102 BIOLOGY
GROUP ACTIVITIES

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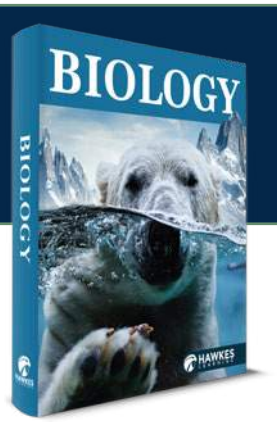

BIOLOGY

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Chapter 1: The Nature of Biology

Group Activity

As a group, choose one biological level of organization. Then, brainstorm several examples of that level. Next, choose one example and build all the way up through biosphere, building from your example. Then, using the same example, move backwards to the lower (smaller) levels of organization from the point of your example.

Chapter 2: Basic Chemistry for Biology

Group Activity

As a group, have each member choose an element from periods 2, 3, or 4 from the periodic table not already discussed in the text. Then, work together to determine each element's electron configuration.

Group Activity

As a group, make a list of the types of chemical bonds and interactions discussed in this chapter. Work together to briefly describe each, providing at least one example. If possible, use the internet to find additional examples not already mentioned in the text. Then, compare and contrast the different types of bonds and interactions. Which are between atoms within a molecule? Which are between molecules?

Chapter 4: Cell Structure

Group Activity

As a group, use Figure 8 to estimate the diameter (distance across) and radius (half the distance across) of a typical bacterial cell and a typical animal cell. Then, assuming that both are spherical cells, calculate the surface area and volume of each. Next, determine the surface-area-to-volume ratio for each. How do they compare? (**Note:** The surface area of a sphere with a radius of r is given by $4\pi r^2$, while the volume of a sphere with a radius of r is given by $\frac{4\pi r^3}{3}$.)

Group Activity

Different tissues contain different amounts of organelles. As a group, make a list of different tissue types that make up a human body. For example, you may list muscle tissue, bone tissue, etc. Now, consider the role of mitochondria in cells. If you had to guess, which of these tissue types do you think would contain the most mitochondria? Which might contain the least? Discuss your answers.

Group Activity

As a group, choose one biological level of organization. Then, brainstorm several examples of that level. Next, choose one example and build all the way up through biosphere, building from your example. Then, using the same example, move backwards to the lower (smaller) levels of organization from the point of your example.

Chapter 5: Structure and Function of Membranes

Group Activity

As a group, think about different types of cells, including human cells, plant cells, and bacterial cells. What types of molecules might each type of cell like to accumulate? What types of molecules might each type of cell try to avoid accumulating? Discuss your reasons why as a group.

Group Activity

As a group, consider the structural and size differences between typical prokaryotes and eukaryotes as well as the differences between animal and plant cells. Why are the bulk transport mechanisms discussed in this section limited to eukaryotic cells? Based on what you know about animal versus plant cell structure, which eukaryotic cell type is more likely to use these bulk transport mechanisms? Why? Discuss your reasoning.

Chapter 6: Bioenergetics

Group Activity

Set up a simple experiment to understand how energy transfers and how it results in a change in entropy.

1. Take a block of ice. This is water in solid form, so it has a high structural order. This means that the molecules cannot move very much and are in a fixed position. The ice's temperature is 0°C. As a result, the system's entropy is low.
2. Allow the ice to melt at room temperature. What is the state of molecules in the liquid water now? How did the energy transfer take place? Is the system's entropy higher or lower? Why?
3. Heat the water to its boiling point. What happens to the system's entropy when the water is heated?

Group Activity

As a group, consider different types of cells in a human body and their ATP needs. Come up with some cell types that likely go through more ATP than average. If you had to guess, what are some cell types that likely use less ATP than average? Discuss as a group why you think so.

Chapter 7: Cellular Respiration

Group Activity

As a group, assign a complex within the electron transport chain to each person. Each person is tasked with learning the processes that occur within each complex and then explaining them to the rest of the group. Keep in mind the following:

- What electron carrier is involved in this complex?
- What enzymes are involved in this complex?
- What proteins are involved in this complex?

Chapter 8: Photosynthesis

Group Activity

As a group, take a walk outside with some blank paper. For the living creatures that you find, discuss specific ways that that creature's energy might trace back to the sun. Draw some of those connections out on your paper using labels and arrows as you discuss. For example, a cat might have these connections:

Cat → Squirrel → Acorn → Oak Tree → Sun

Chapter 10: Cell Reproduction

Group Activity

Work in small groups to build a working model of DNA organization from common materials. Ensure that your model can demonstrate all three levels of DNA compaction.

Group Activity

Determine the Time Spent in Cell-Cycle Stages

As a group, complete the following activity.

Problem: How long does a cell spend in interphase compared to each phase of mitosis?

Background: An image of an onion root tip shows cells arrested in various phases of the cell cycle (Figure 7). Note that it is not visually possible to separate the phases of interphase from each other, but the mitotic phases are readily identifiable. If 100 cells are examined, the number of cells in each identifiable cell-cycle phase will give an estimate of the time it takes for the cell to complete that stage.

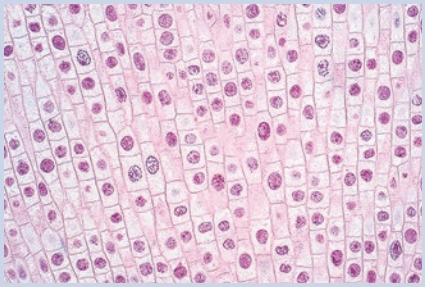

Figure 7: A microscopic image of onion root tip cells is shown.

Problem Statement: Given the events included in all of interphase and those that take place in each phase of mitosis, estimate the length of each phase, based on a 12-hour cell cycle. Before proceeding, state your hypothesis.

Test Your Hypothesis: Test your hypothesis by doing the following:

1. Practice identifying the various phases of the cell cycle, using the drawings of the phases in Figure 3 as a guide.
2. Once you are confident about your identification, record the phase of each cell you encounter as you scan top to bottom and left to right across the rows of onion root tip cells, not skipping any cells as you go.
3. Keep a tally of your observations and stop when you reach 100 cells identified.

Record Your Observations: Make a table similar to Table 1 within which to record your observations.

Table 1: Results of Cell Phase Identification

Phase	Individual Totals	Group Totals	Percent (Decimal)
Interphase			
Prophase			
Prometaphase			
Metaphase			
Anaphase			
Telophase			
Cytokinesis			
Totals	100	100	100% (1.00)

(*cont.*)

Group Activity (cont.)

