

LECTURE PRESENTATIONS

For CAMPBELL BIOLOGY, NINTH EDITION

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Chapter 1

Introduction: Themes in the Study of Life



Lectures by
Erin Barley
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Overview: Inquiring About Life

- An organism's adaptations to its environment are the result of evolution
 - For example, the ghost plant is adapted to conserving water; this helps it to survive in the crevices of rock walls
- **Evolution** is the process of change that has transformed life on Earth

Figure 1.1



Figure 1.2



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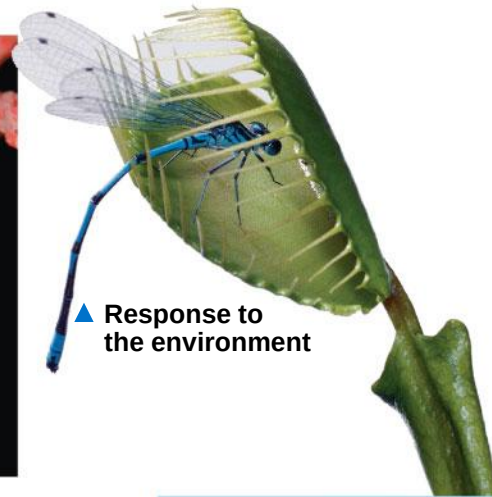
- **Biology** is the scientific study of life
- Biologists ask questions such as
 - How does a single cell develop into an organism?
 - How does the human mind work?
 - How do living things interact in communities?
- Life defies a simple, one-sentence definition
- Life is recognized by what living things do

Figure 1.3

▼ Order



▲ Evolutionary adaptation



▲ Response to the environment



▲ Regulation



▲ Energy processing

► Reproduction



◀ Growth and development

Figure 1.3a



Evolutionary adaptation

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Figure 1.3b



Response to the environment

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Figure 1.3c



Reproduction

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Growth and development

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Figure 1.3e



Energy processing

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Figure 1.3f



Regulation

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Figure 1.3g



Order

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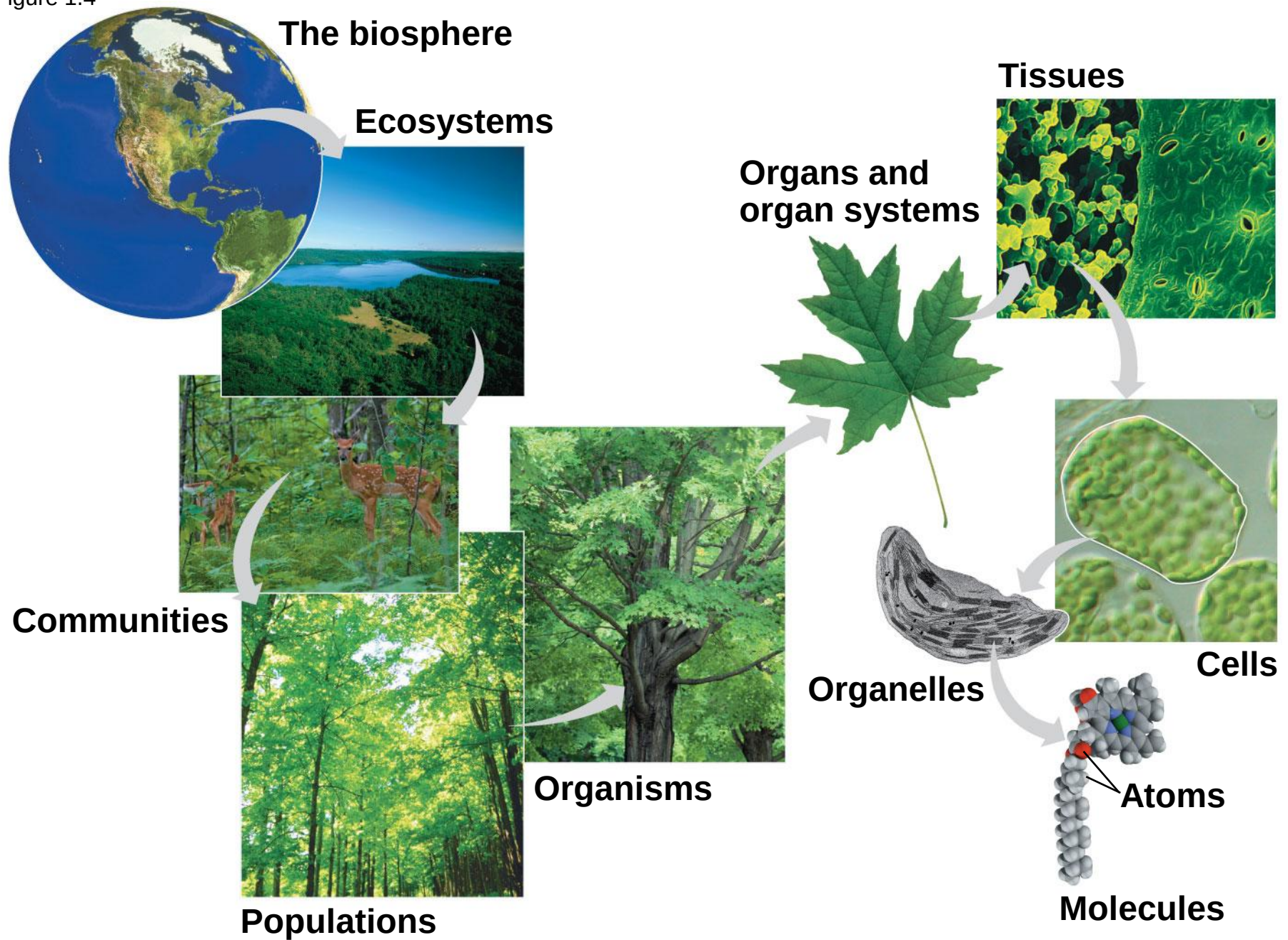
Concept 1.1: The themes of this book make connections across different areas of biology

- Biology consists of more than memorizing factual details
- Themes help to organize biological information

Theme: New Properties Emerge at Each Level in the Biological Hierarchy

- Life can be studied at different levels, from molecules to the entire living planet
- The study of life can be divided into different levels of biological organization

Figure 1.4





The biosphere

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Figure 1.4b



Ecosystems

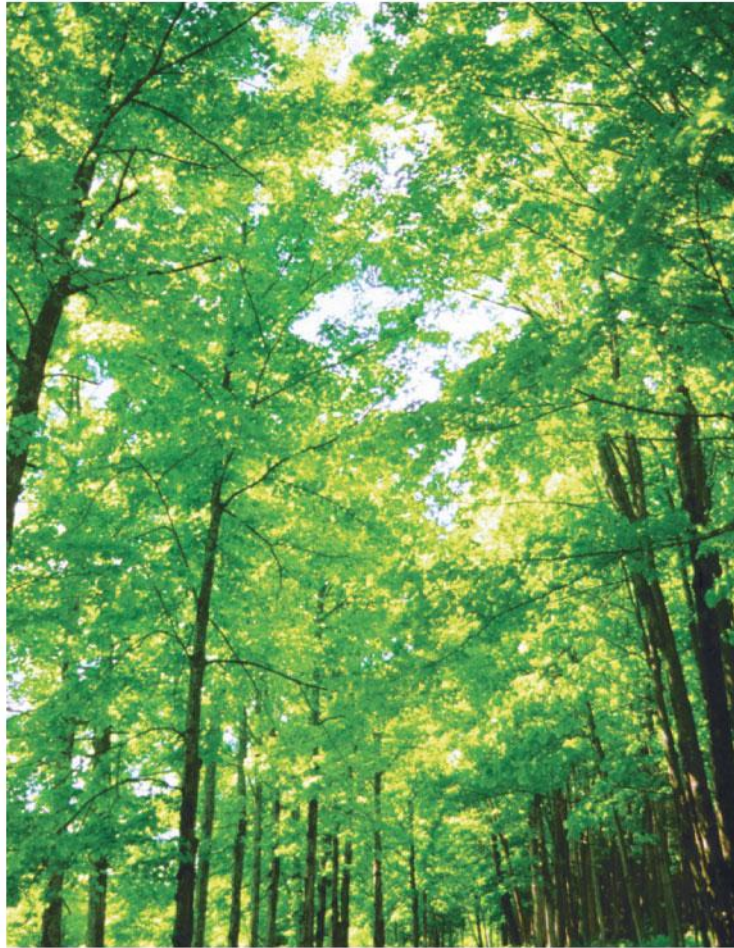
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Communities

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Figure 1.4d



Populations

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Organisms

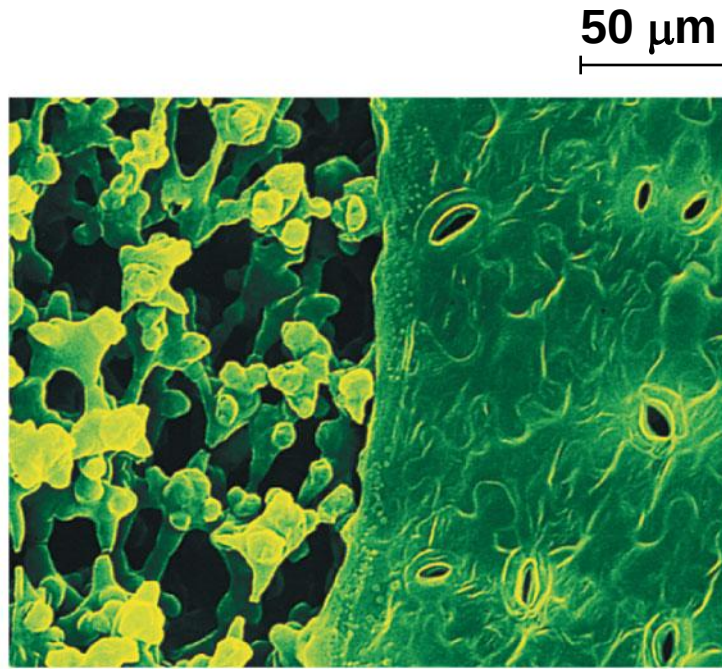
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Organs and organ systems

