Unit 4: Interactions
Big Idea 4: Biological systems interact, and these systems and their interactions possess complex properties.

4.A.1: The subcomponents of biological molecules and their sequence determine the properties of that molecule. 5.1, 5.2, 5.3, 5.4, 5.5

Concept 5.1 Macromolecules are polymers, built from monomers
1. The large molecules of all living things fall into just four main classes. Name them.

2. Circle the three classes that are called macromolecules. Define macromolecule.

3. What is a polymer?

   a monomer?

4. Monomers are connected in what type of reaction? What occurs in this reaction?

5. Large molecules (polymers) are converted to monomers in what type of reaction?

6. The root words of hydrolysis will be used many times to form other words you will learn this year. What does each root word mean?

   hydro–

   lysis

7. Consider the following reaction:

   \[ C_6H_{12}O_6 + C_6H_{12}O_6 \rightarrow C_{12}H_{22}O_{11} \]

   a. The equation is not balanced; it is missing a molecule of water. Write it in on the correct side of the equation.

   b. So, what kind of reaction is this?

   c. Is \( C_6H_{12}O_6 \) (glucose) a monomer, or a polymer?

   d. To summarize, when two monomers are joined, a molecule of ________ is always removed.
**Concept 5.2 Carbohydrates serve as fuel and building material**

8. Let’s look at carbohydrates, which include sugars and starches. First, what are the monomers of all carbohydrates?

9. Most monosaccharides are some multiple of \((\text{CH}_2\text{O})\). For example, ribose is a 5-carbon sugar with the formula \(\text{C}_5\text{H}_{10}\text{O}_5\). It is a pentose sugar. (From the root penta–, meaning 5.) What is the formula of a hexose sugar?

10. Here are the three hexose sugars. Label each of them. Notice that all sugars have the same two functional groups. Name them:

\[
\begin{align*}
\text{C}=\text{O} & \quad \text{______________} \\
\text{—OH} & \quad \text{______________}
\end{align*}
\]

11. What is the difference between an aldehyde sugar and a ketone sugar?

12. So, as a quick review, all of these sugars have the same chemical formula: \(\text{C}_6\text{H}_{12}\text{O}_6\). What term did you learn in Chapter 3 for compounds that have the same molecular formulas but different structural formulas?
13. Here is the abbreviated ring structure of glucose. Where are all the carbons?

![Glucose structure]

Pay attention to the numbering system. This will be important as we progress in our study. Circle the number 3 carbon. Put a square around the number 5 carbon.

14. Let’s look at our reaction in question 7 again: $\text{C}_6\text{H}_{12}\text{O}_6 + \text{C}_6\text{H}_{12}\text{O}_6 \rightarrow \text{C}_{12}\text{H}_{22}\text{O}_{11} + \text{H}_2\text{O}$

Notice that two monomers are joined to make a polymer. Since the monomers are monosaccharides, the polymer is a disaccharide. Three disaccharides are important to us with the formula $\text{C}_{12}\text{H}_{22}\text{O}_{11}$. Name them below and fill out the chart.

<table>
<thead>
<tr>
<th>Disaccharide</th>
<th>Formed from which two monosaccharides?</th>
<th>Found where?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tr>
</tbody>
</table>

15. Have you noticed that all the sugars end in –ose? This root word means ____________.

16. What is a glycosidic linkage?

17. Here is a molecule of starch, which shows 1–4 glycosidic linkages. Translate and explain this terminology in terms of carbon numbering.

![Starch structure]
18. There are two categories of polysaccharides. Name them and give examples.

<table>
<thead>
<tr>
<th>Type of Polysaccharide</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Why can you not digest cellulose? What organisms can?

14. Let’s review some key points about the carbohydrates. Each prompt below describes a unique carbohydrate. Name the correct carbohydrate for each.

a. Has 1–4 β glucose linkages

b. Is a storage polysaccharide produced by vertebrates; stored in your liver

c. Two monomers of this form maltose

d. Glucose + _______ form sucrose

e. Monosaccharide commonly called “fruit sugar”

f. “Milk sugar”

g. Structural polysaccharide that gives cockroaches their crunch

h. Malt sugar; used to brew beer

i. Structural polysaccharide that comprises plant cell walls

Concept 5.3 Lipids are a diverse group of hydrophobic molecules

21. Lipids include fats, waxes, oils, phospholipids, and steroids. What characteristic do all lipids share?

22. What are the building blocks of fats? Label them on this figure.
23. If a fat is composed of 3 fatty acids and 1 glycerol molecule, how many water molecules will be removed to form it? Again, what is this process called?

24. On the figure with question 22, label the ester linkages.

25. Draw a fatty acid chain that is 8 carbons long and is *unsaturated*. Circle the element in your chain that makes it unsaturated, and explain what this means.

26. Name two saturated fats.

27. Name two unsaturated fats.

28. Why are many unsaturated fats liquid at room temperature?

29. What is a *trans fat*? Why should you limit them in your diet?

30. List four important functions of fats.

31. Here is a figure that shows the structure of a phospholipid. Label the sketch to show the phosphate group, the glycerol, and the fatty acid chains. Also indicate the region that is *hydrophobic* and the region that is *hydrophilic*.

32. Why is the "tail" hydrophobic?
33. Which of the two fatty acid chains in the figure with question 31 is unsaturated? Label it. How do you know it is unsaturated?

