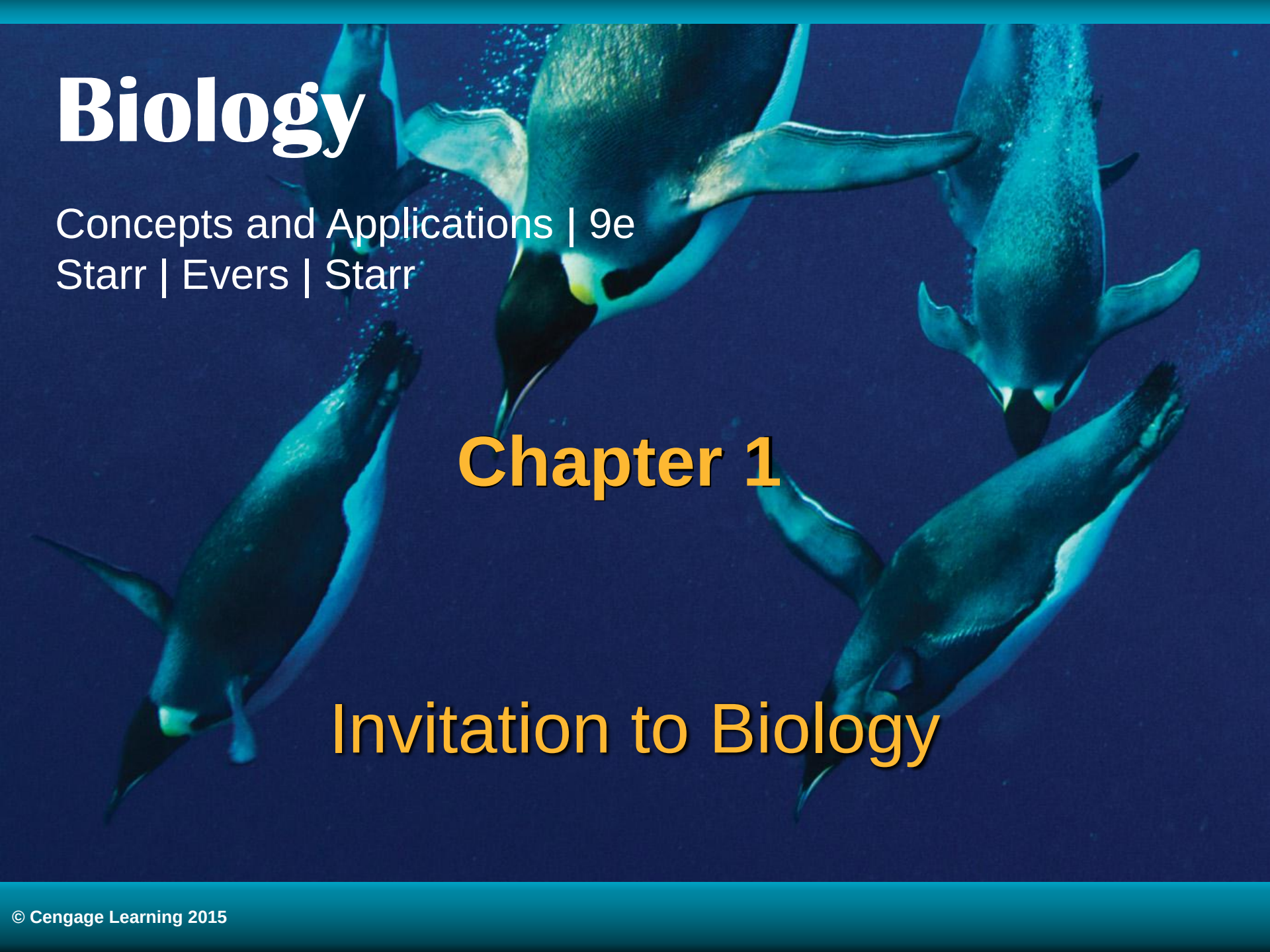


Biology

Concepts and Applications | 9e
Starr | Evers | Starr

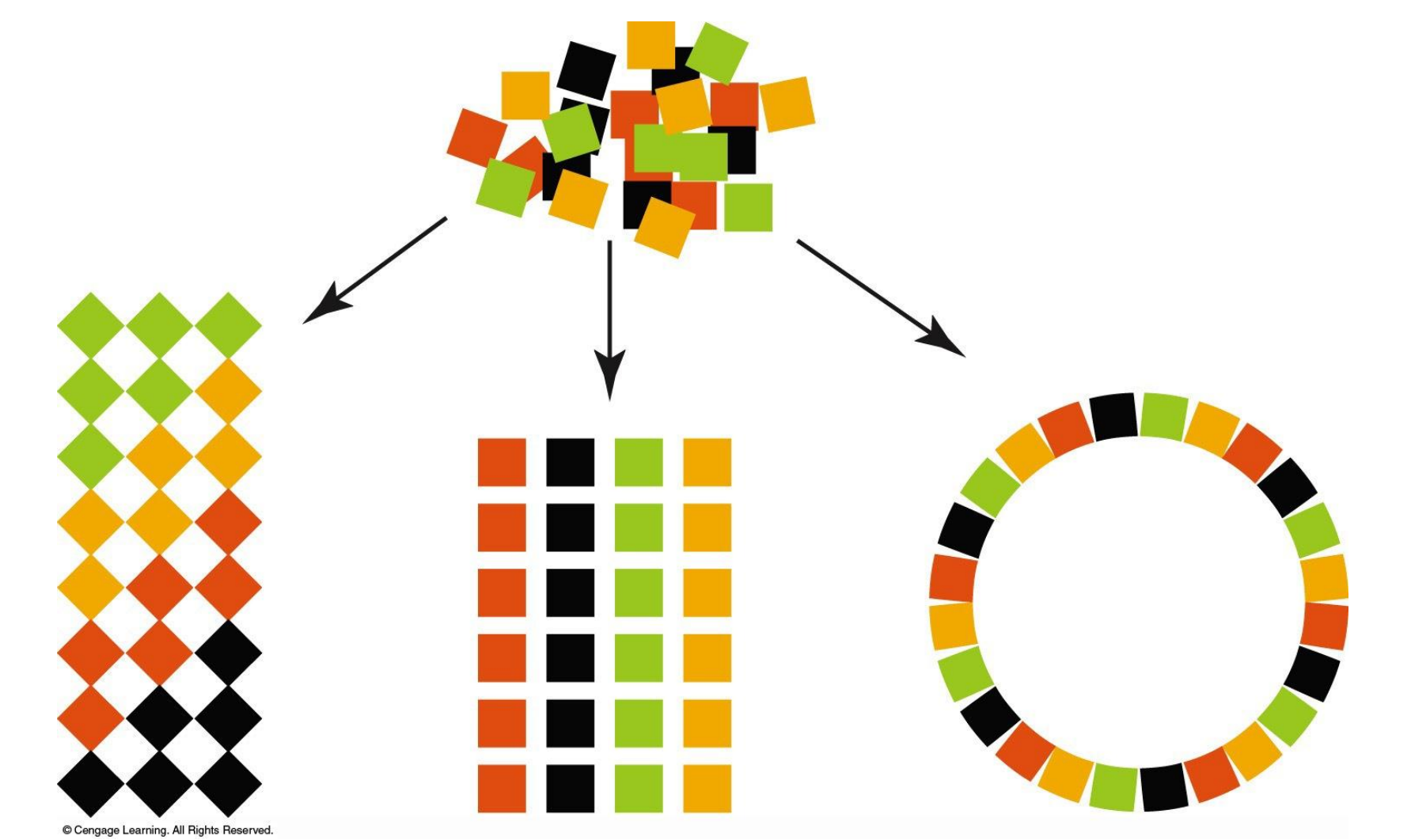
Chapter 1

Invitation to Biology

1.1 How Do Living Things Differ From Nonliving Things?

- Life is more than the sum of its parts
  - Biology: study of life, past and present
  - Defining “life” is a challenge
  - Complex properties, including life, emerge from the interactions of simple parts
  - Emergent property: characteristic of a system that does not appear in any of the system’s component parts

How Do Living Things Differ From Nonliving Things? (cont'd.)



