngeal slit
opening in the pharynx

Platyrrhini
clade of New World monkeys

Plesiadapis
oldest known primate-like mammal

pneumatic bone
air-filled bone

Pongo
genus of orangutans

post-anal tail
muscular, posterior elongation of the body extending beyond the anus in chordates

primary feather
feather located at the tip of the wing that provides thrust

Primates

order of lemurs, tarsiers, monkeys, apes, and humans

prognathic jaw
long jaw

prosimian
division of primates that includes bush babies and pottos of Africa, lemurs of Madagascar, and lorises of Southeast Asia

salamander
tailed amphibian that belongs to the clade Urodela

Sarcopterygii
lobe-finned fish

sauropsid
reptile or bird

sebaceous gland
in mammals, a skin gland that produce a lipid mixture called *sebum*

secondary feather
feather located at the base of the wing that provides lift

Sphenodontia
clade of tuataras

Squamata
clade of lizards and snakes

stereoscopic vision
two overlapping fields of vision from the eyes that produces depth perception

swim bladder
in fishes, a gas filled organ that helps to control the buoyancy of the fish

synapsid
mammal having one temporal fenestra

Tachyglossidae
clade that includes the echidna or spiny anteater

tadpole
larval stage of a frog

temporal fenestra
non-orbital opening in the skull that may allow muscles to expand and lengthen

Testudines
order of turtles

tetrapod
phylogenetic reference to an organism with a four-footed evolutionary history; includes amphibians, reptiles, birds, and mammals

theropod
dinosaur group ancestral to birds

tunicate
sessile chordate that is a member of Urochordata

Urochordata
clade composed of tunicates

Urodela
salamanders

vertebral column
series of separate bones joined together as a backbone

Vertebrata
members of the phylum Chordata that possess a backbone

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29.2: VISUAL CONNECTION QUESTIONS

1.

Figure 29.3 Which of the following statements about common features of chordates is true?

1. The dorsal hollow nerve cord is part of the chordate central nervous system.
2. In vertebrate fishes, the pharyngeal slits become the gills.
3. Humans are not chordates because humans do not have a tail.
4. Vertebrates do not have a notochord at any point in their development; instead, they have a vertebral column.

2.

Figure 29.22 Which of the following statements about the parts of an amniotic egg are false?

1. The allantois stores nitrogenous waste and facilitates respiration.
2. The chorion facilitates gas exchange.
3. The yolk provides food for the growing embryo.
4. The amniotic cavity is filled with albumen.

3.

Figure 29.24 Members of the order Testudines have an anapsid-like skull without obvious temporal fenestrae. However, molecular studies indicate that turtles descended from a diapsid ancestor. Why might this be the case?

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29.3: REVIEW QUESTIONS

4.

Which of the following is *not* contained in phylum Chordata?

1. Cephalochordata
2. Echinodermata
3. Urochordata
4. Vertebrata

5.

Which group of invertebrates is most closely related to vertebrates?

1. cephalochordates
2. echinoderms
3. arthropods
4. urochordates

6.

Hagfish, lampreys, sharks, and tuna are all chordates that can also be classified into which group?

1. Craniates
2. Vertebrates
3. Cartilaginous fish
4. Cephalochordata

7.

Members of Chondrichthyes differ from members of Osteichthyes by having (a) _____.

1. jaw
2. bony skeleton
3. cartilaginous skeleton
4. two sets of paired fins

8.

Members of Chondrichthyes are thought to be descended from fishes that had _____.

1. a cartilaginous skeleton
2. a bony skeleton
3. mucus glands
4. slime glands

9.

A marine biologist catches a species of fish she has never seen before. Upon examination, she determines that the species has a predominantly cartilaginous skeleton and a swim bladder. If its pectoral fins are not fused with its head, to which category of fish does the specimen belong?

1. Rays
2. Osteichthyes
3. Sharks
4. Hagfish

10.

Which of the following is *not* true of *Acanthostega*?

1. It was aquatic.
2. It had gills.
3. It had four limbs.
4. It laid shelled eggs.

11.

Frogs belong to which order?

1. Anura

1. Anura
2. Urodela
3. Caudata
4. Apoda

12.

During the Mesozoic period, diapsids diverged into_____.

1. pterosaurs and dinosaurs
2. mammals and reptiles
3. lepidosaurs and archosaurs
4. Testudines and Sphenodontia

13.

Squamata includes_____.

1. crocodiles and alligators
2. turtles
3. tuataras
4. lizards and snakes

14.

Which of the following reptile groups gave rise to modern birds?

1. Lepidosaurs
2. Pterosaurs
3. Anapsids
4. Archosaurs

15.

A bird or feathered dinosaur is _____.

1. Neornithes
2. *Archaeopteryx*
3. Enantiornithes
4. Paleognathae

16.

Which of the following feather types helps to reduce drag produced by wind resistance during flight?

1. Flight feathers
2. Primary feathers
3. Secondary feathers
4. Contour feathers

17.

Eccrine glands produce _____.

1. sweat
2. lipids
3. scents
4. milk

18.

Monotremes include:

1. kangaroos.
2. koalas.
3. bandicoots.
4. platypuses.

19.

The evolution of which of the following features of mammals is hardest to trace through the fossil record?

1. Jaw structure

2. Mammary glands
3. Middle ear structure
4. Development of hair

20.

Which of the following is *not* an anthropoid?

1. Lemurs
2. Monkeys
3. Apes
4. Humans

21.

Which of the following is part of a clade believed to have died out, leaving no descendants?