34. To summarize, a phospholipid has a glycerol attached to a phosphate group and two fatty acid chains. The head is hydrophilic, and the tail is hydrophobic. Now, sketch the phospholipid bilayer structure of a plasma membrane. Label the hydrophilic heads, hydrophobic tails, and location of water.

35. Study your sketch. Why are the tails all located in the interior?

36. Some people refer to this structure as three hexagons and a doghouse. What is it?

37. What are other examples of steroids?

Concept 5.4 Proteins have many structures, resulting in a wide range of functions

38. Table 5.1 is loaded with important information. Select any five types of proteins and summarize each type here.

<table>
<thead>
<tr>
<th>Type of Protein</th>
<th>Function</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
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</tbody>
</table>
39. Enzymes are an important type of protein. They will be studied in Chapter 8. For now, use this sketch to review what you know about enzymes. Label the active site, the substrate, and the products. Show what happens to water.

40. Is this reaction dehydration synthesis of hydrolysis?

41. The monomers of proteins are amino acids. Sketch an amino acid here. Label the alpha or central carbon, amino group, carboxyl group, and R group.

42. What is represented by R? How many are there?
43. Study the figure. See if you can understand why some R groups are nonpolar, some polar, and others electrically charged (acidic or basic). If you were given an R group, could you place it in the correct group? Work on the R groups until you can see common elements in each category.

44. Define these terms:

- dipeptide
- polypeptide
- peptide bond

Label each of these terms on the diagrams.
45. There are four levels of protein structure. Refer to Figure 5.21, and summarize each level in the following table.

<table>
<thead>
<tr>
<th>Level of Protein Structure</th>
<th>Explanation</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary (I&lt;sup&gt;°&lt;/sup&gt;)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Secondary (II&lt;sup&gt;°&lt;/sup&gt;)</td>
<td>Alpha helix</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Beta pleated sheet</td>
<td></td>
</tr>
<tr>
<td>Tertiary (III&lt;sup&gt;°&lt;/sup&gt;)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quaternary (IV&lt;sup&gt;°&lt;/sup&gt;)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

46. Label each of the levels of protein structure on this figure.
47. Enzymes are globular proteins that exhibit at least tertiary structure. On this figure, identify and explain each interaction that folds this portion.

![Image of enzyme structure]

48. Do you remember when, in Chapter 4, we said, “Change the structure, change the function”? Explain how that principle applies to sickle-cell disease. Why is the structure changed?

![Image of sickle-cell cells]

49. Besides mutation, which changes the primary structure of a protein, protein structure can be changed by denaturation. Define denaturation, and give at least three ways a protein may become denatured.

50. Chaperone proteins or chaperonins assist in the proper folding of proteins. Annotate this figure to explain the process.

![Image of chaperone activity]
Concept 5.5 Nucleic acids store and transmit hereditary information

DNA and RNA will be the core topics of Chapter 17. For now, you should just review the general functions and know the components.

51. The flow of genetic information is from DNA RNA protein. Use this figure to explain the process. Label the nucleus, DNA, mRNA, ribosome, and amino acids.

52. The components of a nucleic acid are a sugar, a nitrogenous base, and a phosphate group. Label each on the figure below.

53. You may recall that early in this chapter we looked at the numbering system for the carbons of a sugar. Label the end of the strand on the left side of the figure below that has the number 5 sugar 5' and the other end of the chain 3'.
54. Notice that there are five nitrogen bases. Which four are found in DNA?

55. Which four are found in RNA?

56. How do ribose and deoxyribose sugars differ?

57. To summarize, what are the three components of a nucleotide?

58. Here is a model of DNA, which was proposed by James Watson and Francis Crick. What is this shape called?

59. Why are the strands said to be antiparallel?

60. What two molecules make up the “uprights”?

61. What molecules make up the rungs?
62. For the two nucleotides of DNA below, provide the complementary base.

A—
C—

63. In a DNA double helix, a region along one DNA strand has this sequence of nitrogenous bases:

5'- T A G G C C T -3'

Write the complementary strand. Indicate the 5' and 3' ends of the new strand.

4.A.2: The structure and function of sub cellular components, and their interactions, provide essential cellular processes. 6.2, 6.3, 6.4, 6.5

**Concept 6.2 Eukaryotic cells have internal membranes that compartmentalize their functions**

5. Which two domains consist of prokaryotic cells?

6. A major difference between prokaryotic and eukaryotic cells is the location of their DNA. Describe this difference.

7. On the sketch of a prokaryotic cell, label each of these features and give its function or description.

- cell wall
- plasma membrane
- bacterial chromosome
- nucleoid
- cytoplasm
- flagella

8. Why are cells so small? Explain the relationship of surface area to volume.

9. Describe how many neurons and intestinal cells each have greatly increased surface area.
Concept 6.3 The eukaryotic cell’s genetic instructions are housed in the nucleus and carried out by the ribosomes

10. In the figure below, label the nuclear envelope, nuclear pores, and pore complex.

11. Describe the nuclear envelope. How many layers is it? What connects the layers?

12. What is the nuclear lamina? Nuclear matrix?

13. Found within the nucleus are the chromosomes. They are made of chromatin. What are the two components of chromatin? When do the thin chromatin fibers condense to become distinct chromosomes?

14. When are the nucleoli visible? What are assembled here?

15. What is the function of ribosomes? What are their two components?
16. Ribosomes in any type of organism are all the same, but we distinguish between two types of ribosomes based on where they are found and the destination of the protein product made. Complete this chart to demonstrate this concept.

