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Correct Answers are located at the end of each chapter.

TRUE/FALSE - Write 'T' if the statement is true and 'F' if the statement is false.

1) If you found an organism that was single-celled and had a nucleus, you would classify it as a member of the Archaea.
   - ◎ true
   - ◎ false

2) "Kingdom" is the most inclusive (broadest) taxonomic category.
   - ◎ true
   - ◎ false

3) The scientific method cannot be used to answer questions about immaterial and philosophical issues.
   - ◎ true
   - ◎ false

4) In an experiment, a control and a standardized variable are the same thing.
   - ◎ true
   - ◎ false

MULTIPLE CHOICE - Choose the one alternative that best completes the statement or answers the question.

5) Which is the correct sequence for levels of biological organization within a multicellular organism?
   - A) atom - molecule - organelle - cell - tissue
   - B) molecule - atom - organelle - tissue - cell
   - C) cell - organelle - atom - tissue - molecule
   - D) organelle - molecule - atom - tissue - cell
   - E) atom - organelle - molecule - cell - tissue

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6) Which is the correct sequence for levels of biological organization occurring beyond an organism?
   A) population - ecosystem - community - biosphere
   B) community - population - ecosystem - biosphere
   C) community - population - biosphere - ecosystem
   D) population - community - ecosystem - biosphere
   E) ecosystem - population - biosphere - community

7) All living organisms are
   A) prokaryotes.
   B) either unicellular or multicellular.
   C) eukaryotes.
   D) multicellular.
   E) unicellular.

8) Organisms that extract energy from nonliving environmental resources are called
   A) heterotrophs.
   B) decomposers.
   C) parasites.
   D) consumers.
   E) producers.

9) You are sorting cards with pictures of organisms and their descriptions into groups. You would place the card with an osprey and the description "organisms that obtain energy by consuming other organisms" with cards for other
   A) autotrophs.
   B) plants.
   C) heterotrophs.
   D) producers.
   E) photosynthesizers.

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10) If you observed a newly discovered 'thing' and tried to decide if it might be alive, what would be the weakest distinction for life?

A) homeostasis
B) movement
C) structural organization
D) evolution
E) energy use

11) The four kingdoms included in the domain Eukarya are

A) Bacteria, Fungi, Plantae, and Animalia.
B) Bacteria, Protista, Plantae, and Animalia.
C) Protista, Fungi, Plantae, and Animalia.
D) Archaea, Bacteria, Plantae, and Animalia.
E) Archaea, Fungi, Plantae, and Animalia.

12) A major difference between prokaryotes and eukaryotes is that prokaryotes

A) have cell walls while eukaryotes do not.
B) do not have a nucleus in their cells while eukaryotes do.
C) have a nucleus in their cells while eukaryotes do not.
D) are autotrophs while eukaryotes are not.
E) are not living organisms, while eukaryotes are.

13) If you were grading a set of exams dealing with the scientific method, which statement would lead to a student losing points?

A) It is a general way of answering questions with evidence.
B) It is a framework to consider ideas in a repeatable way.
C) It begins with observations.
D) It does not apply to problems encountered in everyday life.
E) It enables the testing of ideas.

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14) Which statement about a hypothesis is incorrect?
A) It can be proven true.
B) It can be proven false.
C) It is a tentative explanation.
D) It is based on previous knowledge.
E) It must be testable to be useful.

15) In a scientific experiment, the investigator manipulates the_____ variable(s) to determine whether it causes another variable to change.
A) standardized
B) control group
C) dependent
D) independent
E) control group and standardized

16) In a scientific experiment, the investigator measures the response of the_____ variable(s).
A) independent
B) dependent
C) control group
D) standardized
E) dependent and independent

17) Which of the following is not a "control" in an experimental procedure?
A) a placebo
B) a known standard of comparison
C) a normal group
D) an experimental group
E) a "zero"-value group

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18) A theory differs from a hypothesis in that a theory
A) has more supportive evidence than a hypothesis.
B) is broader in scope than a hypothesis.
C) has predictive power.
D) ties together many existing observations.
E) All answers are correct.