1. *Paranthropus robustus*
2. *Australopithecus africanus*
3. *Homo erectus*
4. *Homo sapiens sapiens*

22.

Which of the following human traits is not a shared characteristic of primates?

1. Hip structure supporting bipedalism
2. Detection and processing of three-color vision
3. Nails at the end of each digit
4. Enlarged brain area associated with vision, and reduced area associated with smell

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29.4: CRITICAL THINKING QUESTIONS

23.

What are the characteristic features of the chordates?

24.

What is the structural advantage of the notochord in the human embryo? Be sure to compare the notochord with the corresponding structure in adults.

25.

What can be inferred about the evolution of the cranium and vertebral column from examining hagfishes and lampreys?

26.

Why did gnathostomes replace most agnathans?

27.

Explain why frogs are restricted to a moist environment.

28.

Describe the differences between the larval and adult stages of frogs.

29.

Describe how metamorphosis changes the structures involved in gas exchange over the life cycle of animals in the clade Anura, and what evolutionary advantage this change provides.

30.

Describe the functions of the three extra-embryonic membranes present in amniotic eggs.

31.

What characteristics differentiate lizards and snakes?

32.

Based on how reptiles thermoregulate, which climates would you predict to have the highest reptile population density, and why?

33.

Explain why birds are thought to have evolved from theropod dinosaurs.

34.

Describe three skeletal adaptations that allow for flight in birds.

35.

How would the chest structure differ between ostriches, penguins, and terns?

36.

Describe three unique features of the mammalian skeletal system.

37.

Describe three characteristics of the mammalian brain that differ from other vertebrates.

38.

How did the evolution of jaw musculature allow mammals to spread?

39.

How did archaic *Homo sapiens* differ from anatomically modern humans?

40.

Why is it so difficult to determine the sequence of hominin ancestors that have led to modern *Homo sapiens*?

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CHAPTER OVERVIEW

30: ECOLOGY AND THE BIOSPHERE

Humans are a part of the ecological landscape, and human health is one important part of human interaction with our physical and living environment.

30.1: Key Terms

30.2: Visual Connection Questions

30.3: Review Questions

30.4: Critical Thinking Questions

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30.1: KEY TERMS

abiotic
nonliving components of the environment

above-ground biomass
total mass of aboveground living plants per area

abyssal zone
deepest part of the ocean at depths of 4000 m or greater

algal bloom
rapid increase of algae in an aquatic system

aphotic zone
part of the ocean where no light penetrates

benthic realm
(also, benthic zone) part of the ocean that extends along the ocean bottom from the shoreline to the deepest parts of the ocean floor

biogeography
study of the geographic distribution of living things and the abiotic factors that affect their distribution

biome
ecological community of plants, animals, and other organisms that is adapted to a characteristic set of environmental conditions

biotic
living components of the environment

canopy
branches and foliage of trees that form a layer of overhead coverage in a forest

channel
width of a river or stream from one bank to the other bank

clathrates
frozen chunks of ice and methane found at the bottom of the ocean

climate
long-term, predictable atmospheric conditions present in a specific area

conspecifics
individuals that are members of the same species

coral reef
ocean ridges formed by marine invertebrates living in warm, shallow waters within the photic zone

cryptofauna
invertebrates found within the calcium carbonate substrate of coral reefs

ecology
study of interaction between living things and their environment

ecosystem services
human benefits and services provided by natural ecosystems

emergent vegetation

wetland plants that are rooted in the soil but have portions of leaves, stems, and flowers extending above the water's surface

endemic
species found only in a specific geographic area that is usually restricted in size

estuary
biomes where a source of fresh water, such as a river, meets the ocean

fall and spring turnover
seasonal process that recycles nutrients and oxygen from the bottom of a freshwater ecosystem to the top

global climate change
altered global weather patterns, including a worldwide increase in temperature, due largely to rising levels of atmospheric carbon dioxide

greenhouse effect
warming of Earth due to carbon dioxide and other greenhouse gases in the atmosphere

greenhouse gases
atmospheric gases such as carbon dioxide and methane that absorb and emit radiation, thus trapping heat in Earth's atmosphere

haze-effect cooling
effect of the gases and solids from a volcanic eruption on global climate

heterospecifics
individuals that are members of different species

intertidal zone
part of the ocean that is closest to land; parts extend above the water at low tide

Milankovitch cycles
cyclic changes in the Earth's orbit that may affect climate

neritic zone
part of the ocean that extends from low tide to the edge of the continental shelf

net primary productivity
measurement of the energy accumulation within an ecosystem, calculated as the total amount of carbon fixed per year minus the amount that is oxidized during cellular respiration

ocean upwelling
rising of deep ocean waters that occurs when prevailing winds blow along surface waters near a coastline

oceanic zone
part of the ocean that begins offshore where the water measures 200 m deep or deeper

pelagic realm
(also, pelagic zone) open ocean waters that are not close to the bottom or near the shore

permafrost
perennially frozen portion of the Arctic tundra soil

photic zone
portion of the ocean that light can penetrate

planktivore
animal species that eats plankton

predator

organism that kills and consumes another organism

Sargassum

type of free-floating marine seaweed

solar intensity

amount of solar power energy the sun emits in a given amount of time

source water

point of origin of a river or stream

thermocline

layer of water with a temperature that is significantly different from that of the surrounding layers

weather

conditions of the atmosphere during a short period of time

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30.2: VISUAL CONNECTION QUESTIONS

1.

Figure 44.10 How might turnover in tropical lakes differ from turnover in lakes that exist in temperate regions? Think of the variation, or lack of variation, in seasonal temperature change.

2.