Analyze Your Data/Report Your Results: To find the length of time onion root tip cells spend in each phase, multiply the percent (recorded as a decimal) by 12 hours. Make a table similar to Table 2 to illustrate your data.

Table 2: Estimate of Cell Phase Length

Phase	Percent as Decimal	Time in This Phase (Hours)
Interphase		
Prophase		
Prometaphase		
Metaphase		
Anaphase		
Telophase		
Cytokinesis		

Draw a Conclusion: Did your results support your estimated times? Were any of the outcomes unexpected? If so, discuss those events in that phase that may have contributed to the calculated time.

Chapter 11: Meiosis and Sexual Reproduction

Group Activity

As a group, each group member should choose a different animal. Using the internet, determine the haploid set number for each organism. Then, for each organism, determine the following:

- The number and composition (single chromosome? duplicated chromosome? tetrad? diploid? haploid? etc.) of chromosomes in a somatic cell during G_1 of interphase
- The number and composition of chromosomes in a somatic cell during G_2 of interphase
- The number and composition of chromosomes in a gamete-producing cell during prophase I of meiosis
- The number and composition of chromosomes of cells produced by meiosis I
- The number and composition of chromosomes of cells produced by meiosis II

Based upon independent assortment alone, how many different, genetically distinct gametes can this organism make?

Compare the answers for each animal selected.

Chapter 12: Mendelian Genetics

Group Activity

As a group of two, perform this experiment for yourselves. Flip the penny and roll the die at the same time 100 times. Keep track of your results. Did you get all 12 outcomes? Did each of the 12 outcomes occur with equal probability?

Group Activity

Pair up into groups and obtain a die and a coin. Take turns assigning hypothetical die and coin outcomes, and having the other partner calculate the probability. For example, you could ask your partner to calculate the probability of getting 3 heads and rolling a 3 twice in a row.

Pair up in groups of two. Can you or your partner curl your tongue up on the sides? Tongue curling in humans is a dominant genetic trait. Predict your possible genotypes and phenotypes for tongue curling.

Suppose a person who is *Tt* for tongue curling marries a person who is also *Tt* for this trait. What are the possible genotypes and phenotypes of their children and the percent chance for each? Fill in the following Punnett square for this cross.

	T	*t*
T		
t		

What are the possible genotypes and phenotypes of their children and the percent chance for each? Fill in the following table.

Genotype	Phenotype	Chance

Group Activity

In a group of three to four, research an X-linked trait in humans. How often are males affected? How often are females affected? Does this line up with what you would expect with X-linked traits?

Group Activity

As a group of two or three, use a Punnett square to predict the outcome of a trihybrid cross between two parents with the genotype *GgJjNn*. Did you get a phenotypic ratio of 27:9:9:9:3:3:3:1?

Group Activity

Testing the Hypothesis of Independent Assortment

To better appreciate the amount of labor and ingenuity that went into Mendel's experiments, let's go through one of Mendel's dihybrid crosses in groups of three or four.

Question: What will be the offspring of a dihybrid cross?

Background: Consider that pea plants mature in one growing season, and you have access to a large garden in which you can cultivate thousands of pea plants. There are several true-breeding plants with the following pairs of traits: tall plants with inflated pods and dwarf plants with constricted pods. Before the plants have matured, you remove the pollen-producing organs from the tall/inflated plants in your crosses to prevent self-fertilization. Upon plant maturation, the plants are manually crossed by transferring pollen from the dwarf/constricted plants to the stigmata of the tall/inflated plants.

Hypothesis: Both trait pairs will sort independently according to Mendelian laws. When the true-breeding parents are crossed, all the F_1 offspring are tall and have inflated pods, which indicates that the tall and inflated traits are dominant over the dwarf and constricted traits, respectively. A self-cross of the F_1 heterozygotes results in 2,000 F_2 progeny. (*cont.*)

Group Activity (cont.)

Test the Hypothesis: Because each trait pair sorts independently, the ratios of tall:dwarf and inflated:constricted are each expected to be 3:1. The tall/dwarf trait pair is called *T*/*t*, and the inflated/constricted trait pair is designated *I*/*i*. Each member of the F_1 generation, therefore, has a genotype of *TtIi*. Now, consider the results of crossing individuals of the F_1 generation. Examine Figure 5, which shows all possible genotypic outcomes for a cross of two *TtIi* individuals. Each individual can donate four combinations of two traits—*TI*, *Ti*, *tI*, or *ti*—meaning that there are 16 possibilities of offspring genotypes. Because the *T* and *I* alleles are dominant, any individual having one or two of those alleles will express the tall or inflated phenotypes, respectively, regardless of if they also have a *t* or *i* allele. Only individuals that are *tt* or *ii* will express the dwarf and constricted alleles, respectively. As shown in Figure 5, you predict that you will observe the following offspring proportions: tall/inflated:tall/constricted:dwarf/inflated:dwarf/constricted in a 9:3:3:1 ratio. Notice from the grid that when considering the tall/dwarf and inflated/constricted trait pairs in isolation, they are each inherited in 3:1 ratios.

Ttli	TI	Ti	tI	ti
TI	TTII	TTIi	TtII	TtIi
Ti	TTIi	TTii	TtIi	Ttii
tI	TtII	TtIi	ttII	ttIi
ti	TtIi	Ttii	ttIi	ttii

Figure 5: This figure shows all possible combinations of offspring resulting from a dihybrid cross of pea plants that are heterozygous for the tall/dwarf and inflated/constricted alleles.

You cross the dwarf and tall plants and then self-cross the offspring. For best results, this is repeated with hundreds or even thousands of pea plants. What special precautions should be taken in the crosses and in growing the plants?

Analyze Your Data: You observe the following plant phenotypes in the F_2 generation: 2,706 tall/inflated, 930 tall/constricted, 888 dwarf/inflated, and 300 dwarf/constricted. Reduce these findings to a ratio and determine if they are consistent with Mendelian laws.

Form a Conclusion: Were the results close to the expected 9:3:3:1 phenotypic ratio? Do the results support the prediction? What might be observed if far fewer plants were used, given that alleles segregate randomly into gametes? Try to imagine growing that many pea plants and consider the potential for experimental error. For instance, what would happen if it was extremely windy one day?