<table>
<thead>
<tr>
<th>Type of Ribosome</th>
<th>Location</th>
<th>Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>Free ribosomes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bound ribosomes</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Concept 6.4 The endomembrane system regulates protein traffic and performs metabolic functions in the cell**

17. List all the structures of the endomembrane system.

18. The endoplasmic reticulum (ER) makes up more than half the total membrane system in many eukaryotic cells. Use this sketch to explain the lumen, transport vesicles, and the difference between smooth and rough ER.

19. List and describe three major functions of the smooth ER.

20. Why does alcohol abuse increase tolerance to other drugs such as barbiturates?
21. The rough ER is studded with ribosomes. As proteins are synthesized, they are threaded into the lumen of the rough ER. Some of these proteins have carbohydrates attached to them in the ER to form glycoproteins. What does the ER then do with these secretory proteins?

22. Besides packaging secretory proteins into transport vesicles, what is another major function of the rough ER?

23. The transport vesicles formed from the rough ER fuse with the Golgi apparatus. Use this sketch to label the cisterna of the Golgi apparatus, and its cis and trans faces. Describe what happens to a transport vesicle and its contents when it arrives at the Golgi.

24. What is a lysosome? What do they contain? What is their pH?

25. One function of lysosomes is intracellular digestion of particles engulfed by phagocytosis. Describe this process of digestion. What human cells carry out phagocytosis?
26. A second function of lysosomes is to recycle cellular components in a process called autophagy. Describe this process.


28. There are many types of vacuoles. Briefly describe:

   food vacuoles

   contractile vacuoles

   central vacuoles in plants

   (give at least three functions/materials stored here)

29. Use this figure to explain how the elements of the endomembrane system function together to secrete a protein and to digest a cellular component. Label as you explain.
Concept 6.5 Mitochondria and chloroplasts change energy from one form to another

30. Mitochondria and chloroplasts are not considered part of the endomembrane system, although they are enclosed by membranes. Sketch a mitochondrion here and label its outer membrane, inner membrane, inner membrane space, cristae, matrix, and ribosomes.

31. Now sketch a chloroplast and label its outer membrane, inner membrane, inner membrane space, thylakoids, granum, and stroma. Notice that the mitochondrion had two membrane compartments, while the chloroplast has three compartments.

32. What is the function of the mitochondria?

33. What is the function of the chloroplasts?

34. Recall the relationship of structure to function. Why is the inner membrane of the mitochondria highly folded? What role do all the individual thylakoid membranes serve? (Same answer for both questions.) Chloroplasts and mitochondria both have ribosomes and their own DNA. You will learn later about their evolution, but for now hold onto these facts. They are semiautonomous organelles that grow and reproduce within the cell. And you’re lucky today— there is not a question here!
35. Explain the important role played by peroxisomes.

SUMMARY
On these diagrams of plant and animal cells, label each organelle and give a brief statement of its function.
4.A.3: Interactions between external stimuli and regulated gene expression result in specialization of cells, tissues and organs. 18.4

**Concept 18.4 A program of differential gene expression leads to the different cell types in a multicellular organism**

This concept deals with the regulation of gene expression in development. Animal development is also discussed in Chapter 47.

37. What three processes lead to the transformation of a zygote into the organism?

38. Explain what occurs in cell differentiation and morphogenesis.

39. Differential gene expression results from different activators in different cells. How do different sets of activators come to be present in two cells? Explain how each of these occurs:
   
   a. distribution of cytoplasmic determinants
   
   b. different inductive signals

40. What is meant by determination? Explain what this means within an embryonic cell.

41. What process ensures that all the tissues and organs of an organism are in their characteristic places? Where do the molecular cues that control this process arise?

42. What is controlled by homeotic genes?
**4.A.4: Organisms exhibit complex properties due to interactions between their constituent parts.** 48.4

**Concept 48.4 Neurons communicate with other cells at synapses**

20. When the wave of depolarization arrives at the synaptic terminal, calcium ion channels open. What occurs to the synaptic vesicles as the Ca\(^{2+}\) level increases?

21. What is contained within the synaptic vesicles?

22. Label the figure below: synaptic vesicle, neurotransmitter, calcium ion channel, presynaptic membrane, postsynaptic membrane, and synapse.

23. Explain how an action potential is transmitted from one cell to another across a synapse by summarizing what is shown above in six steps.

(1)
(2)
(3)
(4)
(5)
(6)
24. There are many different types of neurotransmitters. Each neuron secretes only one type of neurotransmitter. Some neurotransmitters hyperpolarize the postsynaptic membrane. Are these excitatory or inhibitory neurotransmitters?

25. Define and explain summation.

26. A single postsynaptic neuron can be affected by neurotransmitter molecules released by many other neurons, some releasing excitatory and some releasing inhibitory neurotransmitters. What will determine whether an action potential is generated in the postsynaptic neuron?

27. Table 48.1 lists several of the major neurotransmitters. You are not expected to know their actions or secretion sites, but you should recognize that they are neurotransmitters! Go through the list that follows, and say each term aloud. Put a checkmark by any that you have heard mentioned before: acetylcholine, epinephrine, norepinephrine, dopamine, serotonin, GABA, glutamate, glycine, substance P, endorphins, and nitric oxide. That’s all for this question!