Figure 44.12 Which of the following statements about biomes is false?

1. Chaparral is dominated by shrubs.
2. Savannas and temperate grasslands are dominated by grasses.
3. Boreal forests are dominated by deciduous trees.
4. Lichens are common in the arctic tundra.

3.

Figure 44.21 In which of the following regions would you expect to find photosynthetic organisms?

1. the aphotic zone, the neritic zone, the oceanic zone, and the benthic realm
2. the photic zone, the intertidal zone, the neritic zone, and the oceanic zone
3. the photic zone, the abyssal zone, the neritic zone, and the oceanic zone
4. the pelagic realm, the aphotic zone, the neritic zone, and the oceanic zone

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30.3: REVIEW QUESTIONS

4.

Which of the following is a biotic factor?

1. wind
2. disease-causing microbe
3. temperature
4. soil particle size

5.

The study of nutrient cycling though the environment is an example of which of the following?

1. organismal ecology
2. population ecology
3. community ecology
4. ecosystem ecology

6.

Understory plants in a temperate forest have adaptations to capture limited _____.

1. water
2. nutrients
3. heat
4. sunlight

7.

An ecologist hiking up a mountain may notice different biomes along the way due to changes in all of the following except:

1. elevation
2. rainfall
3. latitude
4. temperature

8.

Which of the following biomes is characterized by abundant water resources?

1. deserts
2. boreal forests
3. savannas
4. tropical wet forests

9.

Which of the following biomes is characterized by short growing seasons?

1. deserts
2. tropical wet forests
3. Arctic tundras
4. savannas

10.

Where would you expect to find the most photosynthesis in an ocean biome?

1. aphotic zone
2. abyssal zone
3. benthic realm
4. intertidal zone

11.

A key feature of estuaries is:

1. low light conditions and high productivity
2. salt water and fresh water

3. frequent algal blooms
4. little or no vegetation

12.

Which of the following is an example of a weather event?

1. The hurricane season lasts from June 1 through November 30.
2. The amount of atmospheric CO_2 has steadily increased during the last century.
3. A windstorm blew down trees in the Boundary Waters Canoe Area in Minnesota on July 4, 1999.
4. Deserts are generally dry ecosystems having very little rainfall.

13.

Which of the following natural forces is responsible for the release of carbon dioxide and other atmospheric gases?

1. the Milankovitch cycles
2. volcanoes
3. solar intensity
4. burning of fossil fuels

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30.4: CRITICAL THINKING QUESTIONS

14.

Ecologists often collaborate with other researchers interested in ecological questions. Describe the levels of ecology that would be easier for collaboration because of the similarities of questions asked. What levels of ecology might be more difficult for collaboration?

15.

The population is an important unit in ecology as well as other biological sciences. How is a population defined, and what are the strengths and weaknesses of this definition? Are there some species that at certain times or places are not in populations?

16.

Compare and contrast ocean upwelling and spring and fall turnovers.

17.

Many endemic species are found in areas that are geographically isolated. Suggest a plausible scientific explanation for why this is so.

18.

The extremely low precipitation of subtropical desert biomes might lead one to expect fire to be a major disturbance factor; however, fire is more common in the temperate grassland biome than in the subtropical desert biome. Why is this?

19.

In what ways are the subtropical desert and the arctic tundra similar?

20.

Scientists have discovered the bodies of humans and other living things buried in bogs for hundreds of years, but not yet decomposed. Suggest a possible biological explanation for why such bodies are so well-preserved.

21.

Describe the conditions and challenges facing organisms living in the intertidal zone.

22.

Compare and contrast how natural- and human-induced processes have influenced global climate change.

23.

Predict possible consequences if carbon emissions from fossil fuels continue to rise.

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CHAPTER OVERVIEW

31: POPULATION AND COMMUNITY ECOLOGY

Community ecology is the study of the interactions between species in communities on many spatial and temporal scales, including the distribution, structure, abundance, demography, and interactions between coexisting populations. The primary focus of community ecology is on the interactions between populations as determined by specific genotypic and phenotypic characteristics.

31.1: Key Terms

31.2: Visual Connection Questions

31.3: Review Questions

31.4: Critical Thinking Questions

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31.1: KEY TERMS

age structure
proportion of population members at specific age ranges

aggressive display
visual display by a species member to discourage other members of the same species or different species

aposematic coloration
warning coloration used as a defensive mechanism against predation

Batesian mimicry
type of mimicry where a non-harmful species takes on the warning colorations of a harmful one

behavior
change in an organism's activities in response to a stimulus

behavioral biology
study of the biology and evolution of behavior

biotic potential (r_{max})
maximal potential growth rate of a species

birth rate (*B*)
number of births within a population at a specific point in time

camouflage
avoid detection by blending in with the background

carrying capacity (*K*)
number of individuals of a species that can be supported by the limited resources of a habitat

classical conditioning
association of a specific stimulus and response through conditioning

climax community
final stage of succession, where a stable community is formed by a characteristic assortment of plant and animal species

cognitive learning
knowledge and skills acquired by the manipulation of information in the mind

commensalism
relationship between species wherein one species benefits from the close, prolonged interaction, while the other species neither benefits nor is harmed

competitive exclusion principle
no two species within a habitat can coexist when they compete for the same resources at the same place and time

conditioned behavior
behavior that becomes associated with a specific stimulus through conditioning

courtship display
visual display used to attract a mate

death rate (*D*)
number of deaths within a population at a specific point in time

demographic-based population model
modern model of population dynamics incorporating many features of the *r*- and *K*-selection theory

demography
statistical study of changes in populations over time

density-dependent regulation
regulation of population that is influenced by population density, such as crowding effects; usually involves biotic factors

density-independent regulation
regulation of populations by factors that operate independent of population density, such as forest fires and volcanic eruptions; usually involves abiotic factors

distraction display
visual display used to distract predators away from a nesting site