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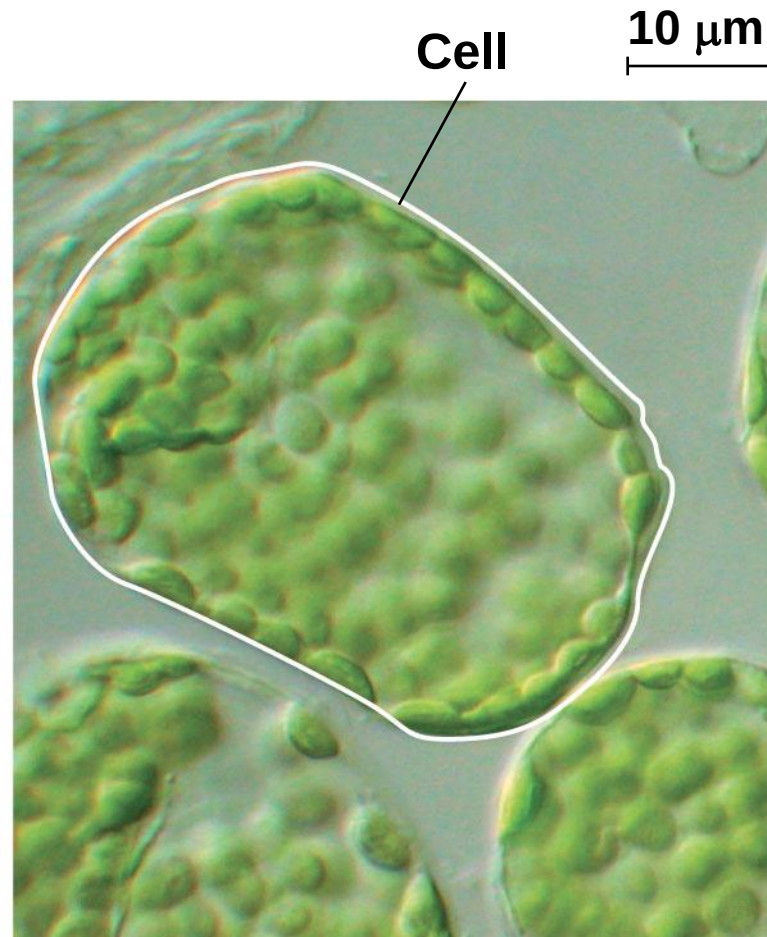
Figure 1.4g



Tissues

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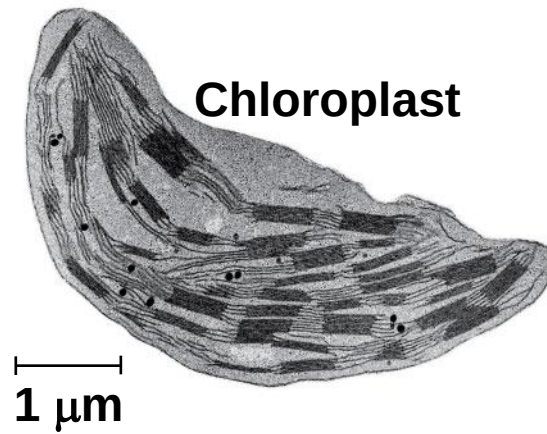
Figure 1.4h



Cells

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Figure 1.4i



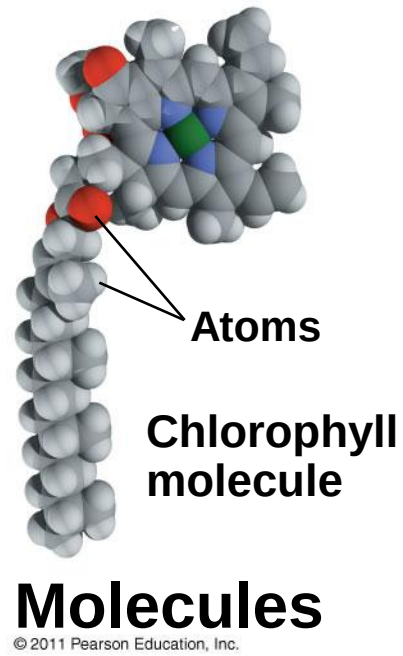
Chloroplast

1 μm

Organelles

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Figure 1.4j



Emergent Properties

- **Emergent properties** result from the arrangement and interaction of parts within a system
- Emergent properties characterize nonbiological entities as well
 - For example, a functioning bicycle emerges only when all of the necessary parts connect in the correct way

The Power and Limitations of Reductionism

- Reductionism is the reduction of complex systems to simpler components that are more manageable to study
 - For example, studying the molecular structure of DNA helps us to understand the chemical basis of inheritance

- An understanding of biology balances reductionism with the study of emergent properties
 - For example, new understanding comes from studying the interactions of DNA with other molecules

Systems Biology

- A system is a combination of components that function together
- **Systems biology** constructs models for the dynamic behavior of whole biological systems
- The systems approach poses questions such as
 - How does a drug for blood pressure affect other organs?
 - How does increasing CO₂ alter the biosphere?

Theme: Organisms Interact with Other Organisms and the Physical Environment

- Every organism interacts with its environment, including nonliving factors and other organisms
- Both organisms and their environments are affected by the interactions between them
 - For example, a tree takes up water and minerals from the soil and carbon dioxide from the air; the tree releases oxygen to the air and roots help form soil