28. There is one neurotransmitter we want you to memorize. It is the most common neurotransmitter in both vertebrates and invertebrates, and it is released by the neurons that synapse with muscle cells at the neuromuscular junction. If you look ahead to Chapter 50, Figure 50.29, you will see a synapse between a neuron and a muscle cell, resulting in depolarization of the muscle cell and its contraction. What is this very important neurotransmitter?
4.A.5: Communities are composed of populations of organisms that interact in complex ways.  
53.1, 53.3, 53.4, 53.6, 54.1, 54.2

**Concept 53.1 Dynamic biological processes influence population density, dispersion, and demographics**

1. What two pieces of data are needed to mathematically determine *density*?

2. What is the difference between density and *dispersion*?

3. Work through Figure 53.2, doing the math to make sure you get the same answer as the text. Note and understand what the letters of the formula mean. Next, try the following problem. A population ecologist wished to determine the size of a population of white-footed deer mice, *Peromyscus leucopus*, in a 1-hectare field. Her first trapping yielded 80 mice, all of which were marked with a dab of purple hair dye on the back of the neck. Two weeks later, the trapping was repeated. This time 75 mice were trapped, out of which 48 of the mice were marked. Using the formula $N = mn/x$, what is the population of mice in the field? (Answer is at the end of this reading guide.)

4. Explain the impact of *immigration* and *emigration* on population density. (To avoid confusion between these two terms, it might help to use this memory trick: *immigration* is the movement into a population, while *emigration* is the exiting of individuals from a population.)
5. Label the dispersion pattern shown by each population in the figure below. Second, and most important, what do the dispersion patterns tell us about the population and its interactions?

![Dispersion patterns](image1)

6. In what population statistic do demographers have a particular interest? How is this data often presented?

7. Is your biology class a cohort? Explain.

8. Survivorship curves show patterns of survival. In general terms, survivorship curves can be classified into three types. Using the figure below, label and explain the three idealized survivorship patterns.

![Survivorship curves](image2)
9. In the natural world, many species show survivorship curves that are combinations of the standard curves. How would an open nesting songbird’s survivorship curve appear if it was Type III for the first year and then Type II for the rest of its life span? Sketch this curve on the survivorship curve graph in question 8.

10. What does a reproductive table show?

**Concept 53.3 The exponential model describes population growth in an idealized, unlimited environment**

Do not let the math in this section be a problem. Instead of trying to understand the calculus involved, concentrate on the idea of exponential growth, how it is graphed, and what this type of growth indicates about a population.

16. What is the advantage to using per capita birth and death rates rather than just the raw numbers of births and deaths?

17. What will the per capita birth and death rates be if a population is demonstrating zero population growth?

18. What does it mean for a population to be in exponential population growth?

19. In the graph below, explain why the line with the value of 1.0 shows a steeper slope that reaches exponential growth more quickly than does the line with the value of 0.5. On this graph, add a third line that approximates a population with an exponential value of 1.25.
20. What are two examples of conditions that might lead to exponential population growth in natural populations?

**Concept 53.4 The logistic model describes how a population grows more slowly as it nears its carrying capacity**

21. What is *carrying capacity*?

22. What are six examples of limiting resources that can influence carrying capacity?

23. In the logistic population growth model, the per capita rate of increase approaches zero as the ____________________________ is reached.

24. If the carrying capacity (or K) is 1,000 and N is 10, the term (K – N)/K is large. Explain why a large value for (K – N)/K predicts growth close to the maximum rate of increase for this population.

25. In the graph below, explain why the logistic model predicts a sigmoid (S-shaped) growth curve when the population density is plotted over time. Hint: The critical part of this answer concerns why growth slows as N approaches K.

![Graph showing exponential and logistic growth](image)
26. The end of this concept attempts to bring together the ideas of life histories and growth models. This is done with the introduction of two new terms: K-selection and r-selection. Explain the ideas behind the creation of these two terms.

27. Compare and contrast these two terms:

   density-independent regulation

   density-dependent regulation

28. Explain how negative feedback plays an essential role in the unifying theme of regulation of populations. Does negative feedback play a role in both density-independent and density-dependent regulation?

29. Complete the following chart.

<table>
<thead>
<tr>
<th>Negative Feedback Mechanism</th>
<th>Explanation</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Competition for resources</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Territoriality</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disease</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Predation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toxic wastes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intrinsic factors</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
30. Give both biotic and abiotic reasons for population fluctuations over the last 50 years in the moose population on Isle Royale, based on *population dynamics*.

31. Explain the importance of immigration and emigration in *metapopulations*.

**Concept 53.6 The human population is no longer growing exponentially but is still increasing rapidly**

32. Summarize human population growth since 1650. (Of all the reported statistics, which one surprises you the most?)

33. What is demographic transition? Use the figure below to explain the process in Sweden and Mexico.
34. You should be able to look at age-structure graphs and make predictions about the future growth of the population. Using Figure 53.25, describe the key features for the three age-structure graphs and predict how the population of each country will grow.

<table>
<thead>
<tr>
<th>Country</th>
<th>Key Features</th>
<th>Predicted Future Growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Afghanistan</td>
<td></td>
<td></td>
</tr>
<tr>
<td>United States</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Italy</td>
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</tr>
</tbody>
</table>

35. Why do infant mortality and life expectancy vary so greatly between certain countries?

36. Can the world’s population sustain an ecological footprint that is currently the average American footprint? Explain.

**Concept 54.1** Community interactions are classified by whether they help, harm, or have no effect on the species involved.

1. What is a community? List six organisms that would be found in your schoolyard community.

2. This section will look at interspecific interactions. Be clear on the meaning of the prefix! To begin, distinguish between intraspecific competition and interspecific competition. Give an example of each.