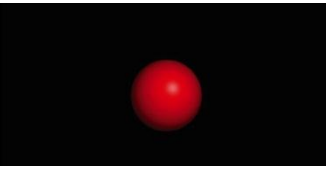
Life’s Organization

- Atom: fundamental building block of matter
- Molecule: association of two or more atoms
- Cell: smallest unit of life
  - Organism: consists of one or more cells

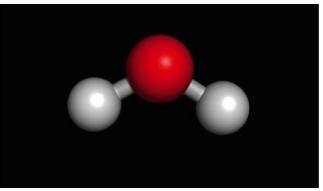
Life’s Organization (cont’d.)

- Tissue: specialized cells organized in a pattern; performs a collective function
- Organ: grouping of tissues engaged in a collective task
- Organ system: set of organs engaged in a collective task that keeps the body functioning properly

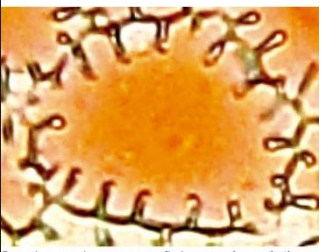
Life's Organization (cont'd.)



1 **atom**
Atoms are fundamental units of all substances, living or not. This image shows a model of a single atom.

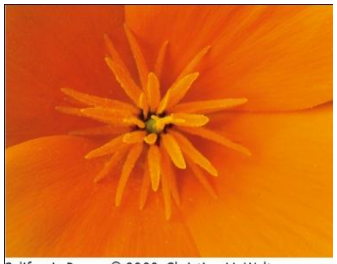


2 **molecule**
Atoms join other atoms in molecules. This is a model of a water molecule. The molecules special to life are much larger and more complex than water.



3 **cell**
The cell is the smallest unit of life. Some, like this plant cell, live and reproduce as part of a multicelled organism; others do so on their own.

4 **tissue**
Organized array of cells that interact in a collective task. This is epidermal tissue on the outer surface of a flower petal.


California Poppy, © 2009, Christine M. Welter.

5 **organ**
Structural unit of interacting tissues. Flowers are the reproductive organs of many plants.


Lady Bird Johnson Wildflower Center

6 **organ system**
A set of interacting organs. The shoot system of this poppy plant includes its aboveground parts: leaves, flowers, and stems.


Michael Szoenyi/Science Source

7 **multicelled organism**
Individual that consists of more than one cell. Cells of this California poppy plant are part of its two organ systems: aboveground shoots and belowground roots.

Life's Organization (cont'd.)

- Population: group of interbreeding individuals of the same species that live in a given area
- Community: all populations of all species in a given area
- Ecosystem: a community interacting with its environment
- Biosphere: all regions of Earth where organisms live

Life's Organization (cont'd.)

Photographers Choice RF/SuperStock

8 population

Group of single-celled or multicelled individuals of a species in a given area. This population of California poppy plants is in California's Antelope Valley Poppy Reserve.

© Sergei Krupnov, www.flickr.com/photos/7969319@N03

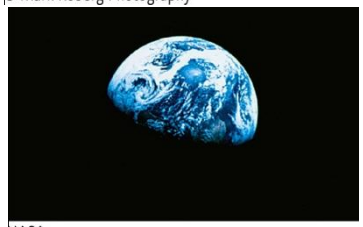
9 community

All populations of all species in a specified area. These plants are part of a community called the Antelope Valley Poppy Reserve.

© Mark Koberg Photography

10 ecosystem

A community interacting with its physical environment through the transfer of energy and materials. Sunlight and water sustain the community in the Antelope Valley.



NASA

11 biosphere

The sum of all ecosystems: every region of Earth's waters, crust, and atmosphere in which organisms live. No ecosystem in the biosphere is truly isolated from any other.

1.2 How Are All Living Things Alike?

TABLE 1.1

Three Key Features of Living Things

Requirement for energy and nutrients	Ongoing inputs of energy and nutrients sustain life.
Homeostasis	Each living thing has the capacity to sense and respond to change.
Use of DNA as hereditary material	DNA is passed to offspring during reproduction.

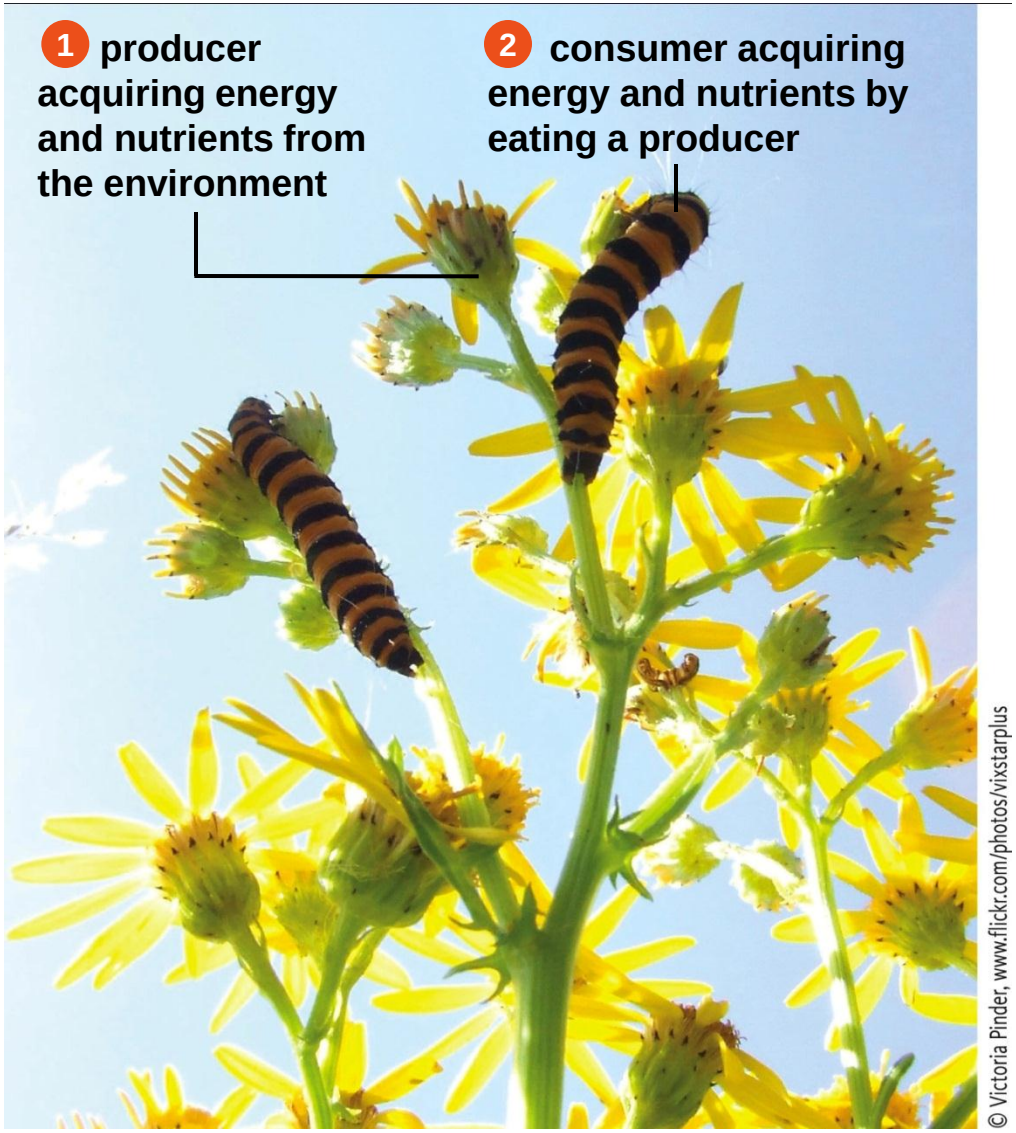
Organisms Require Energy and Nutrients

- Nutrient: substance that an organism needs for growth and survival but cannot make for itself
- Producers: organism that makes its own food using energy and nonbiological raw materials
  - Photosynthesis: producers use light energy to make sugars from carbon dioxide and water