19) A structure consisting of tissues organized to carry out a specific function defines a(n)
A) organ.
B) cell.
C) population.
D) atom.
E) molecule.

20) In cleaning up after lab, you have to sort cards into boxes. You would put all of the below cards into a box marked "ecosystem" except
A) community.
B) biosphere.
C) populations.
D) organisms.
E) nonliving environmental components.

21) Asexual reproduction differs from sexual reproduction in that
A) asexual reproduction produces genetically diverse offspring.
B) asexual reproduction utilizes DNA from two parents to code for traits in offspring.
C) asexual reproduction occurs only in plants.
D) asexual reproduction produces offspring containing DNA from only one parent.
E) asexual reproduction only occurs in animals.

22) If you wanted to demonstrate homeostasis to a friend, you could use as an example
A) a population changing over time.
B) environmental conditions holding constant through time.
C) cells having enough water to survive.
D) plants and animals needing energy sources.
E) an organism maintaining nearly constant internal conditions.

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23) What statement deals with an aspect of experimentation but with the incorrect explanation?

A) The larger the sample size, the more meaningful the results.
B) The smaller the sample size, the more meaningful the results.
C) A control group is an untreated group and provides a basis for comparison.
D) It is important to standardize aspects of an experiment that might affect the outcome, other than the independent variable.
E) All answers are correct.

24) The bacterium *Staphylococcus aureus* belongs to which domain?

A) Eukarya
B) Archaea
C) Prokarya
D) Protista
E) Bacteria

25) The bacterium *Staphylococcus aureus* has which of the following?

A) nucleus and ribosomes
B) DNA and nucleus
C) DNA and cell membrane
D) cell membrane and nucleus
E) None of the answer choices are correct.

26) *Homo sapiens*is in which domain?

A) Archaea
B) Bacteria
C) Eukarya
D) Animalia
E) Protista

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27) What did Charles Darwin predict after observing the 11-inch long nectaries of the *Angraecum sesquipedale* orchid in Madagascar?
A) the existence of a moth with a 10–11 inch long tongue
B) the existence of a competitor that also possessed especially long nectaries
C) the presence of very small bees that could fit into long nectaries
D) that the orchid must reproduce asexually
E) that the orchid was an evolutionary dead end and could no longer reproduce

28) In an experiment, Charles Darwin's prediction about long nectaries and long-tongued moths would be a(n)
A) standardized variable.
B) theory.
C) independent variable.
D) dependent variable.
E) hypothesis.

29) You want to test Charles Darwin's prediction that an orchid with long pollen tubes has a pollinator with long, thin mouthparts that can reach the bottom of the elongated nectar tube. You place nets over some orchids, which allows pollinators with small, short mouthparts to enter but prevents the entry of pollinators with long, thin mouthparts. Next, you compare the number of seeds produced by plants with and without the nets. In this experiment, seed production is a(n)
A) dependent variable.
B) hypothesis.
C) theory.
D) independent variable.
E) standardized variable.

30) What is the advantage to the Madagascan orchid of having an 11-inch long nectar tube?
A) It can produce nectar over a larger area and attract more pollinators.
B) It can collect more rainwater.
C) It can be pollinated easily only by the moths with long tongues.
D) It can collect more sunlight for photosynthesis.
E) It can trap insects as a source of nutrients.

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31) What is the advantage of a moth having a very long tongue if an orchid has a very long nectar spur?

A) It is used to attract mates through sexual selection.
B) It can pollinate only one type of flower.
C) It makes flying more efficient.
D) It can be used to capture other flying insects for food.
E) It can reach nectar that no other pollinator can reach.

32) Pollination is a step of_____ in a plant.

A) sexual reproduction
B) asexual reproduction
C) development
D) metabolism
E) homeostasis

33) Why isn't scientific inquiry foolproof?