Emsleyan/Mertensian mimicry
type of mimicry where a harmful species resembles a less harmful one

energy budget
allocation of energy resources for body maintenance, reproduction, and parental care

environmental disturbance
change in the environment caused by natural disasters or human activities

ethology
biological study of animal behavior

exponential growth
accelerating growth pattern seen in species under conditions where resources are not limiting

fecundity
potential reproductive capacity of an individual

fixed action pattern
series of instinctual behaviors that, once initiated, always goes to completion regardless of changes in the environment

foraging
behaviors species use to find food

foundation species
species which often forms the major structural portion of the habitat

habituation
ability of a species to ignore repeated stimuli that have no consequence

host
organism a parasite lives on

imprinting
identification of parents by newborns as the first organism they see after birth

innate behavior
instinctual behavior that is not altered by changes in the environment

intersexual selection
selection of a desirable mate of the opposite sex

interspecific competition

competition between species for resources in a shared habitat or environment

intrasexual selection
competition between members of the same sex for a mate

intraspecific competition
competition between members of the same species

island biogeography
study of life on island chains and how their geography interacts with the diversity of species found there

iteroparity
life history strategy characterized by multiple reproductive events during the lifetime of a species

J-shaped growth curve
shape of an exponential growth curve

***K*-selected species**
species suited to stable environments that produce a few, relatively large offspring and provide parental care

keystone species
species whose presence is key to maintaining biodiversity in an ecosystem and to upholding an ecological community's structure

kin selection
sacrificing one's own life so that one's genes will be passed on to future generations by relatives

kinesis
undirected movement of an organism in response to a stimulus

learned behavior
behavior that responds to changes in the environment

life history
inherited pattern of resource allocation under the influence of natural selection and other evolutionary forces

life table
table showing the life expectancy of a population member based on its age

logistic growth
leveling off of exponential growth due to limiting resources

mark and recapture
technique used to determine population size in mobile organisms

migration
long-range seasonal movement of animal species

monogamy
mating system whereby one male and one female remain coupled for at least one mating season

mortality rate
proportion of population surviving to the beginning of an age interval that die during the age interval

Müllerian mimicry
type of mimicry where species share warning coloration and all are harmful to predators

mutualism
symbiotic relationship between two species where both species benefit

one-child policy
China's policy to limit population growth by limiting urban couples to have only one child or face the penalty of a fine

operant conditioning
learned behaviors in response to positive and/or negative reinforcement

parasite
organism that uses resources from another species, the host

pioneer species
first species to appear in primary and secondary succession

polyandry
mating system where one female mates with many males

polygyny
mating system where one male mates with many females

population density
number of population members divided by the area or volume being measured

population growth rate
number of organisms added in each reproductive generation

population size (*N*)
number of population members in a habitat at the same time

primary succession
succession on land that previously has had no life

quadrat
square made of various materials used to determine population size and density in slow moving or stationary organisms

***r*-selected species**
species suited to changing environments that produce many offspring and provide little or no parental care

reflex action
action in response to direct physical stimulation of a nerve

relative species abundance
absolute population size of a particular species relative to the population sizes of other species within the community

S-shaped growth curve
shape of a logistic growth curve

secondary succession
succession in response to environmental disturbances that move a community away from its equilibrium

semelparity
life history strategy characterized by a single reproductive event followed by death

signal
method of communication between animals including those obtained by the senses of smell, hearing, sight, or touch

species dispersion pattern
(also, species distribution pattern) spatial location of individuals of a given species within a habitat at a particular point in time

species richness

number of different species in a community

survivorship curve

graph of the number of surviving population members versus the relative age of the member

symbiosis

close interaction between individuals of different species over an extended period of time that impacts the abundance and distribution of the associating populations

taxis

directed movement in response to a stimulus

zero population growth

steady population size where birth rates and death rates are equal

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31.2: VISUAL CONNECTION QUESTIONS

1.

Figure 45.2 As this graph shows, population density typically decreases with increasing body size. Why do you think this is the case?

2.

Figure 45.10b If the major food source of the seals declines due to pollution or overfishing, which of the following would likely occur?

1. The carrying capacity of seals would decrease, as would the seal population.
2. The carrying capacity of seals would decrease, but the seal population would remain the same.
3. The number of seal deaths would increase but the number of births would also increase, so the population size would remain the same.
4. The carrying capacity of seals would remain the same, but the population of seals would decrease.

3.

Figure 45.16 Age structure diagrams for rapidly growing, slow growing, and stable populations are shown in stages 1 through 3. What type of population change do you think stage 4 represents?

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31.3: REVIEW QUESTIONS

4.

Which of the following methods will tell an ecologist about both the size and density of a population?

1. mark and recapture
2. mark and release
3. quadrat
4. life table

5.

Which of the following is best at showing the life expectancy of an individual within a population?

1. quadrat
2. mark and recapture
3. survivorship curve
4. life table

6.

Humans have which type of survivorship curve?

1. Type I
2. Type II
3. Type III
4. Type IV

7.

How is a clumped population distribution beneficial for prey animals?

1. Being a member of a larger group provides protection for each individual from predators.
2. Prey animals rely on each other to acquire food.
3. Prey animals live in small family groups to raise young.
4. Clumped population distributions ensure that at least one member of the population knows how to identify the seasonal migration route.