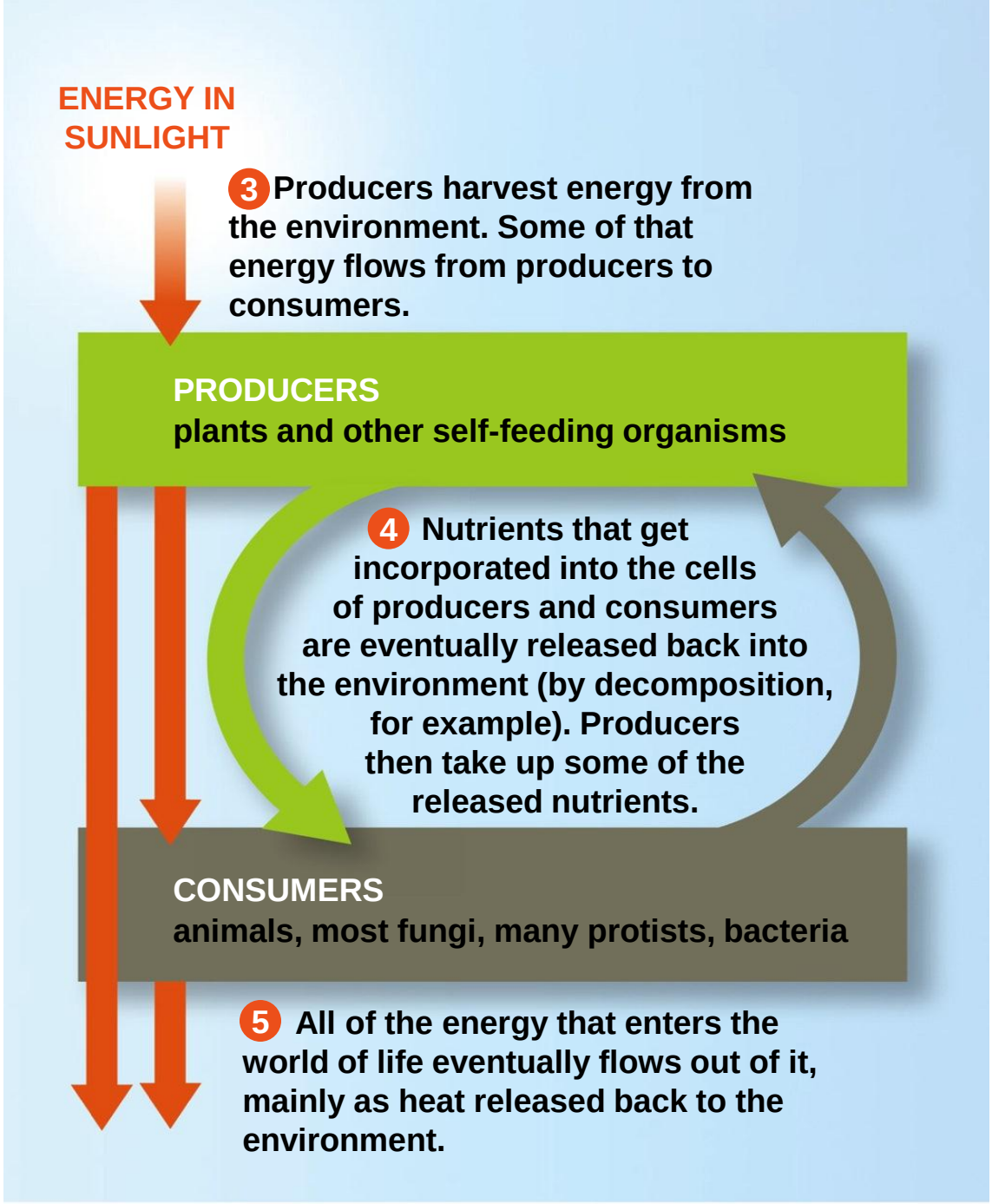
Organisms Require Energy and Nutrients (cont'd.)

- Consumers: organism that gets energy and nutrients by feeding on tissues, wastes, or remains of other organisms
- Energy is not cycled
  - It flows through the world of life in one direction: from the environment through organisms, and back to the environment

Organisms Require Energy and Nutrients (cont'd.)



Organisms Require Energy and Nutrients (cont'd.)



Organisms Sense and Respond to Change

- Every living thing has the ability to sense and respond to change both inside and outside of itself
- Homeostasis: process by which organism keeps its internal conditions within tolerable ranges by sensing and responding to change

Organisms Sense and Respond to Change (cont'd.)

© Dr. Marina Davila Ross, University of Portsmouth.

Organisms Use DNA

- DNA (deoxyribonucleic acid) carries hereditary information that guides:
  - Development: multistep process by which the first cell of a new multicelled organism gives rise to an adult
  - Growth: increase in the number, size, and volume of cells
  - Reproduction: processes by which individuals produce offspring

Organisms Use DNA (cont'd.)

- Inheritance: transmission of DNA to offspring
  - All organisms inherit their DNA from one or two parents
- DNA is the basis of similarities in form and function among organisms
- Small variations in DNA give rise to differences among individuals and among types of organisms

1.3 How Are Living Things Different?

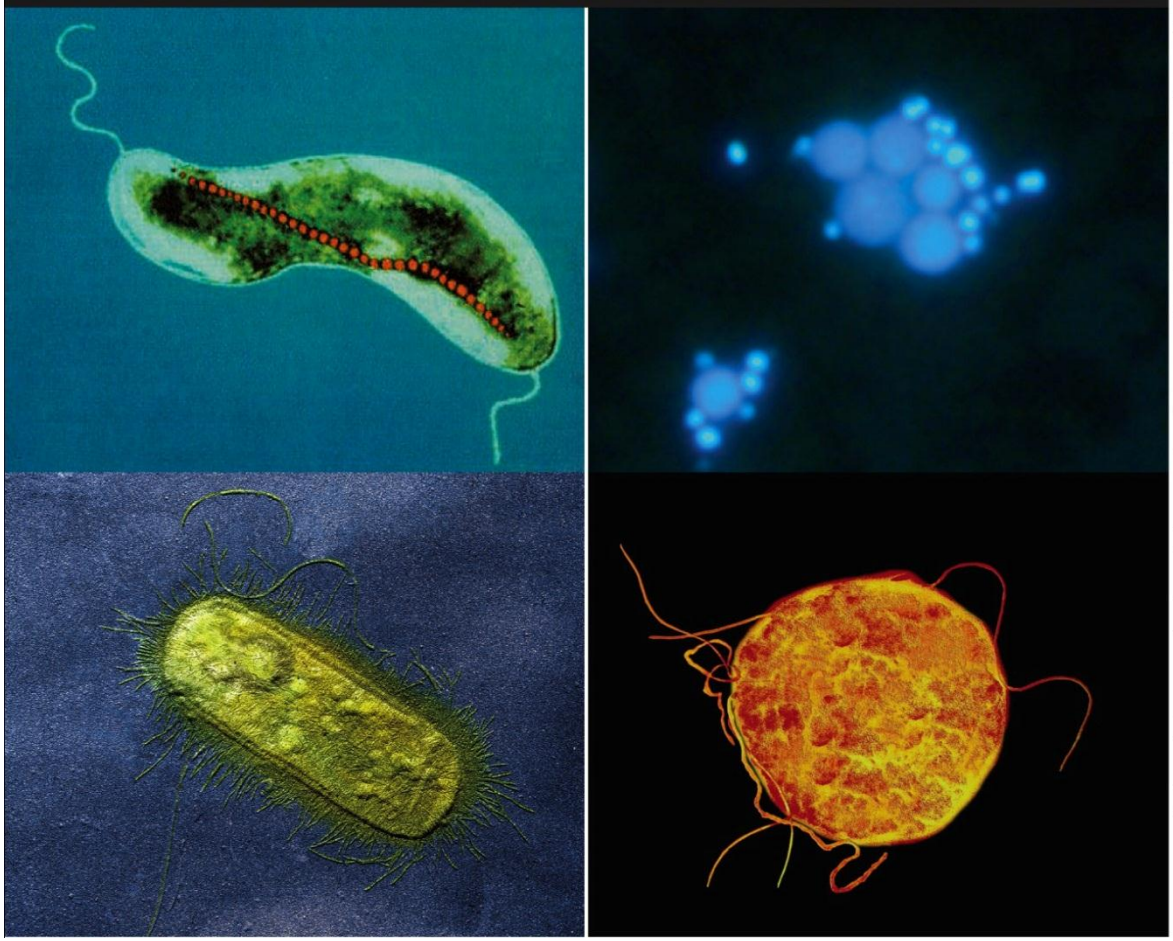
- Biodiversity: scope of variation among living organisms
- Organisms can be grouped on the basis of whether they have a nucleus (a sac that encloses and protects a cell's DNA)
  - Prokaryote: single-celled organism without a nucleus (now used only informally)
  - Eukaryote: organism whose cells characteristically have a nucleus