Figure 1.5

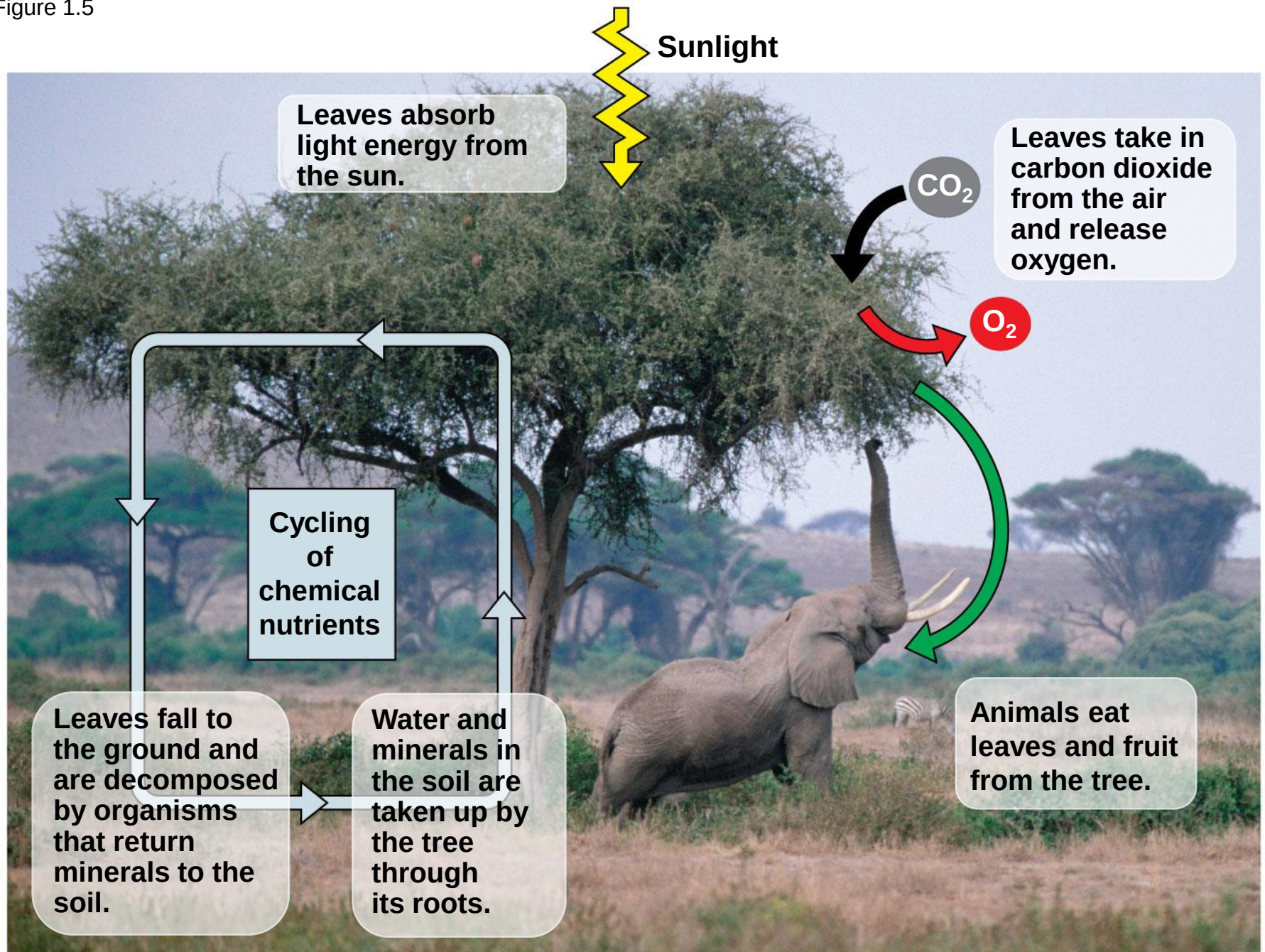


Figure 1.5a



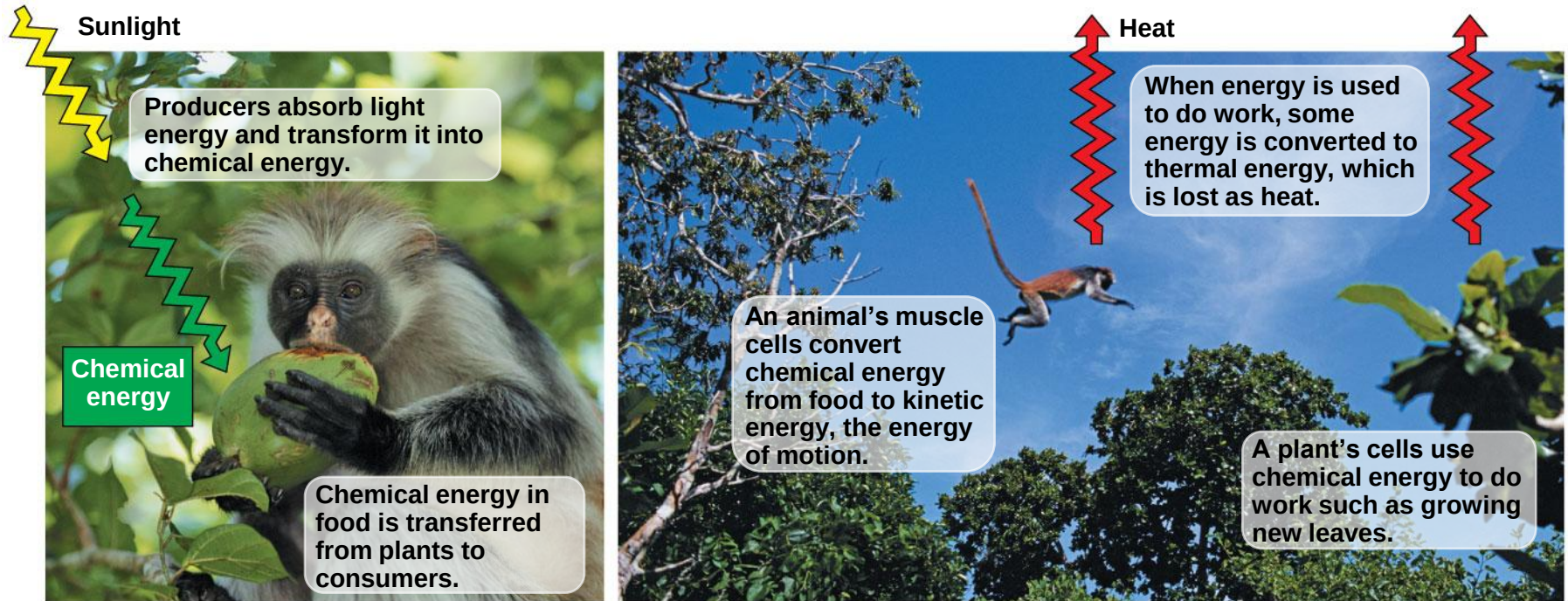
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- Humans have modified our environment
 - For example, half the human-generated CO₂ stays in the atmosphere and contributes to global warming
- Global warming is a major aspect of **global climate change**
- It is important to understand the effects of global climate change on the Earth and its populations

Theme: Life Requires Energy Transfer and Transformation

- A fundamental characteristic of living organisms is their use of energy to carry out life's activities
- Work, including moving, growing, and reproducing, requires a source of energy
- Living organisms transform energy from one form to another
 - For example, light energy is converted to chemical energy, then kinetic energy
- Energy flows through an ecosystem, usually entering as light and exiting as heat

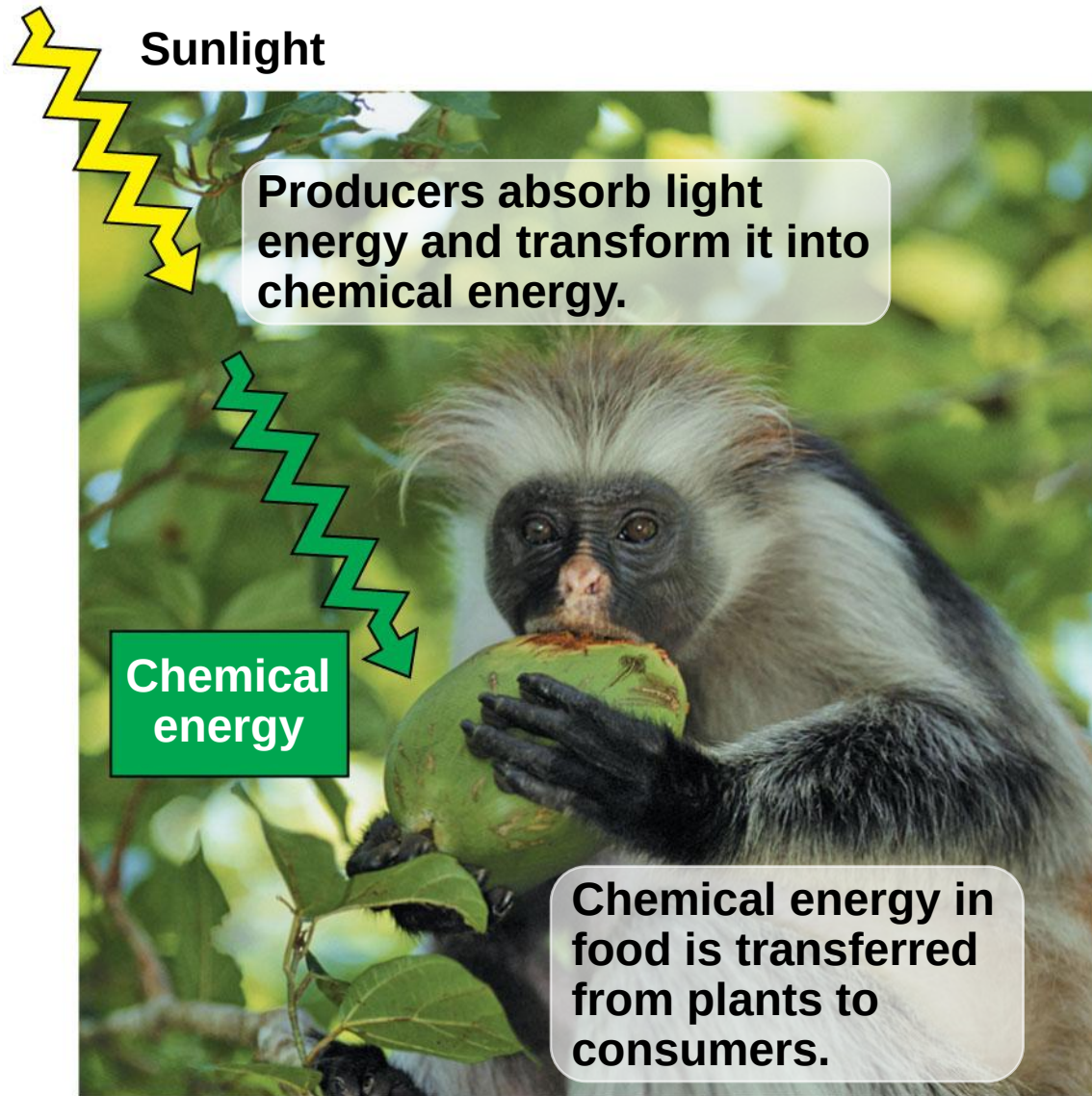
Figure 1.6



(a) Energy flow from sunlight to producers to consumers

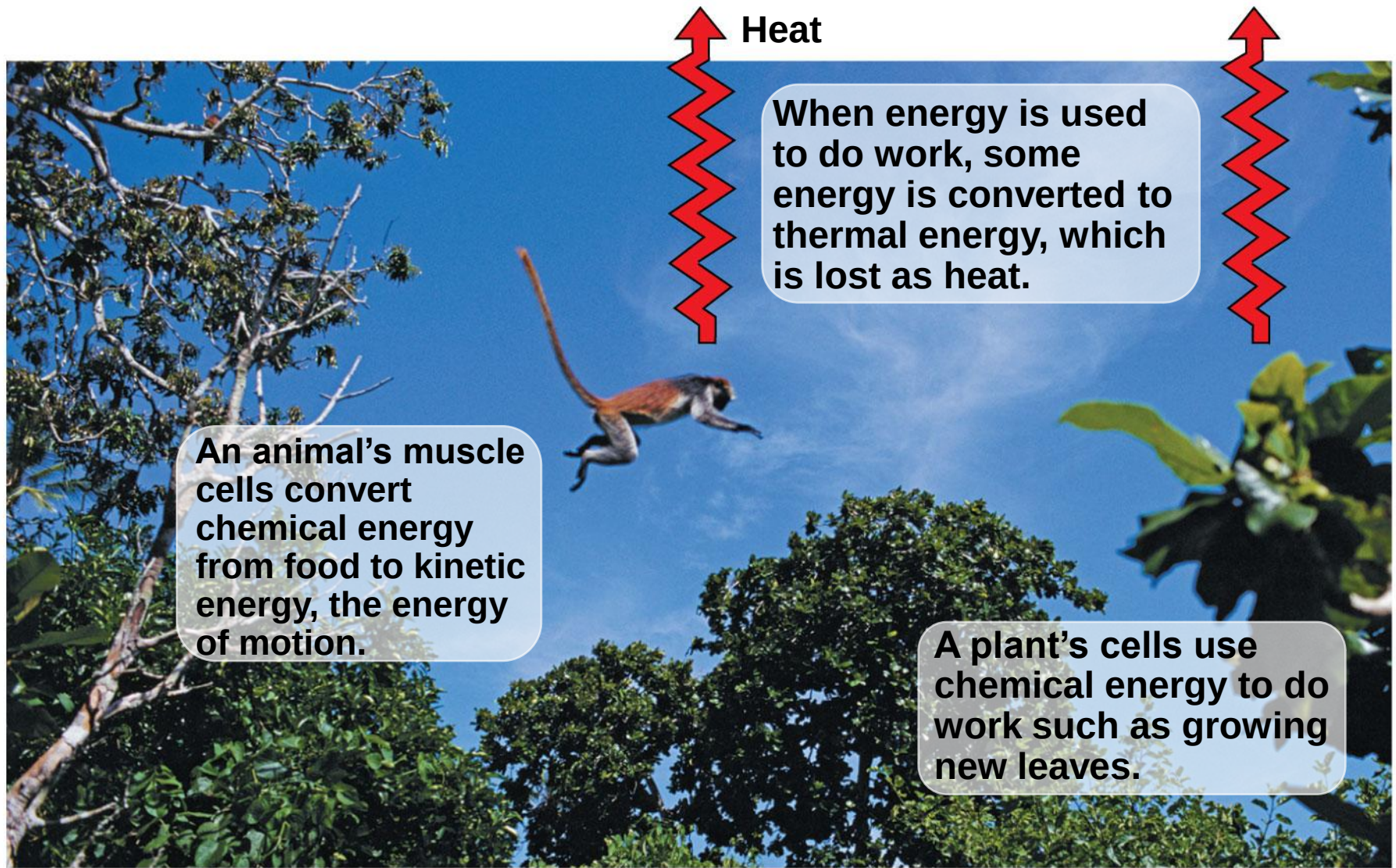
(b) Using energy to do work

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(a) Energy flow from sunlight to producers to consumers