Chapter 14: DNA: Deoxyribonucleic Acid

Group Activity

In a group, use index cards or cardboard to create the nitrogenous bases as puzzle pieces. Create adenine and thymine to fit together and thymine and cytosine to fit together. Make six adenine, six thymine, four guanine, and four cytosine. Try to piece them together using the right amount of hydrogen bonds. What do you observe about how the structure of each piece allows for or prevents bonding with other pieces?

Group Activity

If you need help picturing how the circular bacterial chromosome is replicated, try this:

Get a wide rubber band; think of it as the bacterial chromosome. Draw a dot on it to represent the origin of replication on the chromosome. Now, use scissors to cut *lengthwise,* starting at the dot and moving along the middle of the rubber band in both directions until you have a figure-eight shape. This is a simplistic representation of how replication proceeds along the chromosome in opposite directions. Finally, snip the figure eight to yield two circles that represent the two chromosomes that result from prokaryotic replication.

Chapter 15: Genes and Proteins

Group Activity

Which Has More DNA: A Kiwi or a Strawberry?

Question: Would a kiwi and strawberry that are approximately the same size (Figure 7) also have approximately the same amount of DNA?

Figure 7: Do you think that a kiwi or a strawberry has more DNA per fruit?

Background: Genes are carried on chromosomes and are made of DNA. All mammals are diploid, meaning they have two copies of each chromosome. However, not all *plants* are diploid. The common strawberry is octoploid (8*n*) and the cultivated kiwi is hexaploid (6*n*). Research the total number of chromosomes in the cells of each of these fruits and think about how this might correspond to the amount of DNA in these fruits' cell nuclei. What other factors might contribute to the total amount of DNA in a single fruit? Research the technique of DNA isolation to understand how each step in the isolation protocol helps free the DNA from the cells and condense it out from the solution.

Hypothesis: Hypothesize whether you would be able to detect a difference in DNA quantity from similarly sized strawberries and kiwis. Which fruit do you think would yield more DNA?

Test Your Hypothesis: Isolate the DNA from a strawberry and a kiwi that are similarly sized. Perform the experiment at least three times for each fruit:

1. Prepare a bottle of DNA extraction buffer by gathering 900 mL water, 50 mL dish detergent, and two teaspoons of table salt. Mix by inversion (cap it and turn it upside down a few times).
2. Grind a strawberry and a kiwi by hand in separate plastic bags, use a mortar and pestle, or use a metal bowl and the end of a blunt instrument. Grind for at least two minutes per fruit.
3. Add 10 mL of the DNA extraction buffer to each fruit and mix well for at least one minute.
4. Remove cellular debris by filtering each fruit mixture through cheesecloth or a porous cloth and pouring the mixture into a funnel placed in a test tube or an appropriate container.
5. Pour ice-cold ethanol or isopropanol (rubbing alcohol) into the test tube. You should observe white, precipitated DNA.
6. Gather the DNA from each fruit by winding it around separate glass rods. (*cont.*)

Group Activity (cont.)

Record Your Observations: Because you are not quantitatively measuring DNA volume, for each trial you can record whether the two fruits produced the same or different amounts of DNA as observed by the naked eye. If one or the other fruit produced noticeably more DNA, record this as well. Determine whether your observations are consistent with several pieces of each fruit.

Analyze Your Data: Did you notice an obvious difference in the amount of DNA produced by each fruit? Were your results reproducible?

Draw a Conclusion: Given what you know about the number of chromosomes in each fruit, can you conclude that chromosome number necessarily correlates to DNA amount? Can you identify any drawbacks to this procedure? If you had access to a laboratory, how could you standardize your comparison and make it more quantitative?

Group Activity

Errors in splicing are implicated in cancers and other human diseases. In a group, discuss what kinds of mutations might lead to splicing errors. Think of different possible outcomes if splicing errors occur. Then, look up examples of diseases linked to splicing errors, utilizing peer-reviewed sources of information.

Chapter 16: Gene Expression

Group Activity

An individual's lifestyle can begin to modify epigenetic patterns. Work with a partner and discuss lifestyle factors that you think may have the ability to modify epigenetics. Make a list of five factors. (Hint: Consider aspects related to diet, drug use, physical activity, or any habits performed regularly.)

Then, check your list with a quick internet search. How many correct guesses did you and your partner make?

Chapter 17: Biotechnology and Genomics

Group Activity

How to Use a Genome Map Viewer

Problem Statement: Do the human, macaque, and mouse genomes contain common DNA sequences?

Develop a Hypothesis.

Visit this website to test your group's hypothesis using a genome map viewer (hawkes.biz/genomemap).

The website compares gene sequences of many organisms to the Human Insulin Receptor gene. Explore the type of information provided and select the groups of organisms needed for testing of the hypothesis from the top portion of the displayed data. Focus the attention to the Selected Orthologues. Explore which columns are relevant to the needed information.

On the same page, there are other options to explore. Not all are necessary for the task, however, they might give more insight to the value of genome/gene comparisons.

Chapter 18: Evolution and the Origin of the Species

Group Activity

As a group, brainstorm evidence that supports the theory of evolution. What scientific evidence have you learned about in this lesson that supports this theory? What other scientific evidence can you think of that also supports this theory? When we use the term *theory*, does that mean doubt to its validity still exists? Discuss as a group why you think so. What place does nonscientific evidence hold in supporting or refuting the theory of evolution?

Group Activity

As a group, either go outside or think about a specific location outside. Make a list of as many different species of organisms that you can identify in this location. How can you determine that the various organisms are different species? How might scientists distinguish the various organisms as different species? Discuss your answers as a group.

Chapter 19: The Evolution of Populations

Group Activity

The following are some examples of **phenotypes** and their potential benefits in given populations.

- Bright colors of poison dart frogs (advertise danger—"do not eat me" signal)
- Different colors between males and females (easier to find mate)
- White fur of alpine mammals (blend in with snow)
- Putrid scent of rainforest flower (attract pollinating flies)

Such traits are shared by all members of the same species, meaning the alleles that encode these traits have become fixed. As a group, identify four more phenotypes that have resulted from allele fixation and that function as advantageous traits.

Group Activity

Get together as a group to consider this approach to the scientific method and test the bottleneck effect.

Question: How do natural disasters affect a population's genetic structure?