How Are Living Things Different? (cont'd.)

- Bacteria: most diverse and well-known group of single-celled organisms that lack a nucleus
- Archaea: group of single-celled organisms that lack a nucleus but are more closely related to eukaryotes than to bacteria

How Are Living Things Different? (cont'd.)

A Prokaryotes are single-celled, and have no nucleus. As a group, they are the most diverse organisms.



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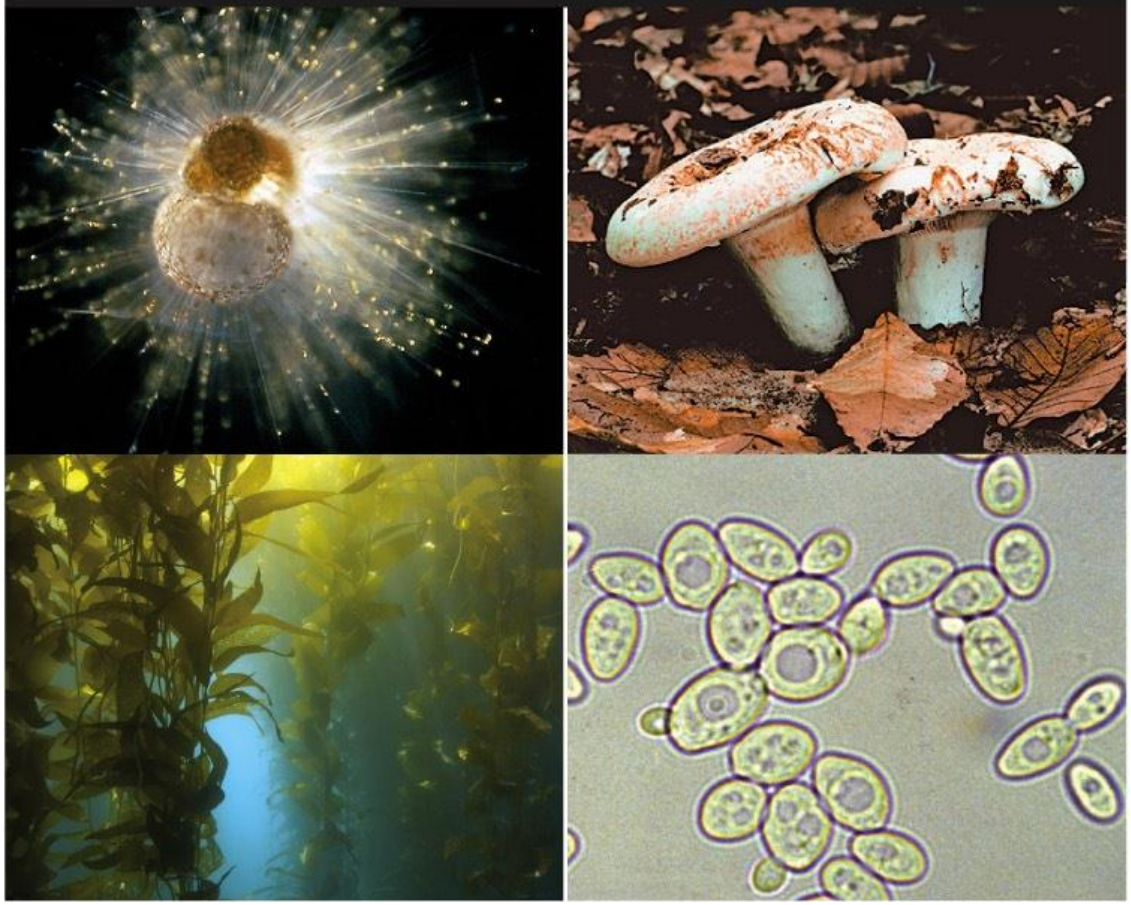
How Are Living Things Different? (cont'd.)

- Protist: diverse group of simple eukaryotes
- Fungus: single-celled or multicelled eukaryotic consumer
  - Breaks down material outside itself, then absorbs nutrients released from the breakdown

How Are Living Things Different? (cont'd.)

B **Eukaryotes** consist of cells that have a nucleus. Eukaryotic cells are typically larger and more complex than prokaryotes.



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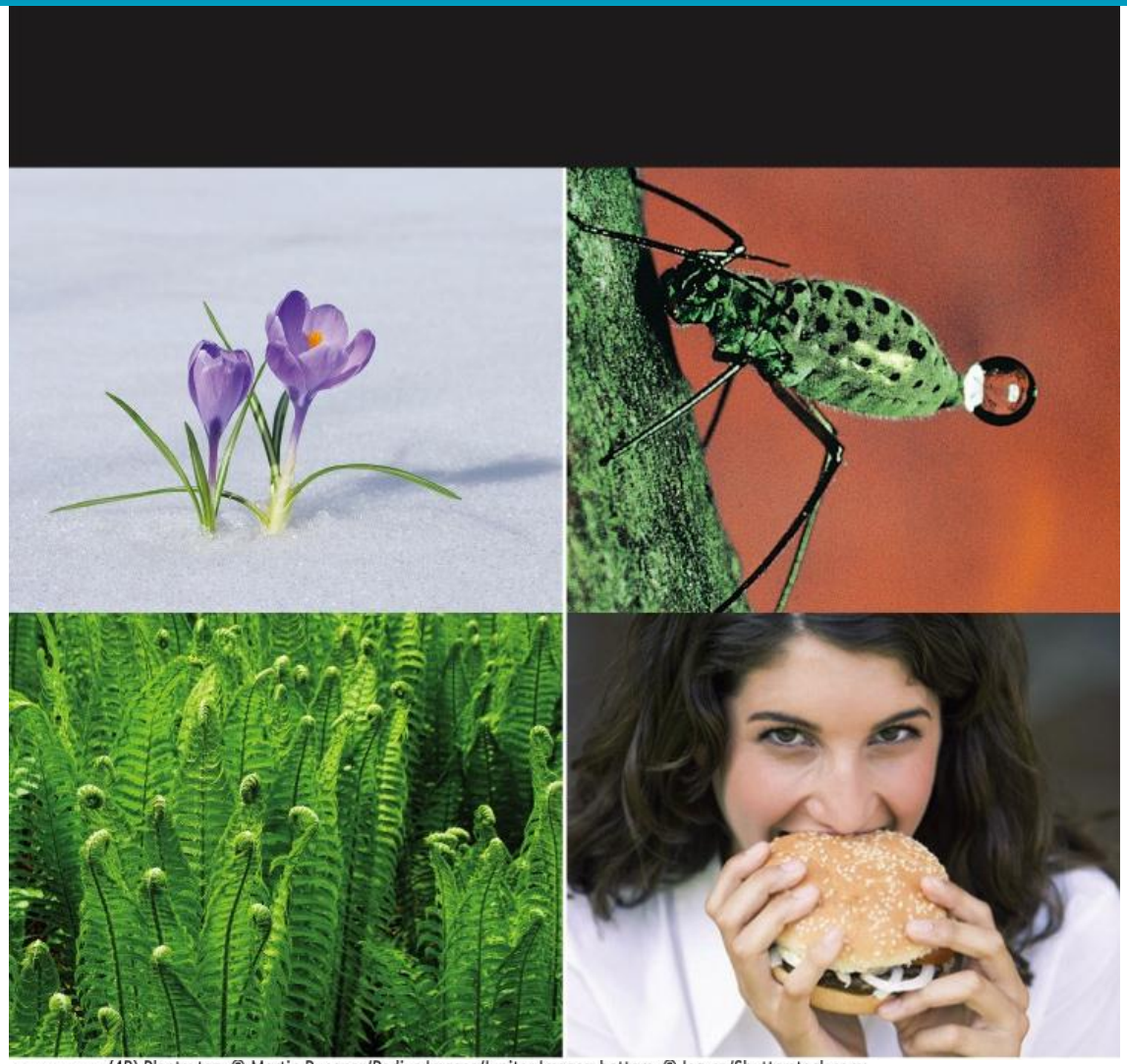
How Are Living Things Different? (cont'd.)