Figure 1.6b



(b) Using energy to do work

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Figure 1.6c



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Figure 1.6d

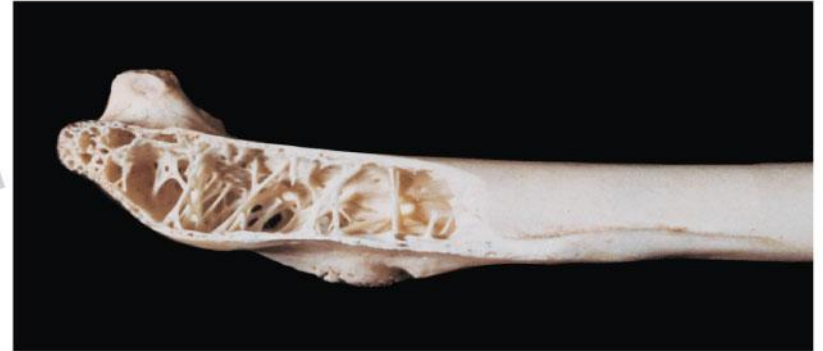


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Theme: Structure and Function Are Correlated at All Levels of Biological Organization

- Structure and function of living organisms are closely related
 - For example, a leaf is thin and flat, maximizing the capture of light by chloroplasts
 - For example, the structure of a bird's wing is adapted to flight

Figure 1.7

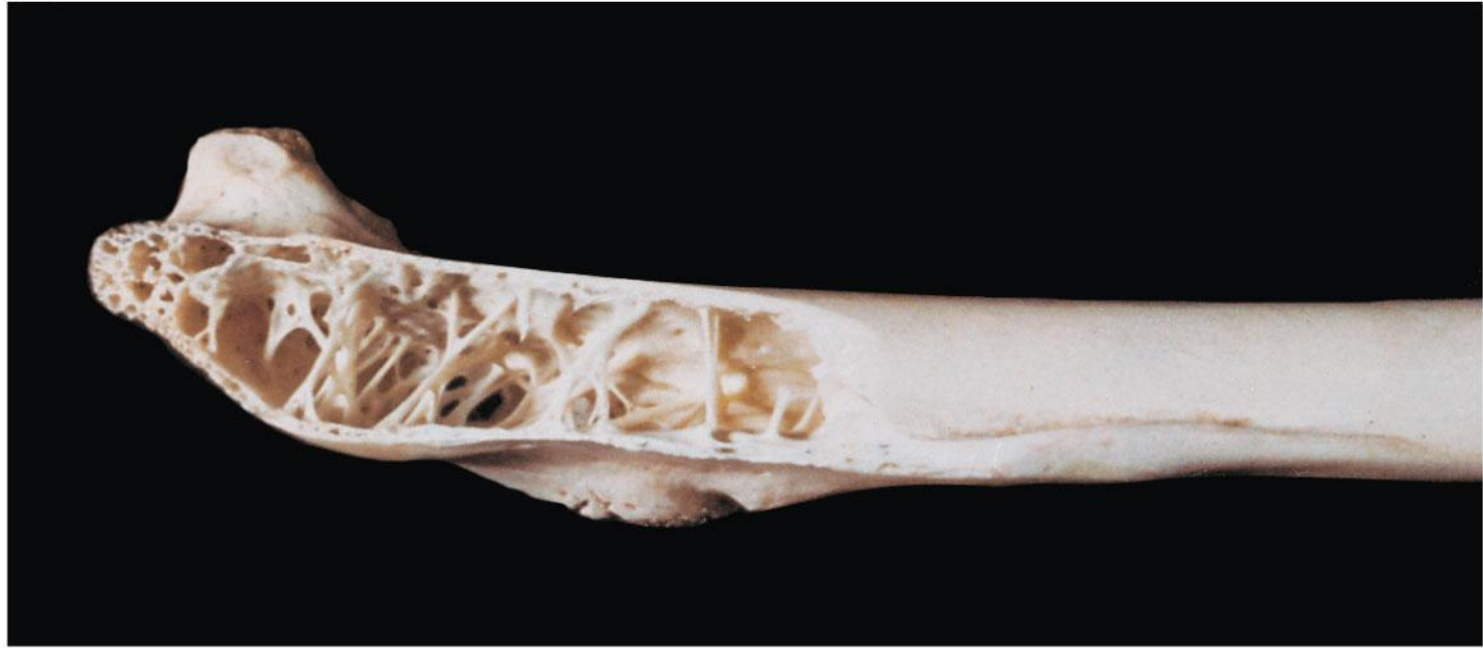


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Figure 1.7a



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(b) Wing bones

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Figure 1.7c



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Theme: The Cell Is an Organism's Basic Unit of Structure and Function

- The cell is the lowest level of organization that can perform all activities required for life
- All cells
 - Are enclosed by a membrane
 - Use DNA as their genetic information

- A **eukaryotic cell** has membrane-enclosed organelles, the largest of which is usually the nucleus
- By comparison, a **prokaryotic cell** is simpler and usually smaller, and does not contain a nucleus or other membrane-enclosed organelles