8.

Which of the following is associated with long-term parental care?

1. few offspring
2. many offspring
3. semelparity
4. fecundity

9.

Which of the following is associated with multiple reproductive episodes during a species' lifetime?

1. semiparity
2. iteroparity
3. semelparity
4. fecundity

10.

Which of the following is associated with the reproductive potential of a species?

1. few offspring
2. many offspring
3. semelparity
4. fecundity

11.

Species with limited resources usually exhibit a(n) _____ growth curve.

1. logistic
2. logical

3. experimental
4. exponential

12.

The maximum rate of increased characteristic of a species is called its _____.

1. limit
2. carrying capacity
3. biotic potential
4. exponential growth pattern

13.

The population size of a species capable of being supported by the environment is called its _____.

1. limit
2. carrying capacity
3. biotic potential
4. logistic growth pattern

14.

Species that have many offspring at one time are usually:

1. *r*-selected
2. *K*-selected
3. both *r*- and *K*-selected
4. not selected

15.

A forest fire is an example of _____ regulation.

1. density-dependent
2. density-independent
3. *r*-selected
4. *K*-selected

16.

Primates are examples of:

1. density-dependent species
2. density-independent species
3. *r*-selected species
4. *K*-selected species

17.

Which of the following statements does not support the conclusion that giraffes are *k*-selected species?

1. Giraffes are approximately 6’ tall and weigh 150 lbs at birth.
2. Wild giraffes begin mating at 6-7 years of age.
3. Newborn giraffes are capable of coordinated walking within an hour of birth, and running within 24 hours of birth.
4. Giraffes rarely give birth to twins.

18.

Which of the following events would **not** negatively impact Yellowstone’s grey wolf carrying capacity?

1. snow in winter
2. a beaver damming a river upstream
3. a forest fire
4. chronic wasting disease in the deer population

19.

A country with zero population growth is likely to be _____.

1. in Africa
2. in Asia

3. economically developed
4. economically underdeveloped

20.

Which type of country has the greatest proportion of young individuals?

1. economically developed
2. economically underdeveloped
3. countries with zero population growth
4. countries in Europe

21.

Which of the following is not a way that humans have increased the carrying capacity of the environment?

1. agriculture
2. using large amounts of natural resources
3. domestication of animals
4. use of language

22.

The first species to live on new land, such as that formed from volcanic lava, are called _____.

1. climax community
2. keystone species
3. foundation species
4. pioneer species

23.

Which type of mimicry involves multiple species with similar warning coloration that are all toxic to predators?

1. Batesian mimicry
2. Müllerian mimicry
3. Emsleyan/Mertensian mimicry
4. Mertensian mimicry

24.

A symbiotic relationship where both of the coexisting species benefit from the interaction is called _____.

1. commensalism
2. parasitism
3. mutualism
4. communism

25.

Which of the following is **not** a mutualistic relationship?

1. a shark using an aquatic cleaning station
2. a helminth feeding from its host
3. a bumblebee collecting pollen from a flower
4. bacteria living in the gut of humans

26.

The ability of rats to learn how to run a maze is an example of _____.

1. imprinting
2. classical conditioning
3. operant conditioning
4. cognitive learning

27.

The training of animals usually involves _____.

1. imprinting
2. classical conditioning

3. operant conditioning
4. cognitive learning

28.

The sacrifice of the life of an individual so that the genes of relatives may be passed on is called _____.

1. operant learning
2. kin selection
3. kinesis
4. imprinting

29.

Why are polyandrous mating systems more rare than polygynous matings?

1. Only males are capable of multiple rounds of reproduction within a single breeding season.
2. Only females care for the young.
3. Females usually experience more intrasexual selection pressure than males.
4. Females usually devote more energy to offspring production and development.

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31.4: CRITICAL THINKING QUESTIONS

30.

Describe how a researcher would determine the size of a penguin population in Antarctica using the mark and release method.

31.

The CDC released the following data in its 2013 Vital Statistics report.

Age interval	Number dying in age interval	Number surviving at beginning of age interval
0-10	756	100,000
11-20	292	99,244
21-30	890	98,953
31-40	1,234	98,164
41-50	2,457	96,811
51-60	5,564	94,352
61-70	10,479	88,788

Table 45.3

Calculate the mortality rate for each age interval, and describe the trends in adult and childhood mortality per 100,000 births in the United States in 2013.

32.

Why is long-term parental care not associated with having many offspring during a reproductive episode?

33.

Describe the difference in evolutionary pressures experienced by an animal that begins reproducing early and an animal that reproduces late in its lifecycle.

34.

Describe the rate of population growth that would be expected at various parts of the S-shaped curve of logistic growth.

35.

Describe how the population of a species that survives a mass extinction event would change in size and growth pattern over time beginning immediately after the extinction event.

36.

Give an example of how density-dependent and density-independent factors might interact.

37.

Describe the age structures in rapidly growing countries, slowly growing countries, and countries with zero population growth.

38.

Since the introduction of the Endangered Species Act the number of species on the protected list has more than doubled. Describe how the human population’s growth pattern contributes to the rise in endangered species.

39.

Describe the competitive exclusion principle and its effects on competing species.

40.

Jaguars are a keystone species in the Amazon. Describe how they can be so essential to the ecosystem despite being significantly less abundant than many other species.

41.

Describe Pavlov’s dog experiments as an example of classical conditioning.

42.

Describe the advantage of using an aural or pheromone signal to attract a mate as opposed to a visual signal. How might the population density contribute to the evolution of aural or visual mating rituals?