- Plant: multicelled, typically photosynthetic producer
- Animal: multicelled consumer that develops through a series of stages and moves about during part or all of its life

How Are Living Things Different? (cont'd.)



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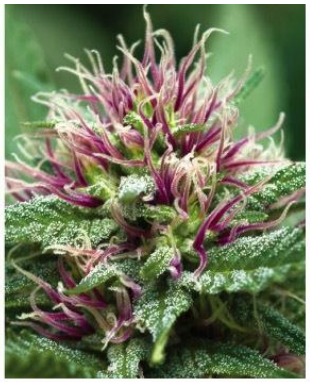
1.4 What Is a Species?

- Species: unique type of organism
- Taxonomy: the science of naming and classifying species
  - Genus: a group of species that share a unique set of traits
  - Specific epithet: second part of a species name
  - Together, the genus name and the specific epithet designate one species

A Rose by Any Other Name . . .

- Trait: an observable characteristic of an organism or species
- Taxon: group of organisms that share a unique set of traits

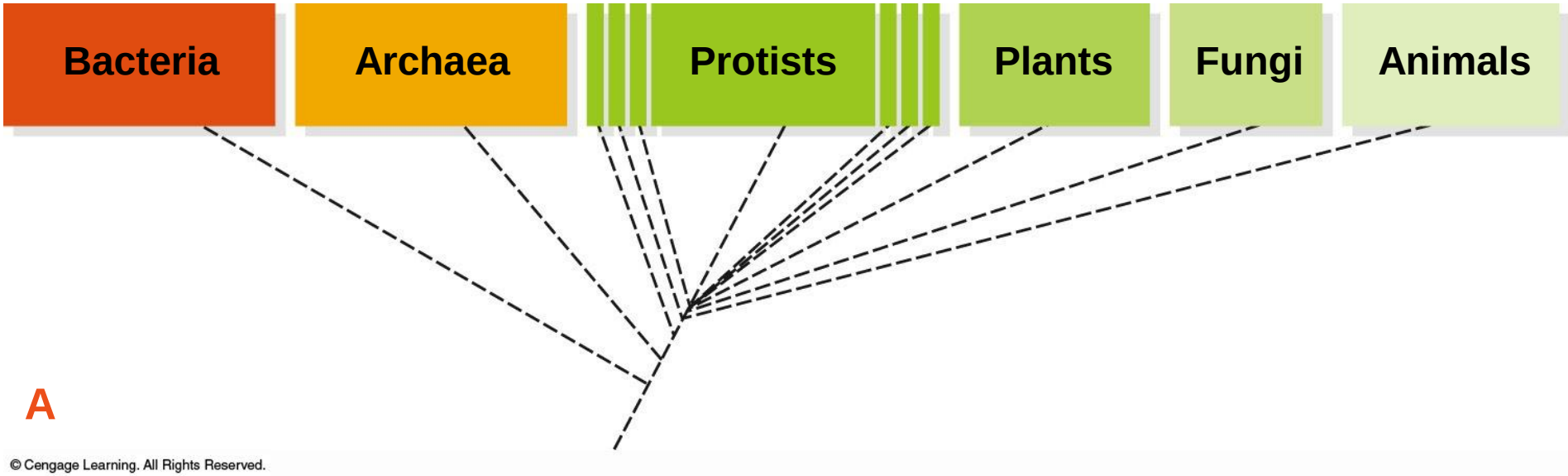
A Rose by Any Other Name . . . (cont'd.)


domain	Eukarya	Eukarya	Eukarya	Eukarya	Eukarya
kingdom	Plantae	Plantae	Plantae	Plantae	Plantae
phylum	Magnoliophyta	Magnoliophyta	Magnoliophyta	Magnoliophyta	Magnoliophyta
class	Magnoliopsida	Magnoliopsida	Magnoliopsida	Magnoliopsida	Magnoliopsida
order	Apiales	Rosales	Rosales	Rosales	Rosales
family	Apiaceae	Cannabaceae	Rosaceae	Rosaceae	Rosaceae
genus	*Daucus*	*Cannabis*	*Malus*	*Rosa*	*Rosa*
species	*carota*	*sativa*	*domestica*	*acicularis*	*canina*
common name	wild carrot	marijuana	apple	prickly rose	dogrose

from left, © xania.g, www.flickr.com/photos/52287712@N00; © kymkemp.com; Nigel Cattlin/Visuals Unlimited, Inc.; Courtesy of Melissa S. Green, www.flickr.com/photos/henkimaa; © Grodana Sarkotic.

A Rose by Any Other Name . . . (cont'd.)



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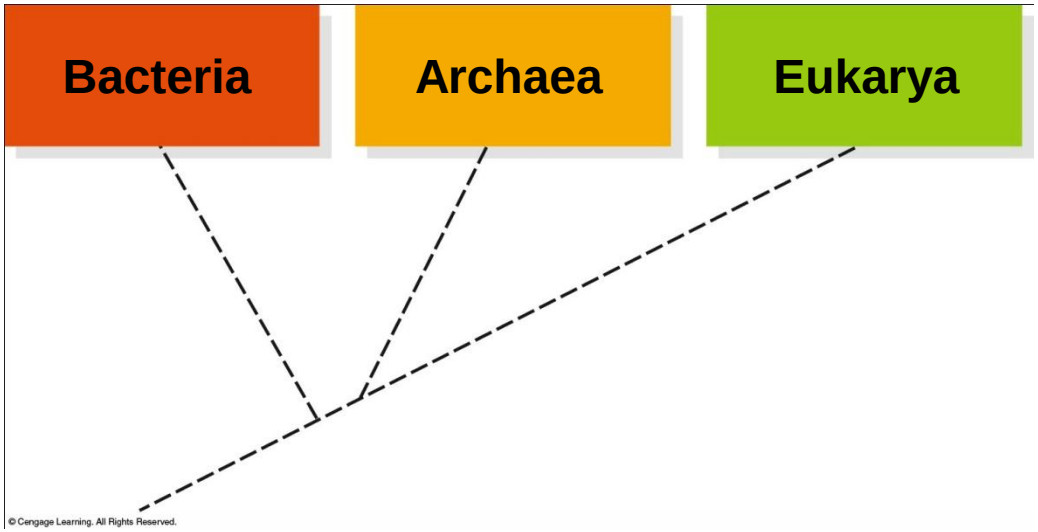