<table>
<thead>
<tr>
<th>Type of Competition</th>
<th>Explanation</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intraspecific</td>
<td></td>
<td></td>
</tr>
<tr>
<td>competition</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interspecific</td>
<td></td>
<td></td>
</tr>
<tr>
<td>competition</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3. What is G. F. Gause’s competitive exclusion principle? Give one example.

4. Define ecological niche.

5. Several species of Anolis lizards live in the same types of trees and have a similar diet. Discuss resource partitioning to explain how interspecific competition is reduced. (Study Figure 54.2.)

6. What is the difference between the fundamental niche and the realized niche?

7. Study Figure 54.5, and then explain what is meant by character displacement. (To do this, you will have to learn or review the difference between sympatric populations and allopatric populations. You will find this information in Chapter 24.)

8. Predation is a term that you probably already know. Can you give examples of some predator-prey combinations as listed below?

<table>
<thead>
<tr>
<th>Predator</th>
<th>Prey</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Animal</td>
<td>Animal</td>
<td></td>
</tr>
<tr>
<td>Animal</td>
<td>Plant</td>
<td></td>
</tr>
<tr>
<td>Fungus</td>
<td>Animal</td>
<td></td>
</tr>
<tr>
<td>Bacteria</td>
<td>Animal</td>
<td></td>
</tr>
<tr>
<td>Fungus</td>
<td>Plant</td>
<td></td>
</tr>
</tbody>
</table>
9. List three special adaptations that predator species possess for obtaining food.

10. List three ways prey species elude predators.

11. Compare the two types of mimicry.

<table>
<thead>
<tr>
<th>Type of Mimicry</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Batesian</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Müllerian</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

12. What is herbivory?

13. Did you list any special herbivore adaptations for predation in your response to question 9? Or plant adaptations to avoid herbivory? List two adaptations for each category here.

14. Describe and give an example of each of the following interactions:

<table>
<thead>
<tr>
<th>Type of Interaction</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>symbiosis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>parasitism</td>
<td></td>
<td></td>
</tr>
<tr>
<td>commensalism</td>
<td></td>
<td></td>
</tr>
<tr>
<td>mutualism</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
15. Which category above includes the other three? Note that other texts may define this term more narrowly.

16. Your text uses +/- symbols to indicate how interspecific interactions affect survival and reproduction of the two species. Use this notation for each of these interactions.

<table>
<thead>
<tr>
<th>Type of Interaction</th>
<th>+/-, +/−, −/−, +/0</th>
</tr>
</thead>
<tbody>
<tr>
<td>predation</td>
<td></td>
</tr>
<tr>
<td>commensalism</td>
<td></td>
</tr>
<tr>
<td>mutualism</td>
<td></td>
</tr>
<tr>
<td>parasitism</td>
<td></td>
</tr>
<tr>
<td>interspecific competition</td>
<td></td>
</tr>
<tr>
<td>herbivory</td>
<td></td>
</tr>
</tbody>
</table>

17. What is species diversity? What are its two components? Why is it important?

18. What does an ecologist summarize in a food web?

19. Know the levels of trophic structure in food chains. Give a food chain here, including four links that might be found in a prairie community, and tell the level for each organism.
20. Name every organism in the pictured food chain, and give the trophic level in the box.

21. According to the energetic hypothesis, why are food chains limited in length? How much energy is typically transferred to each higher level?

22. What is a dominant species? For the area where you live, what would be considered a dominant tree species?

23. How is a keystone species different from a dominant species?
24. Name one keystone species, and explain the effect its removal has on the ecosystem.

25. Explain *facilitator* or *foundation* species and give an example.

**Concept 54.2 Disturbance influences species diversity and composition**

26. What is the intermediate disturbance hypothesis? Give an example of a disturbance event, and explain the effect it has on the community.

27. Ecological succession is the changes in species that occupy an area after a disturbance. What is the difference between primary succession and secondary succession?

4.A.6: Interactions among living systems and with their environment result in the movement of matter and energy. 54.2, 55.1, 55.2, 55.3, 55.4, 56.4

**Overview:**

1. What is an ecosystem?

2. Where does energy enter most ecosystems? How is it converted to chemical energy and then passed through the ecosystem? How is it lost? Remember this: energy cannot be recycled.

3. Besides the energy flow that you described in question 2, chemicals such as carbon and nitrogen cycle through ecosystems. So energy ____________ through an ecosystem and matter ________________.
Concept 55.1 Physical laws govern energy flow and chemical cycling in ecosystems

4. Both energy and matter can be neither __________________ nor __________________.

5. We can measure the efficiency of energy conversion in an ecosystem, as well as whether a given nutrient is being gained or lost from an ecosystem. Let us take a second look at trophic levels. What trophic level supports all others?

6. List three groups of organisms that are photosynthetic autotrophs.

7. What are the primary producers of the deep-sea vents?

8. This concept reviews trophic relationships. Know all terms in your textbook that are bolded. What are trophic levels? What is always at the first trophic level?

9. What are detritivores? What is their importance in chemical cycling? Give some examples of detritivores.

10. State the trophic level of each of the following:

    cow __________ grass __________ man __________ mushroom __________

Concept 55.2 Energy and other limiting factors control primary production in ecosystems

11. What is primary production? Distinguish between gross primary production and net primary production.
12. Write an equation here that shows the relationship between gross and net primary production.

13. You may recall from Chapter 54 that *biomass* is the total mass of all individuals in a trophic level. Another way of defining net primary production is as the amount of new biomass added in a given period of time. Why is net primary production, or the amount of new biomass/unit of time, the key measurement to ecologists?