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CHAPTER OVERVIEW

32: ECOSYSTEMS

Ecosystem ecology is the integrated study of living (biotic) and non-living (abiotic) components of ecosystems and their interactions within an ecosystem framework. This science examines how ecosystems work and relates this to their components such as chemicals, bedrock, soil, plants, and animals.

32.1: Key Terms

32.2: Visual Connection Questions

32.3: Review Questions

32.4: Critical Thinking Questions

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32.1: KEY TERMS

acid rain
corrosive rain caused by rainwater falling to the ground through sulfur dioxide gas, turning it into weak sulfuric acid; can damage structures and ecosystems

analytical model
ecosystem model that is created with mathematical formulas to predict the effects of environmental disturbances on ecosystem structure and dynamics

apex consumer
organism at the top of the food chain

assimilation
biomass consumed and assimilated from the previous trophic level after accounting for the energy lost due to incomplete ingestion of food, energy used for respiration, and energy lost as waste

biogeochemical cycle
cycling of mineral nutrients through ecosystems and through the nonliving world

biomagnification
increasing concentrations of persistent, toxic substances in organisms at each trophic level, from the primary producers to the apex consumers

biomass
total weight, at the time of measurement, of living or previously living organisms in a unit area within a trophic level

chemoautotroph
organism capable of synthesizing its own food using energy from inorganic molecules

conceptual model
(also, compartment model) ecosystem model that consists of flow charts that show the interactions of different compartments of the living and nonliving components of the ecosystem

dead zone
area within an ecosystem in lakes and near the mouths of rivers where large areas of ecosystems are depleted of their normal flora and fauna; these zones can be caused by eutrophication, oil spills, dumping of toxic chemicals, and other human activities

detrital food web
type of food web in which the primary consumers consist of decomposers; these are often associated with grazing food webs within the same ecosystem

ecological pyramid
(also, Eltonian pyramid) graphical representation of different trophic levels in an ecosystem based of organism numbers, biomass, or energy content

ecosystem
community of living organisms and their interactions with their abiotic environment

ecosystem dynamics
study of the changes in ecosystem structure caused by changes in the environment or internal forces

equilibrium
steady state of an ecosystem where all organisms are in balance with their environment and each other

eutrophication

process whereby nutrient runoff causes the excess growth of microorganisms, depleting dissolved oxygen levels and killing ecosystem fauna

fallout
direct deposit of solid minerals on land or in the ocean from the atmosphere

food chain
linear representation of a chain of primary producers, primary consumers, and higher-level consumers used to describe ecosystem structure and dynamics

food web
graphic representation of a holistic, nonlinear web of primary producers, primary consumers, and higher-level consumers used to describe ecosystem structure and dynamics

grazing food web
type of food web in which the primary producers are either plants on land or phytoplankton in the water; often associated with a detrital food web within the same ecosystem

gross primary productivity
rate at which photosynthetic primary producers incorporate energy from the sun

holistic ecosystem model
study that attempts to quantify the composition, interactions, and dynamics of entire ecosystems; often limited by economic and logistical difficulties, depending on the ecosystem

hydrosphere
area of the Earth where water movement and storage occurs

mesocosm
portion of a natural ecosystem to be used for experiments

microcosm
re-creation of natural ecosystems entirely in a laboratory environment to be used for experiments

net consumer productivity
energy content available to the organisms of the next trophic level

net primary productivity
energy that remains in the primary producers after accounting for the organisms' respiration and heat loss

net production efficiency (NPE)
measure of the ability of a trophic level to convert the energy it receives from the previous trophic level into biomass

nonrenewable resource
resource, such as fossil fuel, that is either regenerated very slowly or not at all

primary consumer
trophic level that obtains its energy from the primary producers of an ecosystem

primary producer
trophic level that obtains its energy from sunlight, inorganic chemicals, or dead and/or decaying organic material

residence time
measure of the average time an individual water molecule stays in a particular reservoir

resilience (ecological)
speed at which an ecosystem recovers equilibrium after being disturbed

resistance (ecological)
ability of an ecosystem to remain at equilibrium in spite of disturbances

secondary consumer
usually a carnivore that eats primary consumers

simulation model
ecosystem model that is created with computer programs to holistically model ecosystems and to predict the effects of environmental disturbances on ecosystem structure and dynamics

subduction
movement of one tectonic plate beneath another

tertiary consumer
carnivore that eats other carnivores

trophic level
position of a species or group of species in a food chain or a food web

trophic level transfer efficiency (TLTE)
energy transfer efficiency between two successive trophic levels

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32.2: VISUAL CONNECTION QUESTIONS

1.

Figure 46.8 Why do you think the value for gross productivity of the primary producers is the same as the value for total heat and respiration (20,810 kcal/m^2/yr)?

2.

Figure 46.10 Pyramids depicting the number of organisms or biomass may be inverted, upright, or even diamond-shaped. Energy pyramids, however, are always upright. Why?

3.

Figure 46.17 Which of the following statements about the nitrogen cycle is false?

1. Ammonification converts organic nitrogenous matter from living organisms into ammonium (NH_4^+).
2. Denitrification by bacteria converts nitrates (NO_3^-) to nitrogen gas (N_2).
3. Nitrification by bacteria converts nitrates (NO_3^-) to nitrites (NO_2^-).
4. Nitrogen fixing bacteria convert nitrogen gas (N_2) into organic compounds.

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32.3: REVIEW QUESTIONS

4.

The ability of an ecosystem to return to its equilibrium state after an environmental disturbance is called _____.

1. resistance
2. restoration
3. reformation
4. resilience

5.