Background: When an earthquake or hurricane suddenly wipes out much of a population, the surviving individuals are usually a random sampling of the original group. As a result, the population's genetic makeup can change dramatically. We call this phenomenon the bottleneck effect.

Hypothesis: Repeated natural disasters will yield different population genetic structures; therefore, each time one runs this experiment, the results will vary.

Test the Hypothesis: Count out the original population using different colored beads. For example, red, blue, and yellow beads might represent red, blue, and yellow individuals. After recording the number of each type of individual in the original population, place them all in a bottle with a narrow neck that will only allow a few beads out at a time. Then, pour one-third of the bottle's contents into a bowl. This represents the surviving individuals after a natural disaster kills most of the population. Count the number of the different colored beads in the bowl and record it. Then, place all of the beads back in the bottle and repeat the experiment four more times.

Analyze the Data: Compare the five populations that resulted from the experiment. Do the populations all contain the same number of different colored beads, or do they vary? Remember, these populations all originated from the same exact parent population.

Form a Conclusion: Most likely, the five resulting populations will differ quite dramatically. This is because natural disasters are not selective; they kill and spare individuals at random. Now think about how this might affect a real population. What happens when a hurricane hits the Mississippi Gulf Coast? How do the seabirds that live on the beach fare?

Group Activity

Think about the following environmental conditions a species may experience in its environment:

- Cold temperature
- Twilight
- Frequent rain

In a group, brainstorm what types of beneficial adaptations might emerge to make an individual more fit for these conditions.

Group Activity

Sometimes, natural selection leads to evolutionary dead ends, so to speak. As the environment changes over generations of a species, the traits that were once advantageous may become detrimental. As a group, think about species you may know to have gone extinct during Earth's history and identify traits that may have contributed to their extinction.

Chapter 20: The Tree of Life and Phylogenetics

Group Activity

As a group, choose three different organisms. Then, compare and contrast them. In what ways are they similar? In what ways do they differ? Based upon this information, draw a simple phylogenetic tree showing the evolutionary relationships between these organisms. Then, use the internet to determine the phylogeny of each organism and how they are related. Is the phylogenetic tree that you drew consistent with the information you've obtained from the internet? If not, what may have led your group to draw a different phylogenetic tree?

Group Activity

First, everyone in the group should individually select five different organisms and attempt to group them into clades based on shared characteristics. Then, combine your tree with that of your group and attempt to build a larger tree. You may not all agree with the grouping or selection of clades. Discuss the rationale you have for why you organized your clade the way you did, or how you think it best integrates with that of your group members.

Chapter 21: Viruses

Group Activities

Form groups of three to four students. Choose one of the groups of the Baltimore Classification and find an example of a virus in that group, other than the ones given in Table 3. Research how this virus infects its host and its specific structure and morphology. Present your findings to the class.

As a group, discuss whether viruses are considered living organisms. Provide evidence by comparing and contrasting with other living unicellular organisms, such as bacteria or fungi.

Group Activity

A major group of drugs used to treat HIV are known as antiretrovirals, which block the activity of the enzyme reverse transcriptase. While these drugs are successful at blocking viral replication, once a person has been infected with HIV, it is very difficult to eradicate completely. In a group, discuss aspects of HIV replication that make it nearly impossible to eradicate from infected host cells.

Group Activity

Where did the misconception that vaccines cause autism come from? In groups of two or three, investigate the history of this misconception and the studies associated with it.

Group Activity

Highly lethal viruses, such as Ebola, make it difficult for the virus to cause global pandemics. In addition, it can only be transmitted through direct contact with bodily fluids. Therefore, Ebola is rarely seen outside of a few countries in Africa. As a group, discuss why this is.

Chapter 22: Prokaryotes, Bacteria, and Archaea

Group Activity

Bacteria that live in hypersaline conditions have a significant problem maintaining osmolar homeostasis; in other words, they are in a significantly hypertonic solution. Break up into groups and discuss evolutionary adaptations these bacteria must have made in order to thrive in these conditions.

Group Activity

In groups of three, research some examples of each of the three bacteria shapes. Each person should be responsible for a different shape. Find example bacteria with your shape and research where they are commonly found. Share your research with your group.

Group Activity

In groups of three, research and identify examples in recent history of an epidemic, a pandemic, and an endemic disease.

Chapter 23: Protists

Group Activity

In groups of three or four, create a 3-D model of a chloroplast and a 3-D model of a cyanobacteria. You can use any materials that are available to you. Label each structure. As a class, discuss how the models are similar or different.

Group Activity

In a group, choose one of the six supergroups. Investigate this supergroup. What are some examples of protists that are included in this group? What are their habitats? What are their primary modes of reproduction? What kinds of organelles and structures do they have in common?

Group Activity

A significant fraction of ocean phytoplankton is composed of various protists, including diatoms, dinoflagellates, foraminiferans, and choanoflagellates (Figure 24). Many have outer shells, or tests, made of calcium carbonate or cellullose. The carbon in calcium carbonate and cellulose are derived from carbon dioxide, a greenhouse gas. In a group, discuss how protist phytoplankton represent an important sink, or storage, for global atmospheric carbon dioxide and its relation to global climate change.

Group Activity

The Great Barrier Reef off the east coast of Australia is the largest living structure that can be seen from space. The second largest barrier reef, the Belize Barrier Reef, is found off the east coast of Belize in Central America. Finally, the third largest barrier reef, the Florida Reef, is found off the east coast of the Florida Keys of the United States.

Symbiotic dinoflagellates are essential for building up the calcium carbonate skeletons that make up the physical structure of coral reefs.

Coral reefs can act as physical barriers to rough seas and tropical storms, protecting coastlines from erosion. As a group, discuss some of the other ecosystem services that coral reefs provide to human civilization.

Chapter 24: Fungi

Group Activity

As a group, make a poster showing the different processes where fungi are involved, such as in mycoses and the food industry. Include figures and historical facts, and do not forget to mention the fungi responsible for positive or negative biological events.

Group Activity

In groups of five, research the life cycles of the groups of true fungi (Chytridiomycota, Mucoromycota and Zoopagomycota, Ascomycota, Basidiomycota, and Glomeromycota). Each student is responsible for one group of fungi. Compare your research with that of your group members.

Group Activity

As a group, draw a scheme of the evolution of mycorrhizal symbioses from early plants to trees. Include geological eras, types of plants or algae, and evolutive traits of each stage.

Group Activity

As a group, find examples of mutualism, commensalism, and parasitism in fungi.