Figure 1.8

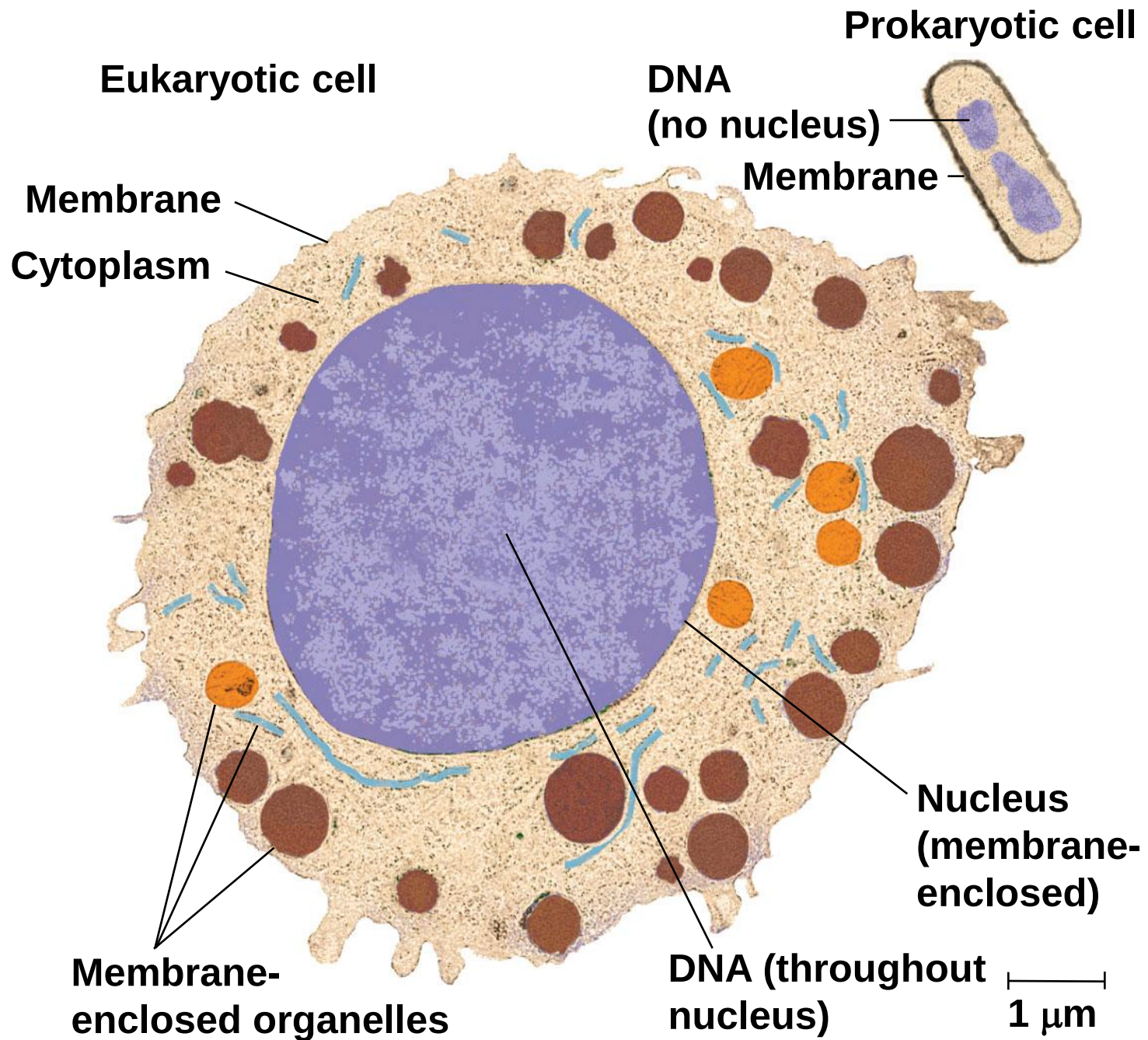
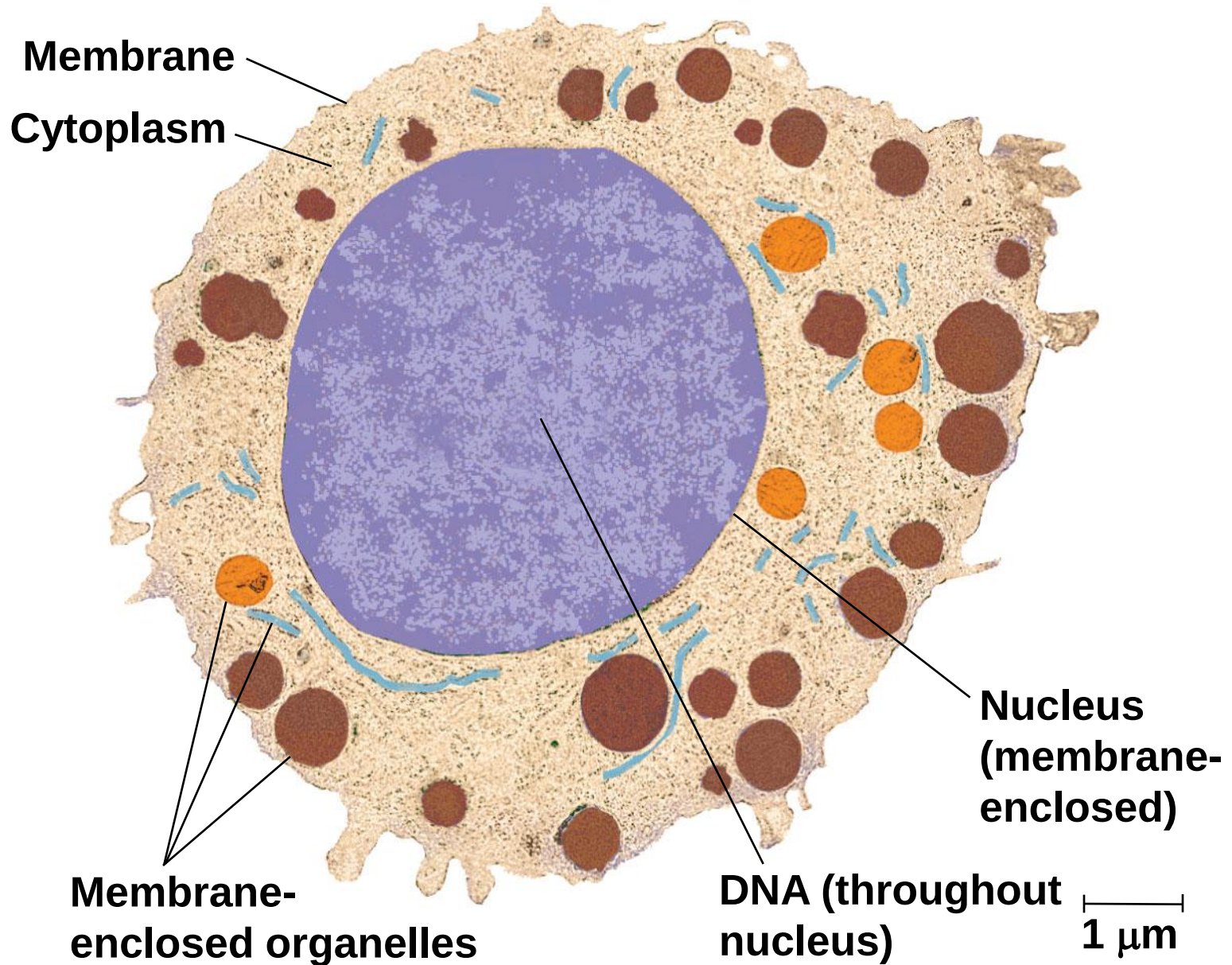
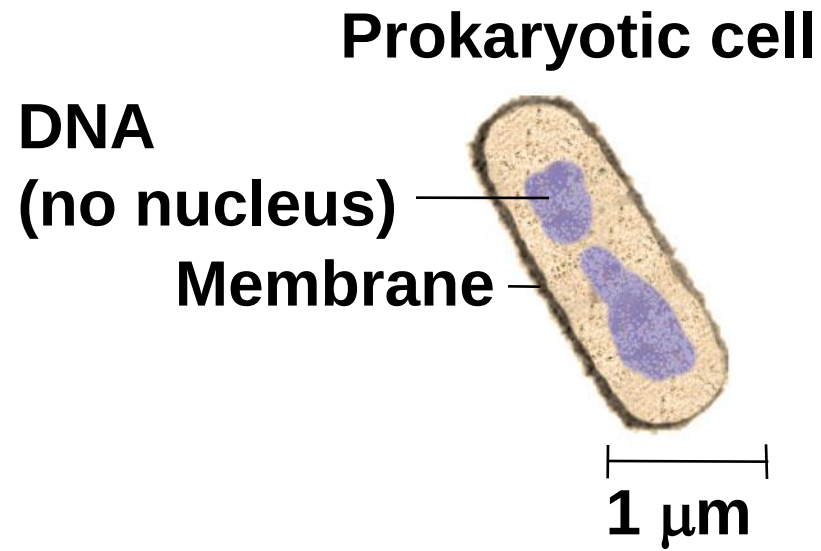


Figure 1.8a

Eukaryotic cell



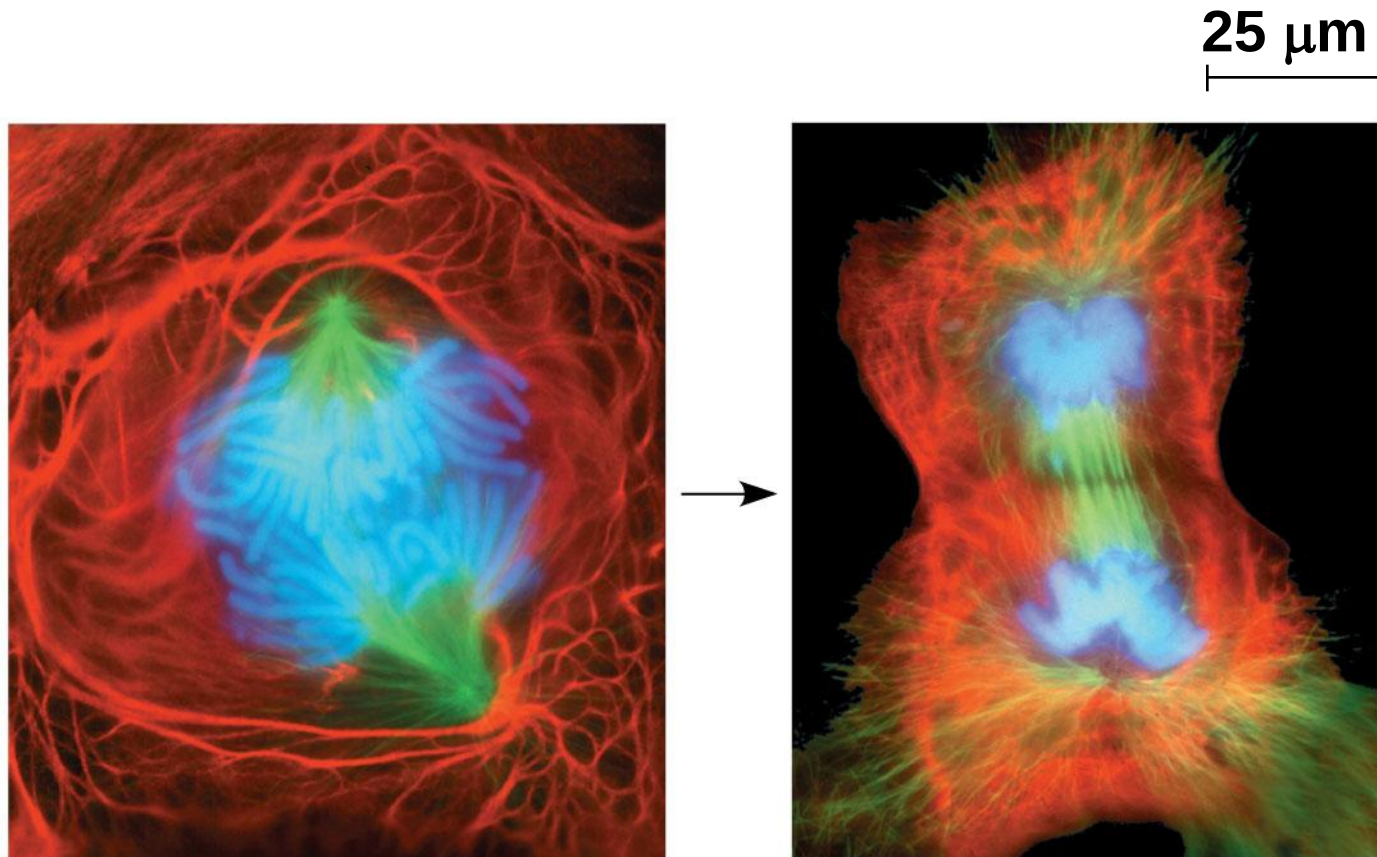


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Theme: The Continuity of Life Is Based on Heritable Information in the Form of DNA

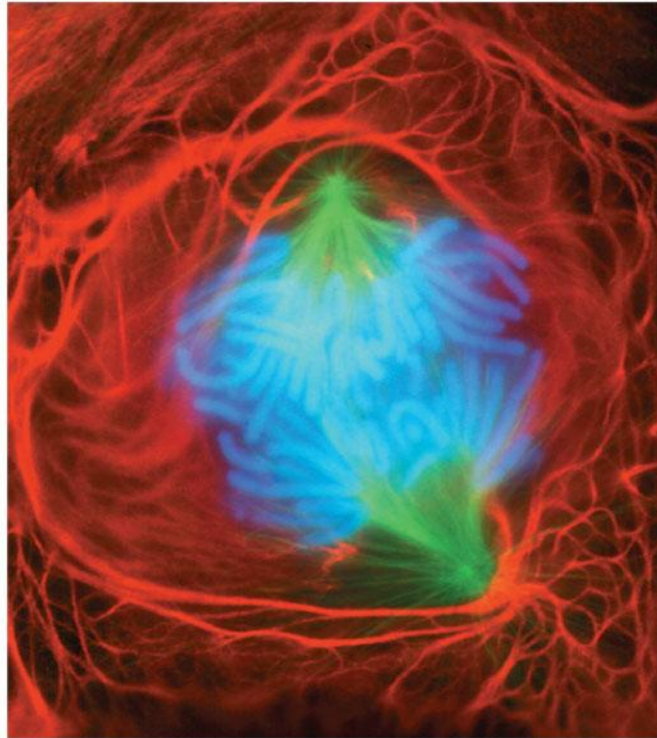
- Chromosomes contain most of a cell's genetic material in the form of **DNA** (deoxyribonucleic acid)
- DNA is the substance of genes
- **Genes** are the units of inheritance that transmit information from parents to offspring
- The ability of cells to divide is the basis of all reproduction, growth, and repair of multicellular organisms