A re-created ecosystem in a laboratory environment is known as a _____.

1. mesocosm
2. simulation
3. microcosm
4. reproduction

6.

Decomposers are associated with which class of food web?

1. grazing
2. detrital
3. inverted
4. aquatic

7.

The primary producers in an ocean grazing food web are usually _____.

1. plants
2. animals
3. fungi
4. phytoplankton

8.

What term describes the use of mathematical equations in the modeling of linear aspects of ecosystems?

1. analytical modeling
2. simulation modeling
3. conceptual modeling
4. individual-based modeling

9.

The position of an organism along a food chain is known as its _____.

1. locus
2. location
3. trophic level
4. microcosm

10.

The loss of an apex consumer would impact which trophic level of a food web?

1. primary producers
2. primary consumers
3. secondary consumers
4. all of the above

11.

A food chain would be a better resource than a food web to answer which question?

1. How does energy move from an organism in one trophic level to an organism on the next trophic level?
2. How does energy move within a trophic level?

3. What preys on grasses?
4. How is organic matter recycled in a forest?

12.

The weight of living organisms in an ecosystem at a particular point in time is called:

1. energy
2. production
3. entropy
4. biomass

13.

Which term describes the process whereby toxic substances increase along trophic levels of an ecosystem?

1. biomassification
2. biomagnification
3. bioentropy
4. heterotrophy

14.

Organisms that can make their own food using inorganic molecules are called:

1. autotrophs
2. heterotrophs
3. photoautotrophs
4. chemoautotrophs

15.

In the English Channel ecosystem, the number of primary producers is smaller than the number of primary consumers because_____.

1. the apex consumers have a low turnover rate
2. the primary producers have a low turnover rate
3. the primary producers have a high turnover rate
4. the primary consumers have a high turnover rate

16.

What law of chemistry determines how much energy can be transferred when it is converted from one form to another?

1. the first law of thermodynamics
2. the second law of thermodynamics
3. the conservation of matter
4. the conservation of energy

17.

The mussels that live at the NW Eifuku volcano are examples of _____.

1. chemoautotrophs
2. photoautotrophs
3. apex predators
4. primary consumers

18.

The movement of mineral nutrients through organisms and their environment is called a _____ cycle.

1. biological
2. bioaccumulation
3. biogeochemical
4. biochemical

19.

Carbon is present in the atmosphere as _____.

1. carbon dioxide
2. carbonate ion

3. carbon dust
4. carbon monoxide

20.

The majority of water found on Earth is:

1. ice
2. water vapor
3. fresh water
4. salt water

21.

The average time a molecule spends in its reservoir is known as _____.

1. residence time
2. restriction time
3. resilience time
4. storage time

22.

The process whereby oxygen is depleted by the growth of microorganisms due to excess nutrients in aquatic systems is called _____.

1. dead zoning
2. eutrophication
3. retrofication
4. depletion

23.

The process whereby nitrogen is brought into organic molecules is called _____.

1. nitrification
2. denitrification
3. nitrogen fixation
4. nitrogen cycling

24.

Which of the following approaches would be the most effective way to reduce greenhouse carbon dioxide?

1. Increase waste deposition into the deep ocean.
2. Plant more environmentally-suitable plants.
3. Increase use of fuel sources that do not produce carbon dioxide as a by-product.
4. Decrease livestock agriculture.

25.

How would loss of fungi in a forest effect biogeochemical cycles in the area?

1. Nitrogen could no longer be fixed into organic molecules.
2. Phosphorus stores would be released for use by other organisms.
3. Sulfur release from eroding rocks would cease.
4. Carbon would accumulate in dead organic matter and waste.

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32.4: CRITICAL THINKING QUESTIONS

26.

Compare and contrast food chains and food webs. What are the strengths of each concept in describing ecosystems?

27.

Describe freshwater, ocean, and terrestrial ecosystems.

28.

Compare grazing and detrital food webs. Why would they both be present in the same ecosystem?

29.

How does the microcosm modeling approach differ from utilizing a holistic model for ecological research?

30.

How do conceptual and analytical models of ecosystems complement each other?

31.

Compare the three types of ecological pyramids and how well they describe ecosystem structure. Identify which ones can be inverted and give an example of an inverted pyramid for each.

32.

How does the amount of food a warm-blooded animal (endotherm) eats relate to its net production efficiency (NPE)?

33.

A study uses an inverted pyramid to demonstrate the relationship between sharks, their aquatic prey, and phytoplankton in an ocean region. What type of pyramid must be used? What does this convey to readers about predation in the area?

34.

Describe what a pyramid of numbers would like if an ecologist models the relationship between bird parasites, blue jays, and oak trees in a hectare. Does this match the energy flow pyramid?

35.

Describe nitrogen fixation and why it is important to agriculture.

36.

What are the factors that cause dead zones? Describe eutrophication, in particular, as a cause.

37.

Why are drinking water supplies still a major concern for many countries?

38.

Discuss how the human disruption of the carbon cycle has caused ocean acidification.

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CHAPTER OVERVIEW

33: CONSERVATION BIOLOGY AND BIODIVERSITY

Conservation biology is the management of nature and of Earth's biodiversity with the aim of protecting species, their habitats, and ecosystems from excessive rates of extinction and the erosion of biotic interactions. It is an interdisciplinary subject drawing on natural and social sciences, and the practice of natural resource management.