A) Multiple interpretations of the data are possible.
B) Definitive answers may not exist.
C) Observations can be misinterpreted.
D) Unexpected conclusions are not always readily accepted.
E) All answers are correct.

34) Which of the following questions cannot be answered by science?

A) What is the meaning of life?
B) Why is the sky the color blue?
C) What causes species' extinctions?
D) How did I start from only an egg and sperm?
E) Why is too much fatty food bad for me?

35) How do you know the computer you are working on is not alive?

A) It is not made of cells.
B) It does not maintain an internal consistency of water, solutes, and other components.
C) It cannot reproduce, asexually or sexually.
D) It cannot evolve.
E) All answers are correct.

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36) Gravity is a theory because it is
A) a tentative explanation of an observation.
B) an untestable prediction.
C) a changeable element of experiments.
D) an opinion or hunch.
E) an encompassing explanation of a natural phenomenon that is well accepted.

37) Which of the following statements regarding sample size is true?
A) It refers to the number of individuals assigned to each treatment.
B) A larger sample size generally provides more credible results.
C) It is a critical step in the experimental design and can influence statistical significance.
D) All of the statements are true regarding sn experiment's sample size.

38) You are reading a science article in a magazine and are trying to evaluate whether the argument is legitimate or "bad science". Which of the following may indicate that this article is presenting a bad scientific argument?
A) It has been published recently.
B) The author lacks credentials.
C) It objectively measures the independent variable.
D) It uses scientific terminology.

SECTION BREAK. Answer all the part questions.

39) You perform an experiment in which you take 16 pots of strawberry plants and give half of them 1 gram of ammonium nitrate per liter of water and the other half receive only water. Each group is then split in half again, and exposed to either 8 or 16 hours of light each day. You monitor the height of the plants for 4 weeks. You observe that plants grown in ammonium nitrate and 16 hours of light grow taller than no ammonium nitrate and 8 hours of light.

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39.1) Which of the following is/are independent variable(s) in this experiment?
A) amount of ammonium nitrate and light
B) amount of water
C) amount of carbon dioxide
D) height of the plants and amount of light
E) height of the plants

39.2) Which of the following is/are dependent variable(s) in this experiment?
A) amount of ammonium nitrate and light
B) amount of carbon dioxide
C) amount of water
D) height of the plants
E) height of the plants and amount of light

39.3) In this experiment, the size of the pot is
A) an independent variable.
B) a dependent variable.
C) a standardized variable.
D) a placebo.
E) a control.

39.4) Ammonium nitrate is
A) an atom.
B) a molecule.
C) a cell.
D) a tissue.
E) a biosphere.

39.5) The proximate reason for the uptake by plants of nutrients like ammonium nitrate is
A) asexual reproduction.
B) sexual reproduction.
C) natural selection.
D) evolution.
E) homeostasis.

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39.6) The leaf of a strawberry plant is

A) an organ.
B) a molecule.
C) an organelle.
D) a cell.
E) an organism.

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Answer Key

Test name: Chapter 01

1) FALSE
2) FALSE
3) TRUE
4) FALSE
5) A
6) D
7) B
8) E
9) C
10) B
11) C
12) B
13) D
14) A
15) D
16) B
17) D
18) E
19) A
20) B
21) D
22) E
23) B
24) E
25) C
26) C
27) A
28) E
29) A
30) C
31) E
32) A
33) E
34) A
35) E
36) E
37) D

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38) B
39) Section Break
39.1) A
39.2) D
39.3) C
39.4) B
39.5) E
39.6) A

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CHAPTER 1 – The Scientific Study of Life

LEARNING OUTLINE

1.1 What Is Life?
- A. Life Is Organized
- B. Life Requires Energy
- C. Life Maintains Internal Constancy
- D. Life Reproduces, Grows, and Develops
- E. Life Evolves

1.2 The Tree of Life Includes Three Main Branches

1.3 Scientists Study the Natural World
- A. The Scientific Method Has Multiple Interrelated Parts
- B. An Experimental Design Is a Careful Plan
- C. Theories Are Comprehensive Explanations
- D. Scientific Inquiry Has Limitations
- E. Biology Continues to Advance

LEARNING OUTCOMES

01.00.01 Describe how science is used to study life.
01.01.01 Describe the characteristics that all living organisms share.
01.02.01 Compare and contrast the three branches of life.
01.03.01 Identify the variables in an experiment.
01.03.02 Apply the scientific method to design experiments and analyze data.
01.03.03 Explain the limitations of the scientific method.