Group Activity

Dutch Elm Disease

Dutch elm disease is a fungal infestation that affects many species of elm (*Ulmus*) in North America. The fungus infects the vascular system of the tree, which blocks water flow within the plant and mimics drought stress. Accidently introduced to the United States in the early 1930s, it decimated American elm shade trees across the continent. It is caused by the fungus *Ophiostoma ulmi*. The elm bark beetle acts as a vector and transmits the disease from tree to tree. Many European and Asiatic elms are less susceptible to the disease than American elms. Working with your group members, research why European and Asiatic elms are less affected by Dutch Elm disease than are American elm trees. What mechanisms do they have to protect against infection? Is there any evidence that some American elms have similar mechanisms? Prepare a short report describing your findings.

Chapter 25: Seedless Plants

Group Activity

Based on what you know about green algae, do you think green algae should be excluded entirely from the plant kingdom? Discuss your thoughts as a group.

Group Activity

As a group, take a cutting from a larger hornwort. Submerge the cutting in water (you may have to weight it down) and observe its growth for one week. Take measurements and record your observations each day. What were some things you noticed about your hornwort? Did anything about its growth surprise you?

Group Activity

As a group, draw an evolutionary scale including geological time and plant evolution. Where would you locate the three bryophyte phyla? Do you think they appeared at different time points?

Group Activity

The evolution of leaves and their relationship has been a matter of debate for the scientific community. As a group, look for evidence and decide whether megaphylls evolved from microphylls or evolved independently.

Chapter 26: Seed Plants

Group Activity

As a class, go somewhere with flowers. The flowers can be inside or outside. Even artificial flowers will work if no real ones are available in your area. Bring a sketchbook and find a flower to draw. Is your flower a “perfect” flower? Explain your answer using arrows and captions to point out features you used to determine whether the flower was “perfect” or not. Then, discuss your findings as a group.

Group Activity

As a class, take a walk and work in pairs to complete the following scavenger hunt. Each pair must find an example of the following: a gymnosperm, an angiosperm, a dicot, and a monocot. Take a picture of each. You must find a unique plant for each category. For example, any monocot that you find must count toward either your monocot or angiosperm category, but not both.

Group Activity

Testing Attraction of Flies by Rotting Flesh Smell

Question: Will flowers that offer cues to bees attract carrion flies if sprayed with compounds that smell like rotten flesh?

Background: Visitation of flowers by pollinating flies is a function mostly of smell. Flies are attracted by rotting flesh and carrion, with the putrid odor seemingly the major attractant. The polyamines putrescine and cadaverine—the products of protein breakdown after animal death—are the source of the pungent smell of decaying meat. Some plants strategically attract flies by synthesizing polyamines similar to those generated by decaying flesh and thereby attract carrion flies.

Flies seek out dead animals because they normally lay their eggs on them and their maggots feed on the decaying flesh. Interestingly, time of death can be determined by a forensic entomologist based on the stages and type of maggots recovered from cadavers.

Hypothesis: Because flies are drawn to other organisms based on smell and not sight, a flower that is normally attractive to bees because of its colors will attract flies if it is sprayed with polyamines similar to those generated by decaying flesh.

Test the Hypothesis:

1. Select flowers usually pollinated by bees. White petunia may be a good choice.
2. Divide the flowers into two groups, and while wearing eye protection and gloves, spray one group with a solution of either putrescine or cadaverine. (Putrescine dihydrochloride is typically available in 98% concentration; this can be diluted to approximately 50% for this experiment.)
3. Place the flowers in a location where flies are present, keeping the sprayed and unsprayed flowers separated.
4. Observe the movement of the flies for one hour. Record the number of visits to the flowers using a table. Given the rapid movement of flies, it may be beneficial to use a video camera to record the fly-flower interaction. Replay the video in slow motion to obtain an accurate record of the number of fly visits to the flowers.
5. Repeat the experiment four more times with the same species of flower but using different specimens.
6. Repeat the entire experiment with a different type of flower that is normally pollinated by bees.

Results of Number of Visits by Flies to Sprayed and Control/Unsprayed Flowers

Trial #	Sprayed Flowers	Unsprayed Flowers
1		
2		
3		
4		
5		

Analyze Your Data: Review the data you have recorded. Average the number of visits that flies made to sprayed flowers over the course of the five trials (on the first flower type) and compare and contrast this average to the average number of visits that flies made to the unsprayed/control flowers. Can you draw any conclusions regarding the attraction of the flies to the sprayed flowers?

For the second flower type used, average the number of visits that flies made to sprayed flowers over the course of the five trials and compare and contrast this average to the average number of visits that flies made to the unsprayed/control flowers. Can you draw any conclusions regarding the attraction of the flies to the sprayed flowers?

Compare and contrast the average number of visits that flies made to the two flower types. Can you draw any conclusions about whether the appearance of the flower had any impact on the attraction of flies? Did smell override any appearance differences, or were the flies attracted to one flower type more than another?

Form a Conclusion: Do the results support the hypothesis? If not, how can your observations be explained?

Group Activity

Discuss in small groups specific ways that you depend on seed plants. Identify three specific seed plant examples. Then, design and illustrate a poster highlighting those seed plants and their usages. As an entire class, display your creations and take a few minutes to read and explore. Identify any plants that repeatedly appear on the different group posters.

Chapter 27: Introduction to Animal Diversity

Group Activity

As a group, research the different kinds of symmetry and find an animal example for each type. For each of your examples, determine if the animal shifts between types of symmetry as it grows.

Group Activity

As a class, compare the order of the three germ layers—endoderm, mesoderm, and ectoderm—with the kinds of tissues each layer gives rise to. Consider the order of the layers and discuss how some tissue types maintain their layering order in the developed organism. For example, epithelial tissue is an outermost tissue layer in developed organisms, and this outermost layering makes sense, seeing as it stems from the outermost germ layer, the ectoderm. Identify a few more examples. Then, discuss some tissues that seem surprising in terms of the layer from which they arise.

Group Activity

Scientists hypothesize that oxygen levels in the atmosphere correlate with maximum body weight. In a group, brainstorm how oxygen levels in the atmosphere might be linked to the size of mammals. For example, could the size of woolly mammoths vs. modern elephants be linked to lowering oxygen levels? What other giant mammals once existed?