33.1: Key Terms

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33.1: KEY TERMS

adaptive radiation
rapid branching through speciation of a phylogenetic tree into many closely related species

biodiversity
variety of a biological system, typically conceived as the number of species, but also applying to genes, biochemistry, and ecosystems

biodiversity hotspot
concept originated by Norman Myers to describe a geographical region with a large number of endemic species and a large percentage of degraded habitat

bush meat
wild-caught animal used as food (typically mammals, birds, and reptiles); usually referring to hunting in the tropics of sub-Saharan Africa, Asia, and the Americas

chemical diversity
variety of metabolic compounds in an ecosystem

chytridiomycosis
disease of amphibians caused by the fungus *Batrachochytrium dendrobatidis;* thought to be a major cause of the global amphibian decline

DNA barcoding
molecular genetic method for identifying a unique genetic sequence to associate with a species

ecosystem diversity
variety of ecosystems

endemic species
species native to one place

exotic species
(also, invasive species) species that has been introduced to an ecosystem in which it did not evolve

extinction
disappearance of a species from Earth; local extinction is the disappearance of a species from a region

extinction rate
number of species becoming extinct over time, sometimes defined as extinctions per million species–years to make numbers manageable (E/MSY)

genetic diversity
variety of genes in a species or other taxonomic group or ecosystem, the term can refer to allelic diversity or genome-wide diversity

heterogeneity
number of ecological niches

megafauna
large animals

secondary plant compound
compound produced as byproducts of plant metabolic processes that is usually toxic, but is sequestered by the plant to defend against herbivores

species-area relationship

relationship between area surveyed and number of species encountered; typically measured by incrementally increasing the area of a survey and determining the cumulative numbers of species

tragedy of the commons

economic principle that resources held in common will inevitably be overexploited

white-nose syndrome

disease of cave-hibernating bats in the eastern United States and Canada associated with the fungus *Geomyces destructans*

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33.2: VISUAL CONNECTION QUESTIONS

1.

Figure 47.6 Scientists measured the relative abundance of fern spores above and below the K-Pg boundary in this rock sample. Which of the following statements most likely represents their findings?

1. An abundance of fern spores from several species was found below the K-Pg boundary, but none was found above.
2. An abundance of fern spores from several species was found above the K-Pg boundary, but none was found below.
3. An abundance of fern spores was found both above and below the K-Pg boundary, but only one species was found below the boundary , and many species were found above the boundary.
4. Many species of fern spores were found both above and below the boundary, but the total number of spores was greater below the boundary.

2.

Figure 47.9 The Svalbard Global Seed Vault is located on Spitsbergen island in Norway, which has an arctic climate. Why might an arctic climate be good for seed storage?

3.

Converting a prairie to a farm field is an example of _____.

1. overharvesting
2. habitat loss
3. exotic species
4. climate change

4.

Figure 47.16 Which of the following statements is not supported by this graph?

1. There are more vulnerable fishes than critically endangered and endangered fishes combined.
2. There are more critically endangered amphibians than vulnerable, endangered and critically endangered reptiles combined.
3. Within each group, there are more critically endangered species than vulnerable species.
4. A greater percentage of bird species are critically endangered than mollusk species.

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33.3: REVIEW QUESTIONS

5.

With an extinction rate of 100 E/MSY and an estimated 10 million species, how many extinctions are expected to occur in a century?

1. 100
2. 10,000
3. 100,000
4. 1,000,000

6.

An adaptive radiation is_____.

1. a burst of speciation
2. a healthy level of UV radiation
3. a hypothesized cause of a mass extinction
4. evidence of an asteroid impact

7.

The number of currently described species on the planet is about _____.

1. 17,000
2. 150,000
3. 1.5 million
4. 10 million

8.

A mass extinction is defined as _____.

1. a loss of 95 percent of species
2. an asteroid impact
3. a boundary between geological periods
4. a loss of 50 percent of species

9.

A secondary plant compound might be used for which of the following?

1. a new crop variety
2. a new drug
3. a soil nutrient
4. a pest of a crop pest

10.

Pollination is an example of _____.

1. a possible source of new drugs
2. chemical diversity
3. an ecosystem service
4. crop pest control

11.

What is an ecosystem service that performs the same function as a pesticide?

1. pollination
2. secondary plant compounds
3. crop diversity
4. predators of pests

12.

Which two extinction risks may be a direct result of the pet trade?

1. climate change and exotic species introduction
2. habitat loss and overharvesting

3. overharvesting and exotic species introduction
4. habitat loss and climate change

13.

Exotic species are especially threatening to what kind of ecosystem?

1. deserts
2. marine ecosystems
3. islands
4. tropical forests

14.

Certain parrot species cannot be brought to the United States to be sold as pets. What is the name of the legislation that makes this illegal?

1. Red List
2. Migratory Bird Act
3. CITES
4. Endangered Species Act (ESA)

15.

What was the name of the first international agreement on climate change?

1. Red List
2. Montreal Protocol
3. International Union for the Conservation of Nature (IUCN)
4. Kyoto Protocol

16.

About what percentage of land on the planet is set aside as a preserve of some type?

1. 1 percent
2. 6 percent
3. 11 percent
4. 15 percent

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33.4: CRITICAL THINKING QUESTIONS

17.

Describe the evidence for the cause of the Cretaceous–Paleogene (K–Pg) mass extinction.

18.

Describe the two methods used to calculate contemporary extinction rates.

19.

Explain how biodiversity loss can impact crop diversity.

20.

Describe two types of compounds from living things that are used as medications.

21.

Describe the mechanisms by which human population growth and resource use causes increased extinction rates.

22.

Explain what extinction threats a frog living on a mountainside in Costa Rica might face.

23.

Describe two considerations in conservation preserve design.

24.

Describe what happens to an ecosystem when a keystone species is removed.

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