B

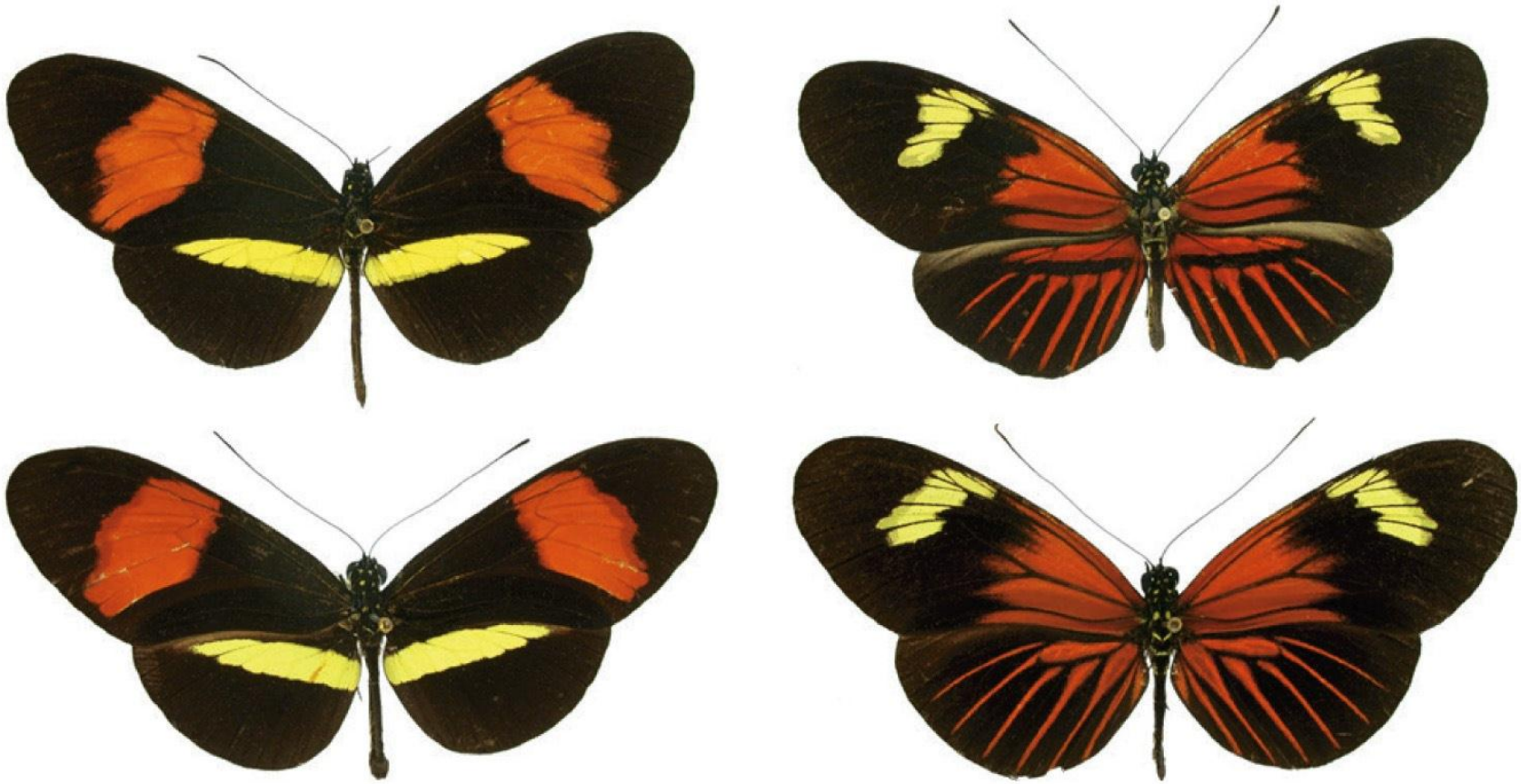
A Rose by Any Other Name . . . (cont'd.)

TABLE 1.2

All of Life in Three Domains

Bacteria	Single cells, no nucleus. Most ancient lineage.
Archaea	Single cells, no nucleus. Evolutionarily closer to eukaryotes than bacteria.
Eukarya	Eukaryotic cells (with a nucleus). Single-celled and multicelled species of protists, plants, fungi, and animals.

A Rose by Any Other Name . . . (cont'd.)



© 2006 Axel Meyer, "Repeating Patterns of Mimicry." *PLoS Biology* Vol. 4, No. 10, e341 doi:10.1371/journal.pbio.0040341. Used with Permission

1.5 How Does Science Work?

- Thinking about thinking
  - Critical thinking: judging information before accepting it
  - Move beyond the content of new information to consider supporting evidence, bias, and alternative interpretations

The Scientific Method

- Science: systematic study of the observable world
- Hypothesis: testable explanation of a natural phenomenon

The Scientific Method (cont'd.)

© Mike Johnson.

The Scientific Method (cont'd.)

- Inductive reasoning: drawing a conclusion based on observation
- Prediction: statement, based on a hypothesis, about a condition that should exist if the hypothesis is correct
- Deductive reasoning: using a general idea to make a conclusion about a specific case

The Scientific Method (cont'd.)

- Model: analogous system used for testing hypotheses
- Experiment: test designed to support or falsify a prediction
- Researchers often investigate causal relationships by changing and observing *variables*
  - Variable: a characteristic or event that differs among individuals or over time

The Scientific Method (cont'd.)

- Independent variable: condition or treatment controlled by the experimenter
- Dependent variable: observed result that is influenced by the independent variable
- Experimental group: receive a certain treatment or have certain characteristics
- Control group: identical to an experimental group, but without exposure to the independent variable

The Scientific Method (cont'd.)

- Data (test results) that are consistent with the prediction support the hypothesis
- Data inconsistent with the prediction are evidence that the hypothesis is flawed and should be revised
- Scientific method: making, testing, and evaluating hypotheses

The Scientific Method (cont'd.)

TABLE 1.3

The Scientific Method

1. **Observe** some aspect of nature.
2. **Think of an explanation** for your observation (in other words, form a hypothesis).
3. **Test the hypothesis.**
   - **a.** Make a prediction based on the hypothesis.
   - **b.** Test the prediction using experiments or surveys.
   - **c.** Analyze the results of the tests (data).
4. **Decide** whether the results of the tests support your hypothesis or not (form a conclusion).
5. **Report** your experiment, data, and conclusion to the scientific community.

1.6 Why Do Biologists Perform Experiments?

- Researchers design experiments in a consistent way
  - Change one independent variable at a time
  - Carefully measure the effects of the change on a dependent variable

Potato Chips and Stomachaches

- Researchers designed an experiment to test the hypothesis that Olestra causes intestinal cramps
  - Prediction: *if* Olestra causes cramps, *then* people who eat Olestra will be more likely to get cramps than people who do not