Figure 1.9



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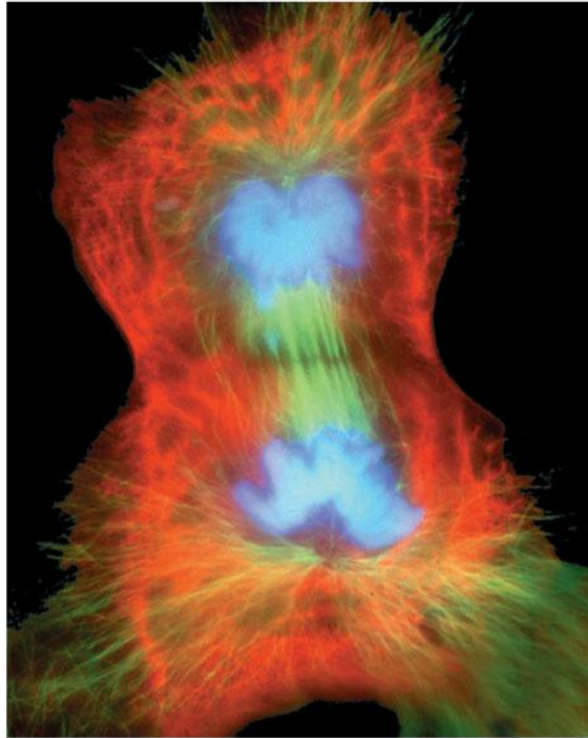
Figure 1.9a



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Figure 1.9b

25 μm

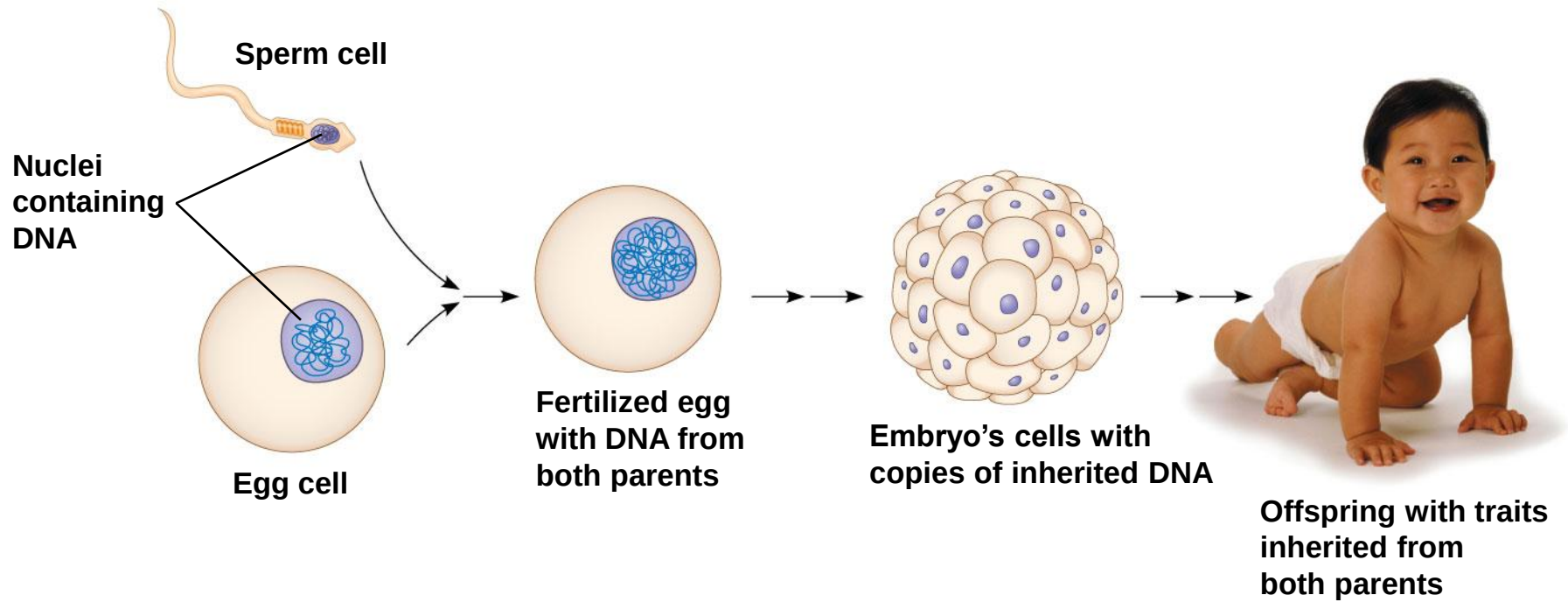


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DNA Structure and Function

- Each chromosome has one long DNA molecule with hundreds or thousands of genes
- Genes encode information for building proteins
- DNA is inherited by offspring from their parents
- DNA controls the development and maintenance of organisms

Figure 1.10



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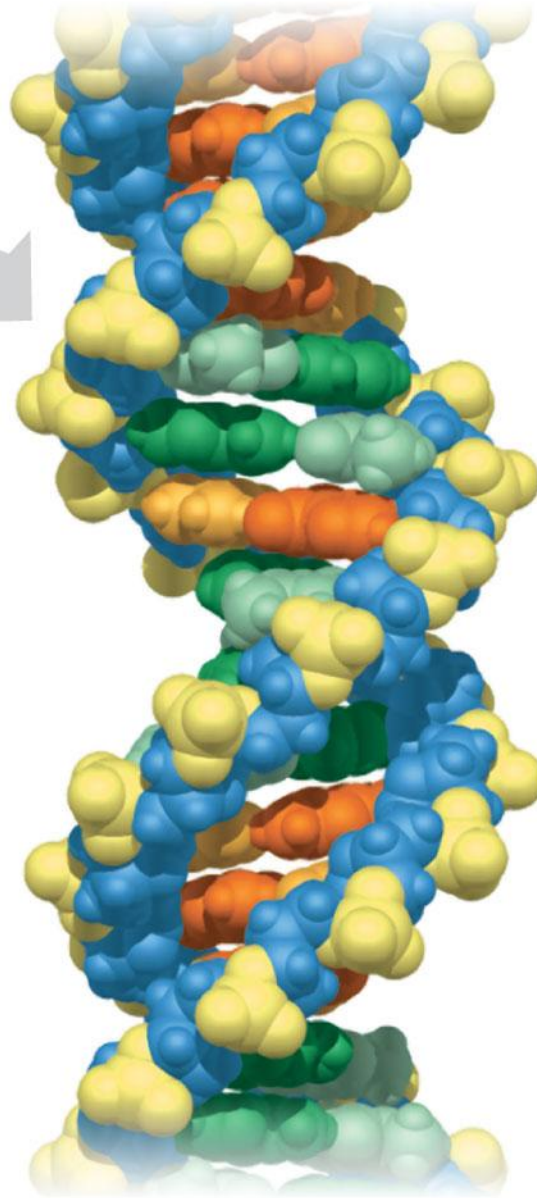
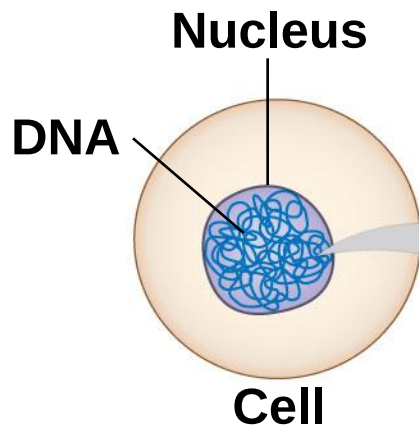
Figure 1.10a



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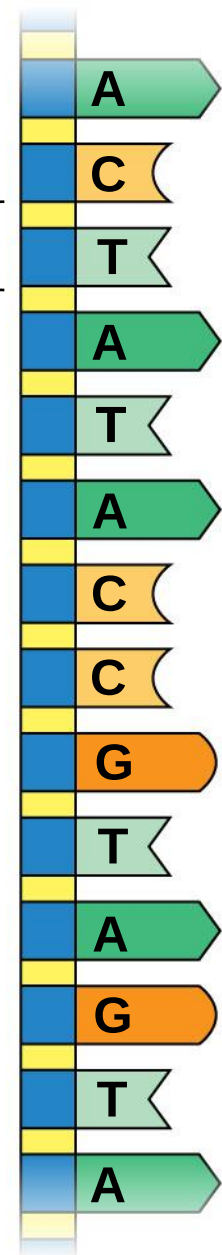
- Each DNA molecule is made up of two long chains arranged in a double helix
- Each link of a chain is one of four kinds of chemical building blocks called nucleotides and nicknamed A, G, C, and T