Chapter 28: Invertebrates

Group Activity

In groups of three or four, gather materials to construct a model of a functional cnidocyte. Try to get it to fire on contact much like the real life counterparts. Then see if you can use it to snare a “prey” item.

Group Activity

As a group, research the most venomous cubozoans and their typical prey. Discuss how the nematocyst arrangement helps them subdue and capture their prey.

Group Activity

Break up into groups of four. Each member of the group is responsible for researching a particular species of one of the four cnidarian classes—Anthozoa, Cubozoa, Scyphozoa, and Hydrozoa. Write down three distinguishing characteristics for the species you are presenting on.

Now, rejoin your group and present your results to your fellow group members.

Group Activity

As a group, construct a model of a flatworm out of clay or other materials. Make sure to label each of the individual parts.

Group Activity

Investigate the different jaw shapes of rotifers. As a group, research how the different shapes help different species of rotifers obtain the food they need.

Group Activity

Break up into groups of three. Each member of the team is required to present on one of the three phyla we have focused on. Write down two unique traits and two examples of the phylum you are working on. Rejoin your group and take turns presenting your information to your team members.

Group Activity

Research some different crustaceans to determine their reproductive strategies. Then, come together as a group, and discuss why these variations might be advantageous to the different species.

Group Activity

As a group, list as many arthropods as you can. If you had to guess, in which subphylum would you classify each arthropod? Discuss as a group if there are disagreements.

Group Activity

Find a group and choose an echinoderm we have discussed in this lesson. Research its life cycle and method(s) of reproduction. Present your findings to the class.

Chapter 29: Vertebrates

Group Activity

As a group, create your own reproductions of contour feathers, down feathers, and flight feathers (both primary and secondary) using different materials, like clay or paper. Discuss how these types of feathers help birds produce lift and thrust for flying and maintain body temperature.

Group Activity

As a group, choose one of the great ape species within *Pan*, *Gorilla*, or *Pongo*. Put together a presentation that describes the defining characteristics of your chosen species as well as their current population and habitat.

Chapter 30: Plant Physiology

Group Activity

A number of stem modifications were described in this section, including tendrils, thorns, rhizomes, corms, stolons, runners, tubers, and bulbs. As a group, discuss common plants with such adaptations. For example, what stem adaptation is commonly associated with tulips? Refer to Figure 13 for additional examples.

Group Activity

We know that water expands when it freezes, which can kill plant cells by water crystals breaking through the cell membrane and destroying the integrity of the cell wall. So, how do trees survive the winter? The key is in the sap. As a group, research and brainstorm how sap helps trees survive freezing winters.

Chapter 31: Soil and Plant Nutrition

Group Activity

Work in a group of two to four people. Have each group member select one of the micronutrients from Table 1 and research its importance to plants. Then, share your findings with the members of your group.

Group Activity

Parasitic and epiphytic plants depend on other plant species for survival. In a group, compare and contrast the defining differences between these groups and their effects on the host plants.

Chapter 32: Plant Reproduction

Group Activity

Sporopollenin is an important, waterproof substance in the reproduction of plants. Break up into a small group (three to five peers) and write down a couple chemical characteristics that you would expect sporopollenin to have. Share your predictions with your peers and combine your answers. Next, find a reliable source about sporopollenin and determine what your group assumed correctly and incorrectly.

Group Activity

As a group, work through this seed dispersal activity to learn how various factors, such as seed dispersal and fruit type, can impact plant conservation efforts (hawkes.biz/seeddispersal).

Chapter 33: The Animal Body

Group Activity

Compare and contrast the behavioral and physical characteristics of endothermic and ectothermic animals. For example, discuss an American alligator (*Alligator mississippiensis*) and a Florida panther (*Puma concolor coryi*) and how their metabolic rates differ.

Chapter 34: The Digestive System

Group Activity

As a group, create a list of at least ten vertebrates. What type of digestive system do each of them have? Discuss as a group why you think so.

Group Activity

Native Americans learned that the combination of corn, beans, and squash provided powerful nutritional benefits. They even had a name for this trio—the Three Sisters.

Work in groups of three. Each group member should research one of the Three Sisters. Place special emphasis on amino acid content. Then, discuss how the combined amino acids in this dietary staple, called succotash, contributed to its nutritional benefits.

Chapter 35: The Circulatory System

Group Activity

Each heartbeat sends a wave of increased blood pressure throughout your blood vessels. These pressure waves are readily detectable in some parts of our body, allowing an opportunity to count our heart rate in beats per minute. This measurement is called our pulse. The inner wrist is a commonly used location for detecting pulse. First, find your pulse using two fingers to press gently along the inner wrist, under the thumb area. Be careful not to press too hard. Now, find a partner and work together to measure your pulse in beats per minute.

Chapter 36: The Respiratory System

Group Activity

How might you use a balloon to obtain crude measurements for some of the measurable aspects of lung volume and capacity listed in Table 1? Be inventive! Come up with a method for estimating two of these quantities using a normal balloon.

Chapter 37: The Immune System

Group Activity

As a group, brainstorm a short list of different infectious diseases. Then, assign each group member one disease. Using internet resources, identify the type of pathogen that causes that disease: virus, free-living bacterium, intracellular bacterium, fungus, protist, or helminth. Which diseases do you think stimulate a strong humoral immune response? Which do you think stimulate a strong cell-mediated immune response? Why?

Chapter 38: The Urinary System

Group Activity

Work in small groups to complete this simple experiment. First, slice up a vegetable, such as a potato or carrot, into uniformly sized strips. Then, soak some strips in fresh water and others in salt water. After 24–72 hours, check the strips. Compare the texture, size, and appearance of the strips that had been soaked in the salt water to the strips that had been soaked in the fresh water. Use your knowledge of osmosis to explain any changes you observe.

Group Activity

In a group, list the organs involved in osmoregulation, the hormones each organ produces, and the effect of each hormone on osmoregulation and blood pressure.

Chapter 41: Sensory Systems

Group Activity

Just-Noticeable Difference

It is easy to differentiate between a one-pound bag of rice and a two-pound bag of rice; there is a one-pound difference, and one bag is twice as heavy as the other. However, would it be as easy to differentiate between a 20- and a 21-pound bag? The smallest detectable difference between two stimuli is known as the just-noticeable difference (JND). According to Weber's Law, the just-noticeable difference in a stimulus is proportional to the magnitude of the original stimulus. In this activity, you will investigate and test Weber's Law.