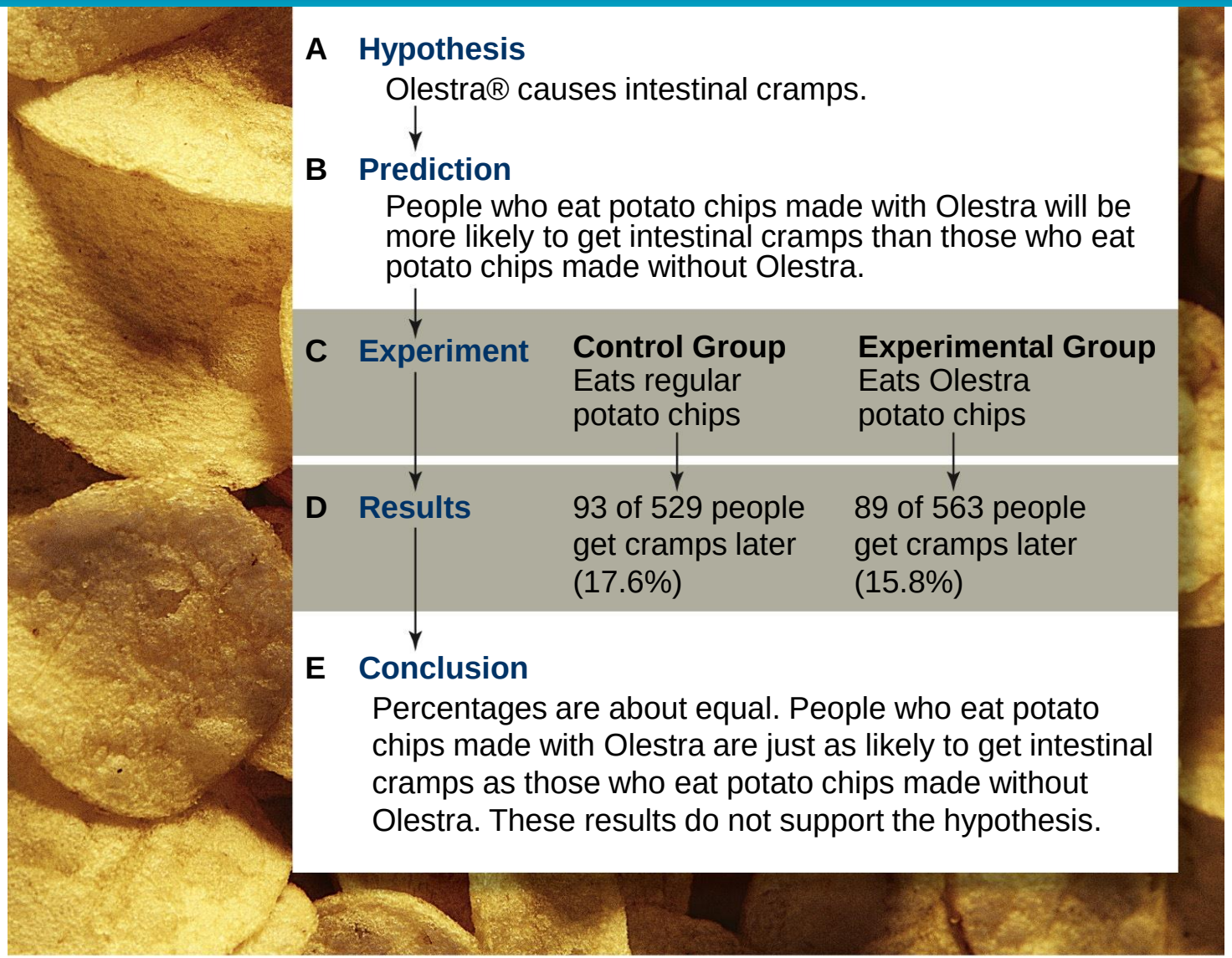
Potato Chips and Stomachaches (cont'd.)

- 1,100 people ate potato chips while watching a movie
- Each person got an unmarked bag that contained 13 ounces of chips
  - Experimental group: ate Olestra-containing potato chips
  - Independent variable: presence or absence of Olestra in the chips

Potato Chips and Stomachaches (cont'd.)

- People were about as likely to get cramps whether or not they ate chips made with Olestra
- These results did not support the prediction, so the researchers concluded that eating Olestra does not cause cramps

Potato Chips and Stomachaches (cont'd.)



A Hypothesis

Olestra® causes intestinal cramps.

B Prediction

People who eat potato chips made with Olestra will be more likely to get intestinal cramps than those who eat potato chips made without Olestra.

	Control Group	Experimental Group
C Experiment	Eats regular potato chips	Eats Olestra potato chips
D Results	93 of 529 people get cramps later (17.6%)	89 of 563 people get cramps later (15.8%)

E Conclusion

Percentages are about equal. People who eat potato chips made with Olestra are just as likely to get intestinal cramps as those who eat potato chips made without Olestra. These results do not support the hypothesis.

Butterflies and Birds

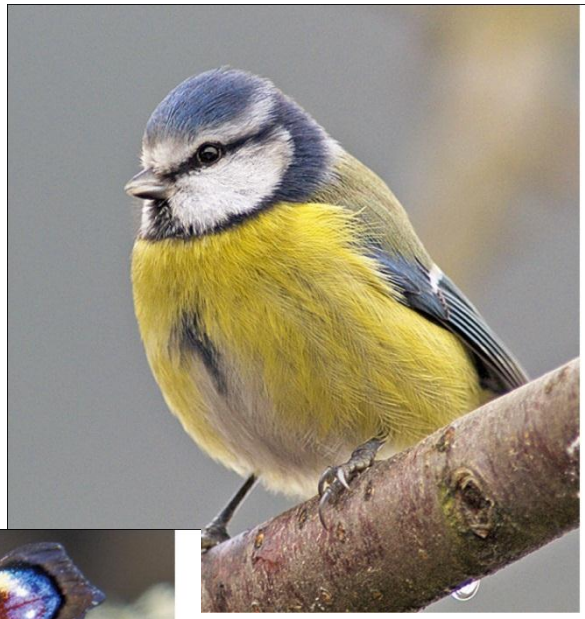
- Researchers investigated whether certain peacock butterfly behaviors defend them against predatory birds
- Initial observations:
  - When a peacock butterfly rests, it folds its wings, so only the dark underside shows
  - When a butterfly sees a predator approaching, it flicks its wings open, producing a hissing sound and a series of clicks

Butterflies and Birds (cont'd.)

A

B

C



Butterflies and Birds (cont'd.)

- First hypothesis: wing-flicking exposes brilliant spots that resemble owl eyes
- Second hypothesis: hissing and clicking sounds may be an additional defense that deters predatory birds

Butterflies and Birds (cont'd.)

- Experimental design:
  - Paint the wing spots of some butterflies black
  - Remove sound-making wing part of others
  - Place butterfly into cage with a hungry blue tit
  - Observe for 30 minutes

Butterflies and Birds (cont'd.)

TABLE 1.4

Results of Peacock Butterfly Experiment*

Wing Spots	Wing Sound	Total Number of Butterflies	Number Eaten	Number Survived
Spots	Sound	9	0	9 (100%)
No spots	Sound	10	5	5 (50%)
Spots	No sound	8	0	8 (100%)
No spots	No sound	10	8	2 (20%)

** Proceedings of the Royal Society of London, Series B (2005) 272: 1203–1207.*

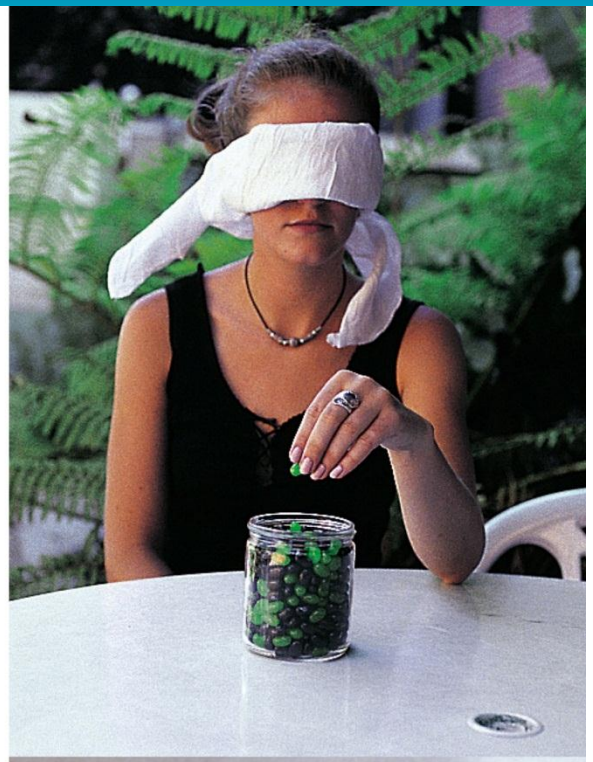
Butterflies and Birds (cont'd.)