Figure 1.11



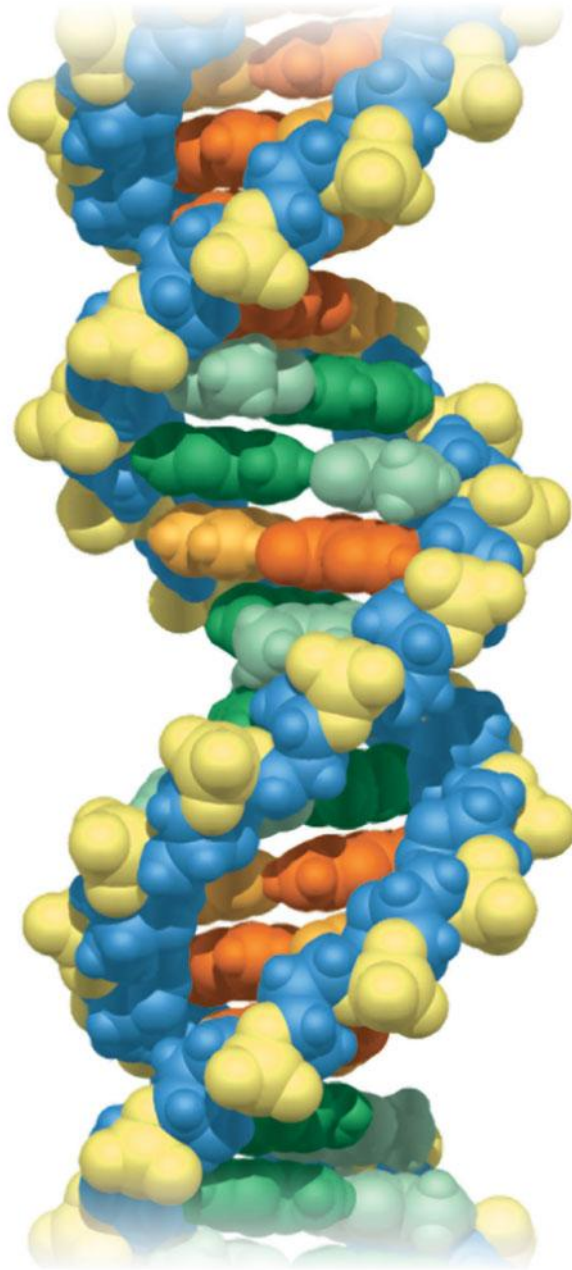
(a) DNA double helix

Nucleotide {



(b) Single strand of DNA

Figure 1.11a



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- Genes control protein production indirectly
- DNA is transcribed into RNA then translated into a protein
- **Gene expression** is the process of converting information from gene to cellular product

Genomics: Large-Scale Analysis of DNA Sequences

- An organism's **genome** is its entire set of genetic instructions
- The human genome and those of many other organisms have been sequenced using DNA-sequencing machines
- **Genomics** is the study of sets of genes within and between species

Figure 1.12



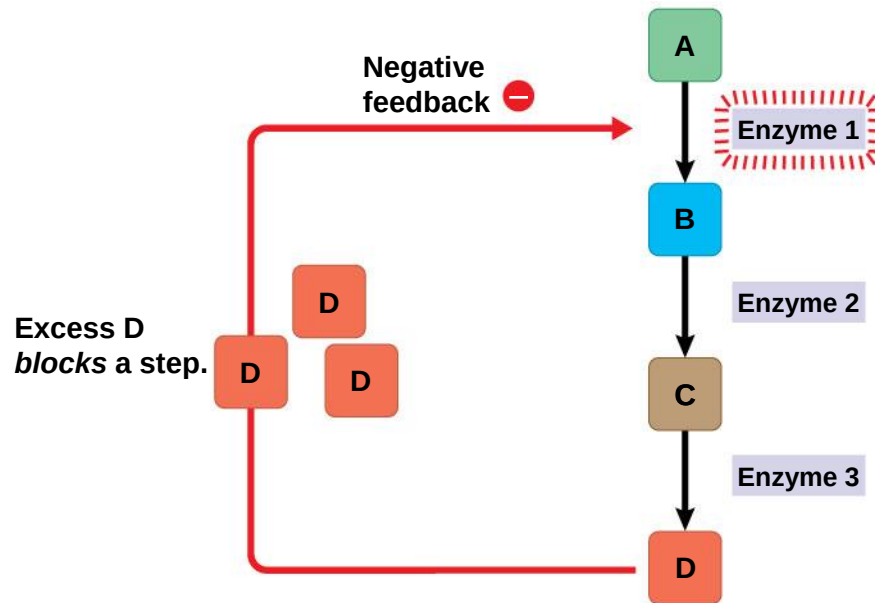
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- The genomics approach depends on
 - “High-throughput” technology, which yields enormous amounts of data
 - **Bioinformatics**, which is the use of computational tools to process a large volume of data
 - Interdisciplinary research teams

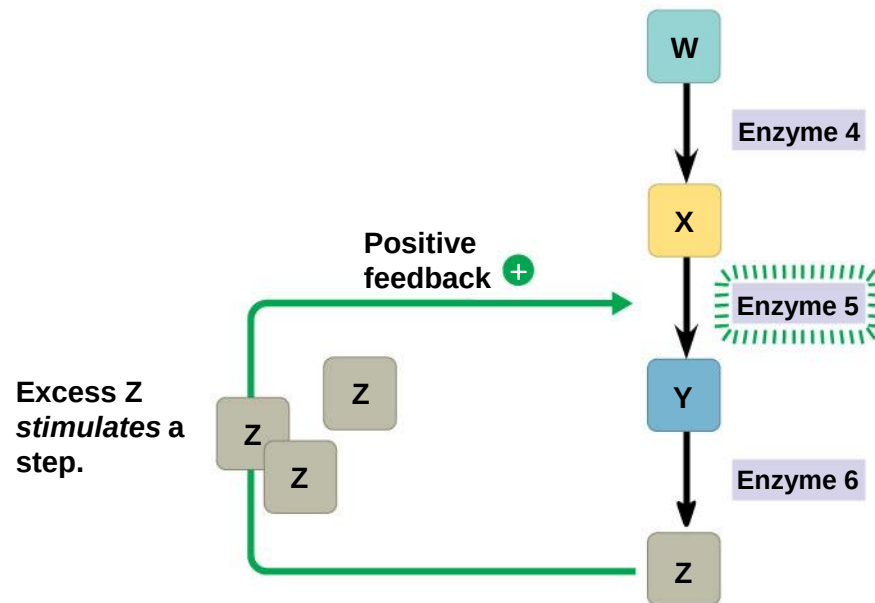
Theme: Feedback Mechanisms Regulate Biological Systems

- Feedback mechanisms allow biological processes to self-regulate
- **Negative feedback** means that as more of a product accumulates, the process that creates it slows and less of the product is produced
- **Positive feedback** means that as more of a product accumulates, the process that creates it speeds up and more of the product is produced