Question: What is the smallest detectible weight difference between a one-pound bag of rice and a larger bag? What is the smallest detectible difference between a 20-pound bag and a larger bag? In both cases, at what weights are the differences detected?

Background: Research background literature on JND and on Weber's Law, a description of a proposed mathematical relationship between the overall magnitude of the stimulus and the JND. You will be testing the JND of different weights of rice in bags. Choose a convenient increment to be stepped through while testing. For example, you could choose 10% increments between one and two pounds (1.1, 1.2, 1.3, 1.4, and so on) or 20% increments (1.2, 1.4, 1.6, and 1.8).

Hypothesis: Develop a hypothesis about the JND in terms of percentage of the whole weight being tested (such as "the JND between the two small bags and between the two large bags is proportionally the same," or "… is not proportionally the same"). So, for the first hypothesis, if the JND between the one-pound bag and a larger bag is 0.2 pounds (that is, 20%; 1.0 pound feels the same as 1.1 pounds, but 1.0 pound feels less than 1.2 pounds), then the JND between the 20-pound bag and a larger bag will also be 20%. (So, 20 pounds feels the same as 22 pounds or 23 pounds, but 20 pounds feels less than 24 pounds.)

Test the Hypothesis: Enlist 24 participants and split them into two groups of 12. To set up the demonstration, assuming a 10% increment was selected, have the first group be the one-pound group. As a counter-balancing measure against a systematic error, however, six of the first group will compare one pound to two pounds, and step down in weight (1.0 to 2.0, 1.0 to 1.9, and so on), while the other six will step up (1.0 to 1.1, 1.0 to 1.2, and so on). Apply the same principle to the 20-pound group (20 to 40, 20 to 38, and so on, and 20 to 22, 20 to 24, and so on). Given the large difference between 20 and 40 pounds, you may wish to use 30 pounds as your larger weight. In any case, use two weights that are easily detectable as different.

Record the Observations: Record the data in a table similar to the table below. For the one-pound and 20-pound groups (base weights) record a plus sign (+) for each participant that detects a difference between the base weight and the step weight. Record a minus sign (–) for each participant that finds no difference. If one-tenth steps were not used, then replace the steps in the "Step Weight" columns with the step you are using. (*cont.*)

Group Activity (cont.)

Table 1: Results of JND Testing (+ = difference; – = no difference)

Step Weight	One Pound	20 Pounds	Step Weight
1.1			22
1.2			24
1.3			26
1.4			28
1.5			30
1.6			32
1.7			34
1.8			36
1.9			38
2.0			40

Analyze the Data/Report the Results: What step weight did all participants find to be equal with one-pound base weight? What about the 20-pound group?

Draw a Conclusion: Did the data support the hypothesis? Are the final weights proportionally the same? If not, why not? Do the findings adhere to Weber's Law?

Chapter 43: The Musculoskeletal System

Group Activity

Working in pairs, come up with three different animals that you suspect operate by way of a hydrostatic skeleton. Then, do a quick internet search and check your list. How many did you get correct? Pick one of these animals to research further. Use the internet or other resources to learn how this animal can move around with its hydrostatic skeleton. Share your animal's method of locomotion with the class.

Group Activity

Scientific Method: Decalcification of Bones

Question: What effect does the removal of calcium and collagen have on bone structure?

Background: Conduct a literature search on the role of calcium and collagen in maintaining bone structure. Conduct a literature search on diseases in which bone structure is compromised.

Hypothesis: Develop a hypothesis that states predictions of the flexibility, strength, and mass of bones that have had the calcium and collagen components removed. Develop a hypothesis regarding the attempt to add calcium back to decalcified bones.

Test the Hypothesis: Test the prediction by removing calcium from chicken bones by placing them in a jar of vinegar for seven days. Test the hypothesis regarding adding calcium back to decalcified bone by placing the decalcified chicken bones into a jar of water with calcium supplements added. Test the prediction by denaturing the collagen from the bones by baking them at 250°C for three hours.

Analyze the Data: Create a table showing the changes in bone flexibility, strength, and mass in the three different environments.

Report the Results: Under which conditions was the bone most flexible? Under which conditions was the bone the strongest?

Draw a Conclusion: Did the results support or refute the hypothesis? How do the results observed in this experiment correspond to diseases that destroy bone tissue?

Group Activity

Working with a partner, make a list of ten types of movements that synovial joints can allow. (For example, your list may include things like extension, adduction, or elevation.) For each movement type on your list, demonstrate the movement. Use a new joint each time.

Chapter 44: Ecology and the Biosphere

Group Activity

In a group of 3–4 students, discuss why it is important to approach the study of ecology from multiple levels—ranging from the organism to the ecosystem.

Group Activity

In groups of two or three, discuss what the climate might be for your hometown. What sorts of temperature patterns are typical of your location? How often does it rain in a given season?

Group Activity

As a group, examine Figure 3. The first image shows average CO_2 concentrations in the troposphere (the lowest level of the atmosphere) across Earth during the year 2011 (top), as well average global CO_2 concentrations in the troposphere in May (left) and October (right) of that year. Note the change in the distribution of CO_2 between May and October. The bottom graph shows the annal mean global tropospheric and surface CO_2 concentrations from 1998 to 2012.

After examining the figure with your group, answer the four questions.