14. Which ecosystem would tend to have a greater biomass/unit area, a prairie or a tropical rain forest? Explain.

15. Describe a technique for measuring net primary production in an aquatic environment.

16. What are some factors that limit primary productivity in aquatic ecosystems?

17. What is a *limiting nutrient*? What is the limiting nutrient off the shore of Long Island, New York? In the Sargasso Sea?

18. Phytoplankton growth can be increased by additional nitrates and phosphates. What are common sources of each of these?

19. What is eutrophication? What are factors that contribute to eutrophication?
Concept 55.3 Energy transfer between trophic levels is typically only 10% efficient

20. What is trophic efficiency?

21. Generally, what percentage of energy available at one trophic level is available at the next?

   [Diagram]

   This is important!
   Remember it.

22. Consider a food chain with 1,000 joules (an energy unit) available at the producer level. If this food chain is grass --> grasshopper --> lizard --> crow, how much energy is found at the level of the crow? (See answer at the end of this section.) Show your work here.

23. Notice that most biomass pyramids have greatest biomass on the bottom of the pyramid. Label the trophic levels on the figure. Explain why the second pyramid of biomass is inverted.
24. Why do people who have limited diets in overpopulated parts of the world eat low on the food chain?

**Concept 55.4 Biological and geochemical processes cycle nutrients between organic and inorganic parts of an ecosystem**

Pay particular attention to the nutrient cycles in Figure 55.14. Note the key processes in each cycle.

25. Use the figure below to describe the water cycle. Specify the roles of evaporation, transpiration, and rainfall.

26. Use the second figure on the following page to describe the carbon cycle. In doing so, explain how carbon enters the living system and how it leaves, indicate the role of microorganisms in the cycle, and identify the reservoir for carbon.

Write the equation for photosynthesis here:

Write the equation for cellular respiration here:
27. Use the diagram below to describe the nitrogen cycle. In doing so, indicate the role of microorganisms in nitrogen fixation, nitrification, and denitrification.

![Nitrogen Cycle Diagram]

28. Review the Case Study: Nutrient Cycling in the Hubbard Brook Experimental Forest. What effect has deforestation been shown to have on chemical cycling?

Solution to Question 22: Grass (1,000 J) grasshopper (100 J) lizard (10 J) crow (1 J)

Concept 56.4 Restoration ecology attempts to restore degraded ecosystems to a more natural state

14. What is the goal of restoration ecology?

15. Restoration ecology uses two key strategies. Explain how each strategy works:

   bioremediation

   biological augmentation
4.B.1: Interactions between molecules affect their structure and function. 5.4, 8.4, 8.5

**Concept 8.4** Enzymes speed up metabolic reactions by lowering energy barriers

15. What is a catalyst?

16. What is *activation energy* (EA)?

On the graph, label the *x-axis* “Progress of the reaction” and the *y-axis* “Free Energy.” Label EA on this sketch, both with and without enzyme.

![Graph showing activation energy and free energy](image)

a. What effect does an enzyme have on EA?

b. Label $\Delta G$. Is it positive or negative?

c. How is $\Delta G$ affected by the enzyme?

17. Label this figure while you define each of the following terms:

   - **enzyme**
   - **substrate**
   - **active site**
   - **products**
18. What is meant by *induced fit*? How is it shown in this figure?

19. Explain how protein structure is involved in enzyme specificity.

20. Enzymes use a variety of mechanisms to lower activation energy. Describe four of these mechanisms.

   (1)

   (2)

   (3)

   (4)

21. Many factors can affect the rate of enzyme action. Explain each factor listed here.

   a. initial concentration of substrate

   b. pH

   c. temperature

22. Recall that enzymes are globular proteins. Why can extremes of pH or very high temperatures affect enzyme activity?

23. Name a human enzyme that functions well in pH 2. Where is it found?

24. Distinguish between *cofactors* and *coenzymes*. Give examples of each.
25. Compare and contrast competitive inhibitors and noncompetitive inhibitors. Label each type of inhibitor in this figure.

![Diagram of competitive vs. noncompetitive inhibitors]

**Concept 8.5 Regulation of enzyme activity helps control metabolism**

15. What is allosteric regulation?

16. How is it somewhat like noncompetitive inhibition? How might it be different?

17. Explain the difference between an allosteric activator and an allosteric inhibitor.

18. Although it is not an enzyme, hemoglobin shows cooperativity in binding O2. Explain how hemoglobin works at the gills of a fish.

19. Study this figure from your book (Figure 8.22).

   a. What is the substrate molecule to initiate this metabolic pathway?

   b. What is the inhibitor molecule?

   c. What type of inhibitor is it?

   d. When does it have the most significant regulatory effect?

   e. What is this type of metabolic control called?
4.B.2: Cooperative interactions within organisms promote efficiency in the use of energy and matter. 6.4, 40.1

**Concept 40.1 Animal form and function are correlated at all levels of organization**

1. Animals need to exchange materials with their environment. This process occurs as substances dissolved in an aqueous medium move across the plasma membrane of each cell. For each of the following organisms, explain how this is possible:

   - amoeba
   - hydra
   - tapeworm
   - whale

2. What is *interstitial fluid*?

3. What is a *tissue*?

4. There are four types of tissues. For each, give examples, the general function, and where you would find each type.

<table>
<thead>
<tr>
<th>Tissue Type</th>
<th>Examples</th>
<th>General Function</th>
<th>Locations</th>
</tr>
</thead>
</table>
| Epithelial  | *cuboidal*  
              *simple columnar*  
              *simple squamous*  
              *stratified squamous* | | |
| Connective  | *cartilage*  
              *adipose*  
              *blood*  
              *bone*  
              *fibrous connective*  
              *loose connective* | | |
| Muscle      | *skeletal*  
              *smooth*  
              *cardiac* | | |
| Nervous     | Cell types:  
              *neurons*  
              *glial cells* | | |
4.B.3: Interactions between and within populations influence patterns of species distribution and abundance. 25.4, 56.1, 55.5

**Concept 25.4 The rise and fall of dominant groups reflect continental drift, mass extinctions, and adaptive radiations**

24. If you have not studied geology, you will find this concept introduces a fascinating look at the changes in our planet as explained by continental drift. Define *continental drift*. How can continents move?

25. On the figure below, label Pangaea, Gondwana, and Laurasia.

26. See if you can answer each of these short questions:
   a. What is the *San Andreas* Fault?
   
   b. What caused the uplift of the Himalayas?
   
   c. How can a fossil freshwater reptile be found in both Brazil and west Africa, areas separated today by a wide expanse of ocean?
   
   d. Why are no *eutherians* (placental) mammals indigenous to Australia?
27. A mass extinction is the loss of large numbers of species in a short period, caused by global environmental changes. What caused the Permian mass extinction 250 million years ago (mya)? Summarize the species that were lost.

28. A second important mass extinction is the Cretaceous mass extinction that happened about 65 mya. Everyone’s favorite group, the dinosaurs, was lost, along with more than half of all marine species. What caused it?

29. What are adaptive radiations?

30. Why did a large-scale adaptive radiation occur after each mass extinction?

In the overview at the beginning of the chapter, the author sets the stage for this final chapter of the book. This chapter will deal with both conservation biology and restoration ecology. Let’s begin by comparing and contrasting these two terms.

**conservation biology**

**restoration ecology**

**Concept 56.1 Human activities threaten Earth’s biodiversity**

1. 1. Ecologists organize biodiversity on three levels. In the table below, explain the impact of decreasing diversity in each division. Begin reading on page 1248, where the topic changes to threats to biodiversity before answering this question.

<table>
<thead>
<tr>
<th>Level of Biodiversity</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Genetic diversity</td>
<td></td>
</tr>
<tr>
<td>Species diversity</td>
<td></td>
</tr>
<tr>
<td>Ecosystem diversity</td>
<td></td>
</tr>
</tbody>
</table>
2. Explain the difference between *endangered species* and *threatened species*.

3. Use this table to organize your thoughts on how the following three threats affect biodiversity.

<table>
<thead>
<tr>
<th>Threat to Biodiversity</th>
<th>How it reduces biodiversity</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Habitat loss</em></td>
<td></td>
</tr>
<tr>
<td><em>Introduced species</em></td>
<td></td>
</tr>
<tr>
<td><em>Overexploitation</em></td>
<td></td>
</tr>
</tbody>
</table>

4. List five *introduced species* that present a serious threat to their new communities. Explain the damage done by each introduced species. ***Include two introduced species that are a threat in your own region of the country. Indicate these with an asterisk.***

<table>
<thead>
<tr>
<th>Introduced Species</th>
<th>Damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td></td>
</tr>
<tr>
<td>(2)</td>
<td></td>
</tr>
<tr>
<td>(3)</td>
<td></td>
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<tr>
<td>(4)</td>
<td></td>
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<tr>
<td>(5)</td>
<td></td>
</tr>
</tbody>
</table>
Concept 55.5 Human activities now dominate most chemical cycles on Earth

This section looks at human impact on ecosystems.

1. How has agriculture affected nitrogen cycling? What are some negative consequences of nutrient enrichment?

2. In what ways have human activities contributed to acid precipitation? What are some negative consequences of acid precipitation?

3. Explain the process of biological magnification. Discuss at least one example.

4. What is meant by the greenhouse effect? What would life on Earth be like without this effect?

5. What is contributing to the great increase in atmospheric carbon dioxide? What are potential effects of this increase?

6. How is atmospheric ozone depleted? What are projected effects of this depletion?
4.B.4: Distribution of local and global ecosystems changes over time. 25.4, 56.1, 55.5

4.C.1: Variation in molecular units provides cells with a wider range of functions. 5.1, 5.2, 5.3, 5.4, 5.5, 21.5

**Concept 21.5 Duplication, rearrangement, and mutation of DNA contribute to genome evolution**

19. What is the evolutionary significance of the relationship between the genes on human chromosome 16 and those same blocks of genes on mouse chromosomes 7, 8, 16, and 17?

20. A good summary of several processes involved in genomic evolution can be found in the globin gene families. Label and explain these processes as described in Figure 21.13.

21. Using the concept of a protein domain in your answer, explain why exon shuffling could lead to a novel protein.
4.C.2: Environmental factors influence the expression of the genotype in an organism.

Concept 14.3 Inheritance patterns are often more complex than those predicted by simple Mendelian genetics

20. Explain how incomplete dominance is different from complete dominance, and give an example of incomplete dominance.

21. Compare and contrast codominance with incomplete dominance.

22. Dominant alleles are not necessarily more common than recessive alleles in the gene pool. Explain why this is true.

23. Explain what is meant when a gene is said to have multiple alleles.

24. Blood groups are so important medically that you should be able to solve genetics problems based on blood types. The first step in accomplishing that is to understand the genotypes of each blood type. Before working any problems, complete this ABO blood type chart.