WHERE DOES IT ALL FIT IN?

Chapter 1 introduces the fundamental principles that scientists use to understand the scope of biological knowledge. Stress to students that the concepts of evolution, life's organizational hierarchy, living properties, and scientific method are essential for understanding the other topics covered in this textbook. Concepts in Chapter 1 will be referred to frequently when discussing the different levels of organismic complexity covered in the following chapters. It is also important to stress to students that the information covered throughout the remaining chapters was derived from careful scientific inquiry using the principles of the scientific method outlined in this chapter.

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SYNOPSIS

This chapter provides students with three fundamental ideas needed to understand the scope and breadth of biology: 1. A description of the characteristics of life, 2. A description of the classification system for living things and the main branches of the tree of life, and 3. A summary of the scientific method used to obtain scientific knowledge and increase our understanding of biological systems.

The chapter starts by stating that cells are the basic unit of life. Next, the five characteristics of living things are explained:

1. Living things are organized in a hierarchical way ranging from atoms at the lowest level to the biosphere at the highest level.
2. All living things require energy, and organisms can be categorized as producers, consumers, or decomposers based on the way they obtain energy within the ecosystem. The concepts of energy flow through food webs and energy transfer are discussed.
3. Living things maintain a constant set of conditions inside their bodies and their cells. This constant set of conditions is called homeostasis. The ability of organisms to respond to environmental stimuli is important for their ability to maintain homeostasis.
4. All living things are capable of reproducing themselves. The characteristics and implications of sexual and asexual reproduction are discussed.
5. All living things evolve, and natural selection is the mechanism by which evolution occurs. Natural selection produces adaptations in organisms that are heritable characteristics, thus enabling organisms to survive and reproduce in their environments.

Next, the chapter discusses the field of taxonomy that scientists use for naming and classifying organisms. Our system of taxonomy is based on the evolutionary relationships of organisms. All living things have been classified into three domains of life based on similarities in their DNA sequences. Descriptions of the characteristics of each domain are provided, and the hierarchical levels of classification below domain are summarized.

An introduction to scientific methodology is critical for students to understand the process by which biological information is acquired and refined. The steps in the scientific method include making observations, asking questions about those observations, making potential answers (hypotheses) to those questions, making predictions about the hypotheses, collecting data to test the hypotheses, analyzing the data and drawing conclusions as to whether the data support or reject the hypotheses. Results of scientific inquiries are communicated to the public through peer-reviewed journals.

Next, the chapter discusses controlled experiments. Variables are the changeable elements of a controlled experiment. Types of variables include dependent variables, independent variables, and standardized variables. Controlled experiments make use of two or more groups. One or more “experimental” groups are compared to a “control” group that does not receive the treatment. Scientists use statistics to evaluate quantitative results of experiments.

Theories provide explanations to natural phenomena and are normally broad in scope and based on a number of related hypotheses that have not been rejected. Theories are the things scientists are most certain about because large amounts of evidence support them. The importance of

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understanding the inherent limitations of carrying out scientific inquiry is also discussed. The chapter stresses that science is a human endeavor and that data may be subject to differences in interpretation.

COMMON STUDENT MISCONCEPTIONS

There is ample evidence in the educational literature that student misconceptions of information will inhibit the learning of concepts related to the misinformation. The following concepts covered in Chapter 1 are commonly the subject of student misconceptions. This information on "bioliteracy" was collected from faculty and the science education literature.