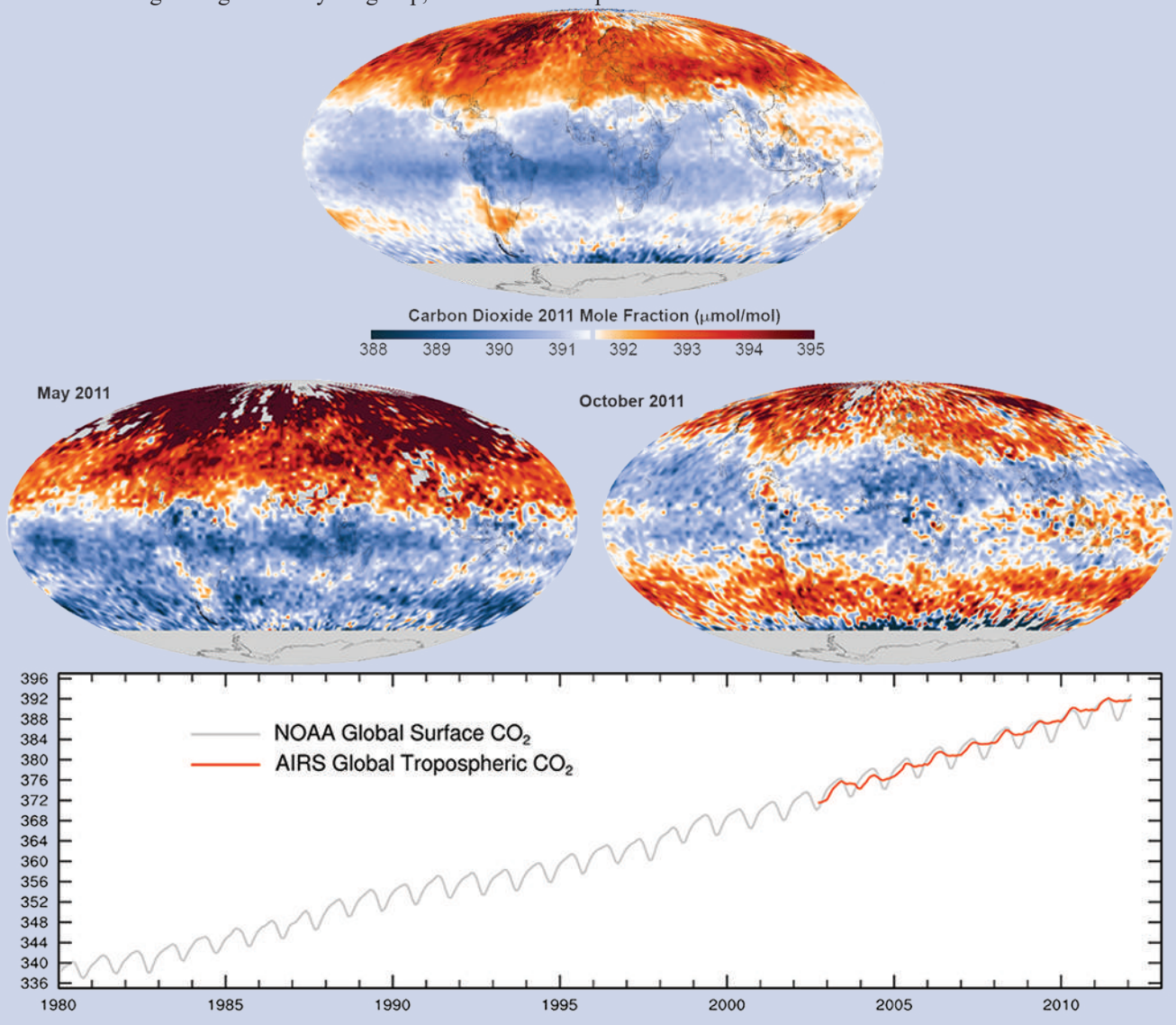

Figure 3: The top image displays the average global tropospheric CO_2 across Earth for all of 2011, in May of 2011, and in October of 2011. The bottom graph displays the annual mean carbon dioxide concentration at the surface, in the troposphere, and at Earth's surface between 1980 and 2012.

7. How does the average CO_2 in 1995 compare to that in 2010?
8. Consider the change in the distribution of CO_2 between May and October of 2011. What do you think causes such seasonal fluctuations in the concentration of CO_2 in the atmosphere?
9. What do you think will happen to the concentration of CO_2 in the atmosphere in the next 50 years? Explain the reasons for your predictions.
10. What are some negative effects of the rise in CO_2? Are there any positive effects?

Chapter 45: Population and Community Ecology

Group Activity

As a group, use a 1 m^2 quadrat and count the number of individuals of your choice in a particular location. Quadrats can be constructed from items such as string, meter sticks, or PVC pipe. Repeat this process three times in different areas and calculate the average of the three quadrat counts. The average count represents the population density of individuals per 1 m^2. This can be completed inside using nonliving objects in place of organisms, or it can be completed outside using living organisms, such as flowers, ants, etc.

Group Activity

Form a group of three or four. Choose a species you would like to study as a group. Research the population changes of this species over the last 50 years. What factors do you think have affected the population?

Group Activity

In groups of three or four, investigate another species besides the ones mentioned here that exhibits semelparity and another that exhibits iteroparity. Compare and contrast these species. What are some reasons why semelparity may be advantageous to one species while iteroparity is advantageous to the other?

Group Activity

Rather than thinking of *K*-selected and *r*-selected as distinct categories, the terms describe two ends of a spectrum ranging from most *K*-selected to most *r*-selected. As a group, draw a scale from 1–10. Assign *K*-selected at one extreme (#1), and assign *r*-selected at the other extreme (#10). Then, work together to come up with four example species to illustrate your continuum. Include an example species at both extreme ends of the continuum (1 and 10). Then, provide example species that lie along the middle.

Group Activity

In groups, find examples of each of the three types of mimicry. Share your examples with the rest of the class.

Group Activity

As a group, identify as many different plant and animal species as you can in the outdoor space nearest to you. Define the biodiversity of this habitat. Does it have a high species richness? Are some species more abundant than others?

Draw your own map of the area. Label where different species live and how abundant they are.

Group Activity

For part one, work in small groups. Pick one movie that contains altruistic behaviors or decision-making. Be sure to choose a film that all group members have seen. Consider a significant altruistic behavior or decision made during the movie's plot. As a group, brainstorm ways that this altruistic behavior may not be "pure altruism" and write them down. If your group concludes that the film depicts an act of "true altruism," then write that down instead.

For part two, your group will partner with a second group and take turns briefly sharing your movie analyses. Challenge each other to identify any aspects of "non-altruistic" behavior that may have been missed.

Chapter 46: Ecosystems

Group Activity

Visit this website to access photos taken from a trail camera in Gorongosa National Park (hawkes.biz/trophiclevels).

Navigate through the photos of each species and predict the trophic level (producer, primary consumer, secondary consumer, or tertiary consumer) of each species. You can use the "Field Guide" to help make your predictions. Record your reasons for your predictions, and compare your predictions with the rest of your group.

Group Activity

Break up into a group of 4–10, trying to maintain an even number of members in your group. Half the members of your group will design a simple ecological experiment taking the mesocosm approach. The other half is tasked with designing a simple ecological experiment taking the microcosm approach. Once you are done with your respective tasks, combine your team once more, and share your experiment with the other group. The other group will identify the strengths and weaknesses of your experiment. Switch roles and complete the exercise.