<table>
<thead>
<tr>
<th>Genotype</th>
<th>Red Blood Cell Appearance</th>
<th>Phenotype (blood group)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
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</tbody>
</table>
25. Question 2 in the 14.3 Concept Check is a blood type problem. Complete it here, and show your work.

26. What is pleiotropy? Explain why this is important in diseases like cystic fibrosis and sickle-cell disease.

27. Explain epistasis.

28. Explain why the dihybrid cross detailed in Figure 14.12 has 4 white mice instead of the 3 that would have been predicted by Mendel's work.

29. Why is height a good example of polygenic inheritance?

30. Quantitative variation usually indicates ______________________________.

31. Using the terms norm of reaction and multifactorial, explain the potential influence of the environment on phenotypic expression.
4.C.3: The level of variation in a population affects population dynamics. 23.1, 23.2, 23.3

This chapter begins with the idea that we focused on as we closed the last chapter: Individuals do not evolve! Populations evolve. The Overview looks at the work of Peter and Rosemary Grant with Galápagos finches to illustrate this point, and the rest of the chapter examines the change in populations over time. As in the last chapter, first read each concept to get the big picture and then go back to work on the details presented by our questions. Don’t lose sight of the conceptual understanding by getting lost in the details!

Overview

1. What is microevolution?

2. What are the three main mechanisms that can cause changes in allele frequency?

3. Which is the only mechanism that is adaptive, or improves the match between organisms and their environment?

Concept 23.1 Mutation and sexual reproduction produce the genetic variation that makes evolution possible

4. Because Darwin did not know about the work of Gregor Mendel, he could not explain how organisms pass heritable traits to their offspring. In looking at genetic variation, what are discrete characters, and what are quantitative characters?

5. Using the techniques of molecular biology, what are the two ways of measuring genetic variation in a population?

6. Geographic variation may be shown in a graded manner along a geographic axis known as a cline. What external factors might produce a cline? Why does the existence of a cline suggest natural selection?
7. What is the ultimate source of new alleles?

8. Mutations are any change in the nucleotide sequence of an organism’s DNA. These mutations provide the raw material from which new traits may arise and be selected. What occurs in a point mutation?

9. What is translocation? How could it be beneficial?

10. How does gene duplication occur? How might it play a role in evolution?

11. Much of the genetic variation that makes evolution possible comes through sexual reproduction. What are the three mechanisms by which sexual reproduction shuffles existing alleles?

**Concept 23.2 The Hardy-Weinberg equation can be used to test whether a population is evolving**

12. What is a population?

13. What is a gene pool?

14. The greater the number of fixed alleles, the lower the species’ diversity. What does it mean to say that an allele is fixed?
15. The *Hardy-Weinberg principle* is used to describe a population that is *not* evolving. What does this principle state?

16. If the frequency of alleles in a population remains constant, the population is at *Hardy-Weinberg equilibrium*. There are five conditions for *Hardy-Weinberg equilibrium*. It is very important for you to know these conditions, so enter them neatly into the box below.

**CONDITIONS FOR HARDY-WEINBERG EQUILIBRIUM**

1. 
2. 
3. 
4. 
5. 

It is not very likely that all five of these conditions will occur, is it? Allelic frequencies change. Populations evolve. This data can be tested by applying the *Hardy Weinberg equation*. Let’s look at how to do this.

**Equation for Hardy-Weinberg Equilibrium**

\[ p^2 + 2pq + q^2 = 1 \]

Where \( p^2 \) is equal to the frequency of the homozygous dominant in the population, \( 2pq \) is equal to the frequency of all the heterozygotes in the population, and \( q^2 \) is equal to the frequency of the homozygous recessive in the population.

Consider a gene locus that exists in two allelic forms, \( A \) and \( a \), in a population.

Let \( p \) = the frequency of \( A \), the dominant allele

and \( q \) = the frequency of \( a \), the recessive allele.

So,

\[ p^2 = AA, \]
\[ q^2 = aa, \]
\[ 2pq = Aa \]

If we know the frequency of one of the alleles, we can calculate the frequency of the other allele:

\[ p + q = 1, \text{ so} \]
\[ p = 1 - q \]
\[ q = 1 - p \]
17. So, here is a problem to try. Suppose in a plant population that red flowers (R) are dominant to white flowers (r). In a population of 500 individuals, 25% show the recessive phenotype. How many individuals would you expect to be homozygous dominant and heterozygous for this trait? (A complete solution for this problem is at the end of this section.)

18. In a population of plants, 64% exhibit the dominant flower color (red), and 36% of the plants have white flowers. What is the frequency of the dominant allele? (There are a couple of twists in this problem, so read and think carefully. A complete solution for this problem is at the end of this section.)

Concept 23.3 Natural selection, genetic drift, and gene flow can alter allele frequencies in a population

19. First, let’s try to summarize the big idea from this section. Scan through the entire concept to pull out this information. Three major factors alter allelic frequency and bring about evolutionary change. List each factor, and give an explanation.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Explanation</th>
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</table>

20. Which of the factors above results in a random, nonadaptive change in allelic frequencies?
21. Which of the factors above tends to reduce the genetic differences between populations and make populations more similar?

22. Of the three factors you listed above, only one results in individuals that are better suited to their environment. Which is it?

23. Explain what happens in each of these examples of genetic drift:

   - founder effect
   - bottleneck effect