- The test results supported the hypotheses
- Predatory birds are indeed deterred by peacock butterfly sounds, and even more so by wing spots

1.7 What Are Some Potential Pitfalls in Scientific Inquiry?

- Sampling error: difference between results obtained from a subset, and results from the whole
  - Can be a substantial problem with a small subset
  - Experimenters start with a relatively large sample, and repeat their experiments

What Are Some Potential Pitfalls in Scientific Inquiry? (cont'd.)



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A **Natalie chooses a random jelly bean from a jar. She is blindfolded, so she does not know that the jar contains 120 green and 280 black jelly beans.**

The jar is hidden from Natalie's view before she removes her blindfold. She sees one green jelly bean in her hand and assumes that the jar must hold only green jelly beans. This assumption is incorrect: 30 percent of the jelly beans in the jar are green, and 70 percent are black. The small sample size has resulted in sampling error.

What Are Some Potential Pitfalls in Scientific Inquiry? (cont'd.)

© Gary Head

B **Still blindfolded, Natalie randomly picks out 50 jelly beans from the jar. She ends up choosing 10 green and 40 black ones.**

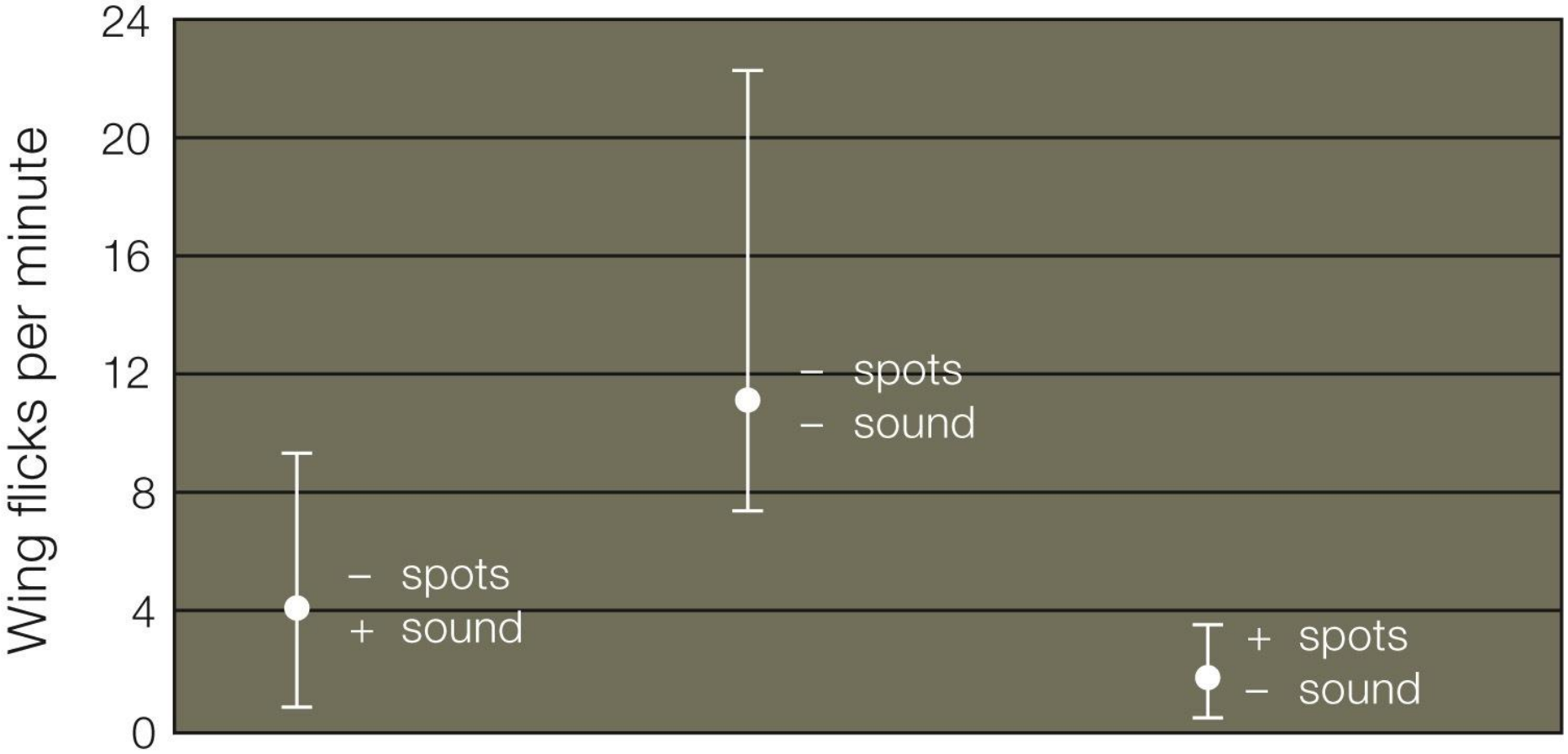
The larger sample leads Natalie to assume that one-fifth of the jar's jelly beans are green (20 percent) and four-fifths are black (80 percent). The larger sample more closely approximates the jar's actual green-to-black ratio of 30 percent to 70 percent.

The more times Natalie repeats the sampling, the greater the chance she has of guessing the actual ratio.

What Are Some Potential Pitfalls in Scientific Inquiry? (cont'd.)

- Sampling error (cont'd.)
  - Probability: chance that a particular outcome of an event will occur
  - Statistically significant: a result is very unlikely to have occurred by chance alone

What Are Some Potential Pitfalls in Scientific Inquiry? (cont'd.)



Bias in Interpreting Results

- Human beings are by nature subjective, and scientists are no exception
- Experimenters risk interpreting their results in terms of what they want to find out
- To minimize bias, experiments should yield quantitative results
  - Data that can be measured or gathered objectively

The Limits of Science

- Science does not address:
  - Subjective questions
    - Example: “Why do I exist?”
  - Supernatural
    - Science neither assumes nor denies that supernatural phenomena occur

The Limits of Science (cont'd.)

- Scientists have caused controversy for discovering natural explanations
  - 1540: Nicolaus Copernicus proposed that Earth orbits the sun
  - 1610: Galileo Galilei imprisoned for providing evidence for the Copernican model of the solar system

What Is a Theory?

- Scientific theory: hypothesis that has not been disproven after many years of rigorous testing
  - Consistent with all data ever gathered
  - Contributes to successful predictions about other phenomena

What Is a Theory? (cont'd.)

TABLE 1.5

Examples of Scientific Theories

Atomic theory	All substances consist of atoms.
Big bang	The universe originated with an explosion and continues to expand.
Cell theory	All organisms consist of one or more cells, the cell is the basic unit of life, and all cells arise from existing cells.
Evolution	Change occurs in the inherited traits of a population over generations.
Global warming	Human activities are causing Earth's average temperature to increase.
Plate tectonics	Earth's crust is cracked into pieces that move in relation to one another.

photo, © Raymond Gehman/Corbis; Table 1.2, © Cengage Learning.

What Is a Theory? (cont'd.)

- Law of nature: generalization that describes a consistent natural phenomenon for which there is incomplete scientific explanation

1.9 Application: The Secret Life of Earth

- Many new species and species thought to be extinct, or near extinction, were recently discovered in New Guinea
  - The current rate of extinctions is about 1,000 times faster than ever recorded
    - Human activities are responsible for the acceleration
- The more we learn about the natural world, the more we realize we have yet to learn

Application: The Secret Life of Earth (cont'd.)

Tim Laman/National Geographic Creative.