- Students think life is too complex to be explained with scientific reasoning.
- Students believe inanimate objects cannot possess some of the characteristics of living organisms.
- Students are unaware that acquired characteristics cannot be inherited.
- Students commonly think all organisms have the same level of hierarchical organization.
- Students believe most organisms on the Earth are either animals or plants.
- Students think there is a single list of steps called "The Scientific Method."
- Students believe hypotheses are merely guesses about natural phenomena.
- Students think theories are a scientist's opinion.
- Students are unaware that theories change over time.
- Students think the control is not affected by variables.
- Students believe use of scientific models is not accepted by much of the scientific community.
- Students commonly think statistics are used to make data fit the hypothesis.
- Students think the independent variable in an experiment is always controlled by the researcher.
- Students believe evolution is a means of disproving the existence of a supernatural being.
- Students think biological principles can be described without evolutionary theory.
- Students do not associate evolution beyond the individual organism level.
- Students are unaware that evolutionary adaptation does not occur during the lifetime of an organism.
- Students think the death of an individual organism can change the whole fate of the Earth.

The following articles provide strategies for increasing bioliteracy in the college classroom:

Baldwin JD, Ebert-May D, Burns, D. 1999. The development of a college biology self-efficacy instrument for non-majors. Science Education, 83(4): 397-408.

Ebert-May D. 2001. Research-based change: how one college professor approached the challenge of changing teaching. In: Implementing the Science Standards in Higher Education, eds. W. J. McIntosh and E. Siebert, pp. 36-39. Arlington, VA: National Science Teachers Association.

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Khodor J, Halme DG, Walker GC. 2004. A Hierarchical Biology Concept Framework: A Tool for Course Design. Cell Biology Education, 3(2): 111-121.

Klymkowsky MW, Garvin-Doxas K, Zeilik M. 2003. Bioliteracy and teaching efficacy: what biologists can learn from physicists. Cell Biol Educ, 2(3):155-161.

INSTRUCTIONAL STRATEGY PRESENTATION ASSISTANCE

Simple class activities are tangible ways of introducing the scientific method before a lecture on Chapter 1. The scientific method can be portrayed using a nonworking flashlight (have a nonfunctional bulb and dead batteries in it). Guide the class through the process of the scientific method needed to hypothesize and test what is needed to fix the flashlight. It is important to have working spare parts to get the flashlight to work again.

Many students undervalue the scientific method when they see contradictory research studies in the news. Show the students some conflicting news articles related to everyday issues such as the health value of drinking wine or avoiding certain fats. This can then be used as a discussion point about the limitations of science and why certain studies of similar design may yield opposite conclusions.

Molecular phylogeny is a science that bridges an understanding of hierarchical levels of life with taxonomy. An article called “Dogs, cats, and kin: A molecular species-level phylogeny of Carnivora” can be used as a discussion point of how an understanding of the molecular level of life contributes to evolutionary taxonomic relationships (Agnarsson, I., Kuntner, M., & May-Collado, L. J. (2010). Dogs, cats, and kin: a molecular species-level phylogeny of Carnivora. *Molecular phylogenetics and evolution*, *54*(3), 726-745). Of particular interest is Figure 1 (Summary of relationships among carnivoran families) which shows the relationships of the different carnivores based on molecular data. Have the students discuss if the molecular similarities are consistent with the relationships they would assume based on overt appearance of the animals.

Use projected images of various types of prokaryotic and eukaryotic organisms to demonstrate the biodiversity that will be covered in the textbook. Then go to the World Wildlife Fund website to show students how various agencies study and protect global biodiversity. Type “biodiversity” into the search window to see the various biodiversity resources.

Use some lecture or recitation time to discuss the “What’s the Point?,” “Why We Care,” “Burning Question” boxes, and the end-of-chapter reading “Investigating Life.” The information in these resources encourages students to use the chapter information in critical thinking situations.

When assigning the chapter as a reading, encourage the students to stop and complete the “Mastering Concepts” features as a way of assessing their knowledge of what they read. In addition, the “Pull It Together” feature provides students with a visual summary of the important concepts in the chapter.

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HIGHER-LEVEL ASSESSMENT

Higher-level assessment measures a student's ability to use terms and concepts learned from the lecture and the textbook. A complete understanding of biology content provides students with the tools to synthesize new hypotheses and knowledge using the facts they have learned. The following table provides examples of assessing a student's ability to apply, analyze, synthesize, and evaluate information from Chapter 1.

Application	• Have students design an experiment explaining the claim that soybean products taken in the diet by pregnant women may alter fetal development. • Have students apply the concept of homeostasis to explain the difference in characteristics between a living and a dead animal. • Ask students to hypothesize an evolutionary explanation for the fact that some people have the genetic ability to control muscles to wiggle their ears.
Analysis	• Ask students to explain how the survival of prokaryotes may differ from that of animals as a result of their level of hierarchical complexity. • Ask students to select two of the most important criteria needed to identify a probable living organism collected from another planet. • Have the class analyze whether each characteristic of living organisms provided in Chapter 1 equally represents animals and plants.
Synthesis	• Ask students to describe how taxonomy would contribute to medical treatments used to control infectious diseases. • Ask students to predict how a physician would treat a disease if the concept of scientific method was not developed. • Have students explain how the release of a toxic pollutant into the oceans that kills one particular fish could affect each level of hierarchy associated with a lake in which the fish lives.
Evaluation	• Ask students to discuss implications of a disease caused by a purported organism that does not seem to have any of the characteristics of life discussed in the chapter. • Ask students to come up with some strategies to reduce the number of factors that limit the accuracy of scientific experimentation.

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	• Have students evaluate the pros and cons of using computer models as a substitute for experimentation in gaining an understanding of human diseases.

IN-CLASS CONCEPTUAL DEMONSTRATION

Brine Shrimp or *Daphnia* as a Model of Living Properties

Brine shrimp provide a simple living model for investigating some of the properties of organisms. They are simple to view under a microscope and can be clearly projected on a screen using 100x magnification with a wet mount specimen. This activity demonstrates some of the characteristics of life covered in Chapter 1.
Materials

- Microscope with digital camera connected to an LCD projector
- Small container of large brine shrimp or *Daphnia*
- 1 microscope slide
- 1 small dropper
- 1 small dropper bottle of trypan blue (dissolve 0.2 g trypan blue in 100 ml distilled)
- 1 projector microscope or microscope attached to a video projector
- 1 small bottle of cold water with a dropper
- 1 small bottle of 50°C water with a dropper
- 1 small bottle of room temperature 3% hydrogen peroxide with a dropper
- 1 small bottle of brewed dark coffee
- 1 small bottle of room temperature pure methanol with a dropper

Procedure and Inquiry

1. Place 3 or 4 brine shrimp or *Daphnia* on slide. Use just enough water to keep the organisms immobilized, but submerged in water. Do not add a coverslip.
2. Observe the organisms under a microscope and focus the image under slow to medium power so that a whole brine shrimp can be seen clearly.
3. Ask the students if they observe any properties of life and different levels of organization exhibited by the brine shrimp or *Daphnia*.
4. Add the 50ºC water to the slide and ask the students to observe what happens. After a while the organism should move its legs or gills faster. Then ask the students if they observe any properties of life (some may answer metabolism, movement, or response to stimuli).
5. Add one drop of 3% hydrogen peroxide to the slide and ask the students to observe what happens. They should see bubbling due to catalase activity from bacteria on the surface of the shrimp or *Daphnia*. Then ask the students if they observe any properties of life (some may answer metabolism or response to stimuli).
6. Add one drop of strong brewed coffee to the slide and ask the students to observe what happens. Again, ask them to observe and explain. They should see the shrimp or *Daphnia*

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speed up kicking activity.

7. Add the trypan blue to the slide. Let the students observe the shrimp or *Daphnia* as you add 3 drops of the methanol. The students should observe some of the cells turning blue as the cells eventually die outside of the normal internal environment of the body. Have them make hypotheses about this last observation.

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