Figure 1.13



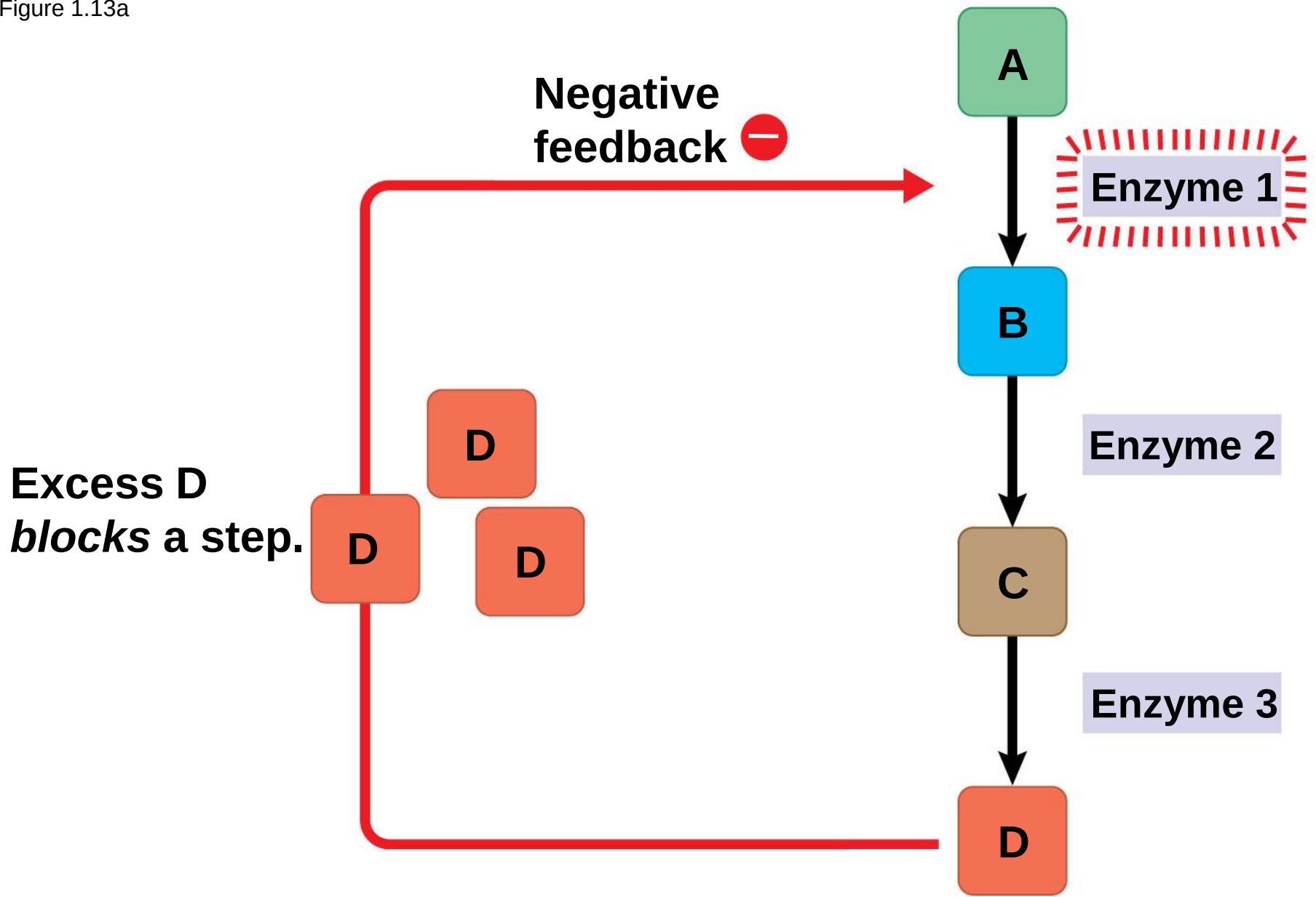
(a) Negative feedback



(b) Positive feedback

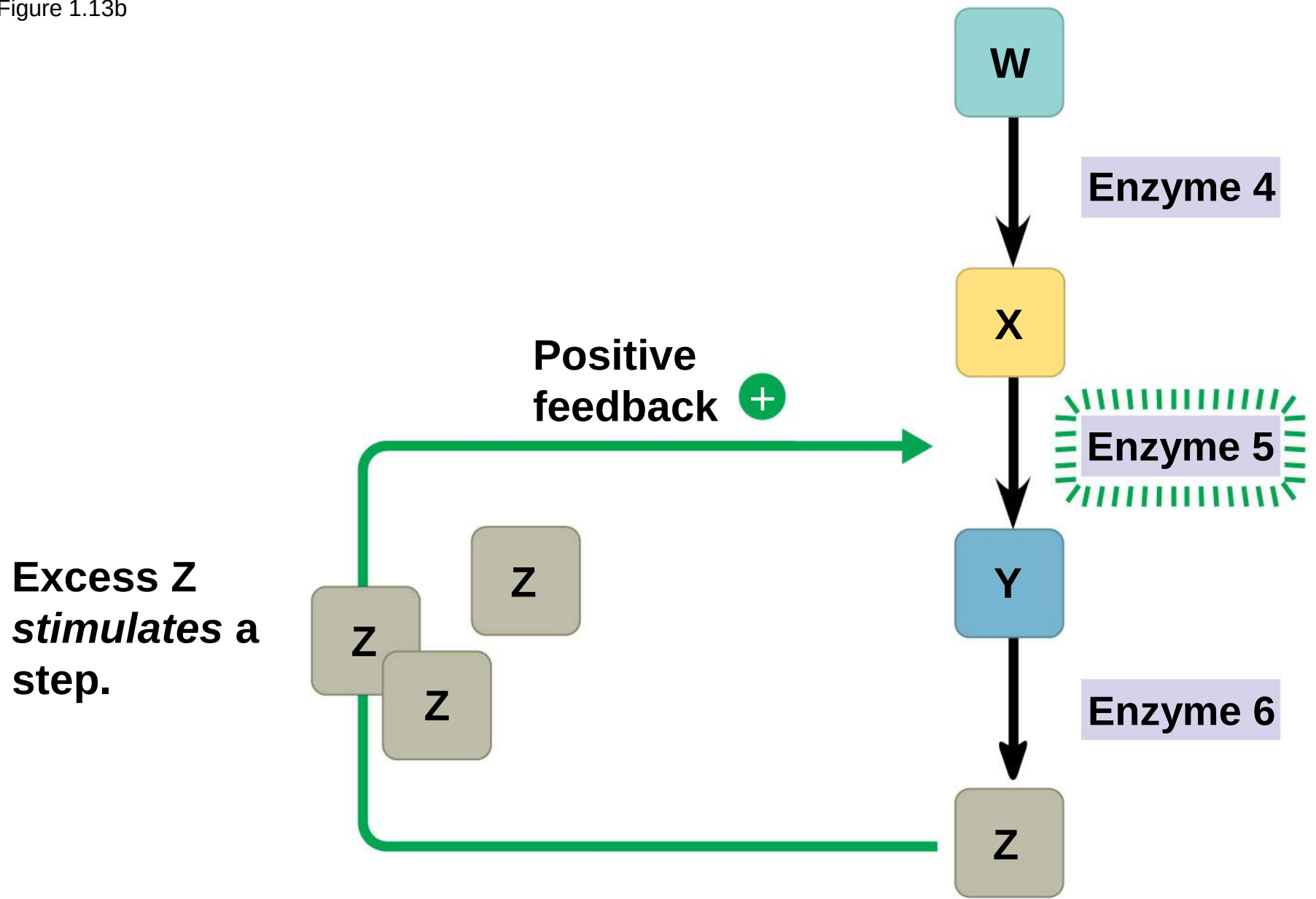
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Figure 1.13a



(a) Negative feedback

Figure 1.13b



(b) Positive feedback

Evolution, the Overarching Theme of Biology

- Evolution makes sense of everything we know about biology
- Organisms are modified descendants of common ancestors

- Evolution explains patterns of unity and diversity in living organisms
- Similar traits among organisms are explained by descent from common ancestors
- Differences among organisms are explained by the accumulation of heritable changes

Concept 1.2: The Core Theme: Evolution accounts for the unity and diversity of life

- “Nothing in biology makes sense except in the light of evolution”—Theodosius Dobzhansky
- Evolution unifies biology at different scales of size throughout the history of life on Earth

Classifying the Diversity of Life

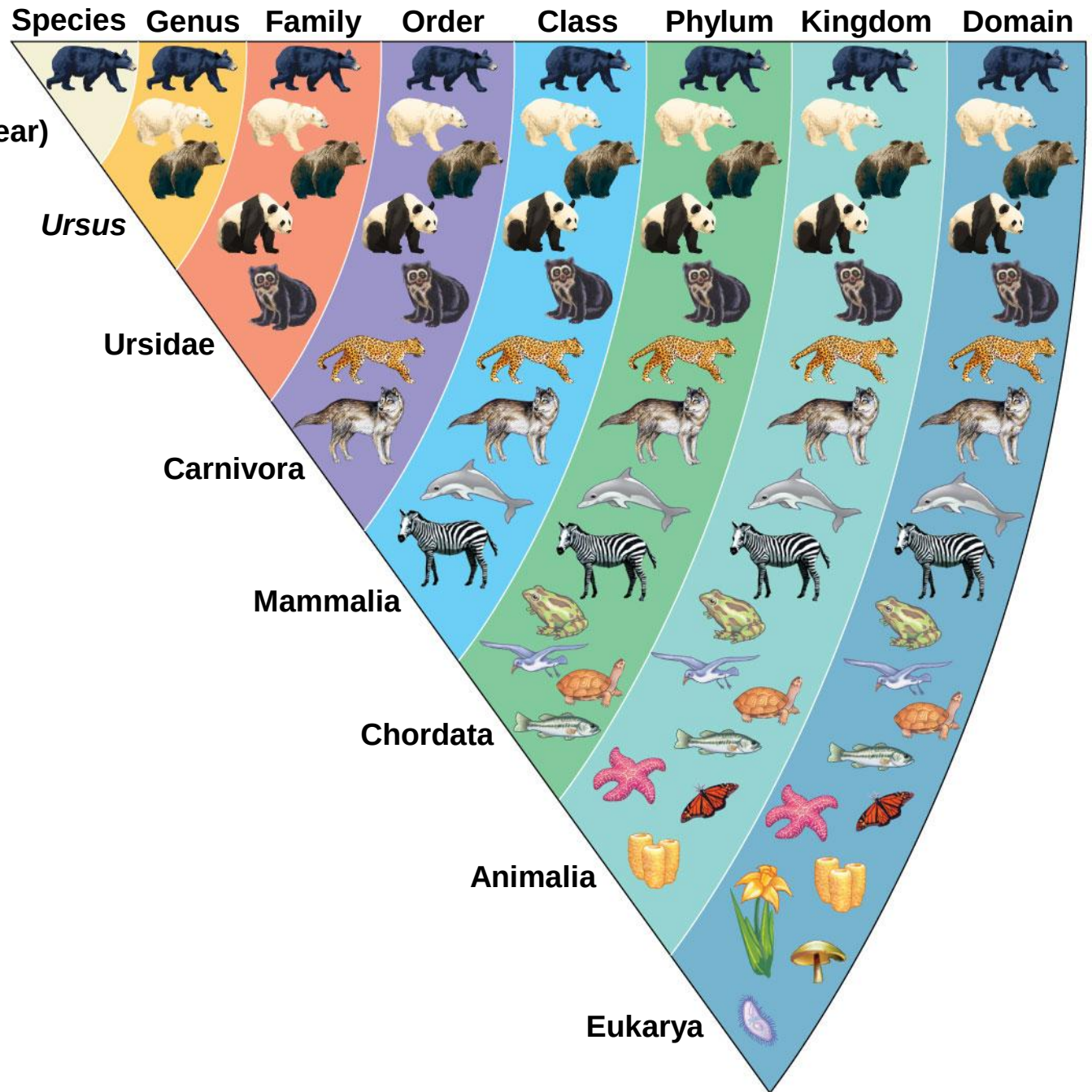
- Approximately 1.8 million species have been identified and named to date, and thousands more are identified each year
- Estimates of the total number of species that actually exist range from 10 million to over 100 million

Grouping Species: The Basic Idea

- Taxonomy is the branch of biology that names and classifies species into groups of increasing breadth
- Domains, followed by kingdoms, are the broadest units of classification

Figure 1.14

Ursus americanus
(American black bear)

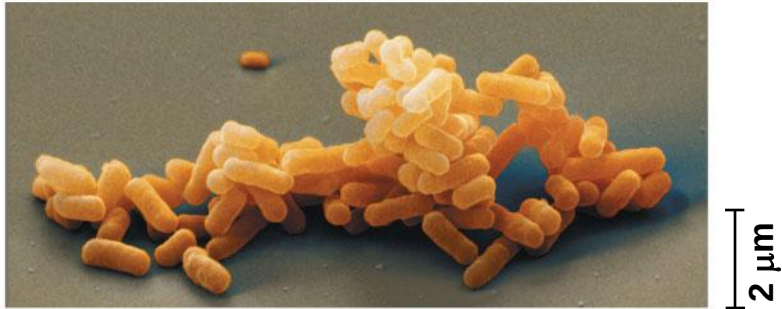


The Three Domains of Life

- Organisms are divided into three domains
- Domain **Bacteria** and domain **Archaea** compose the prokaryotes
- Most prokaryotes are single-celled and microscopic

Figure 1.15

(a) Domain Bacteria



(b) Domain Archaea



(c) Domain Eukarya



▲ Kingdom Plantae



► Kingdom Fungi

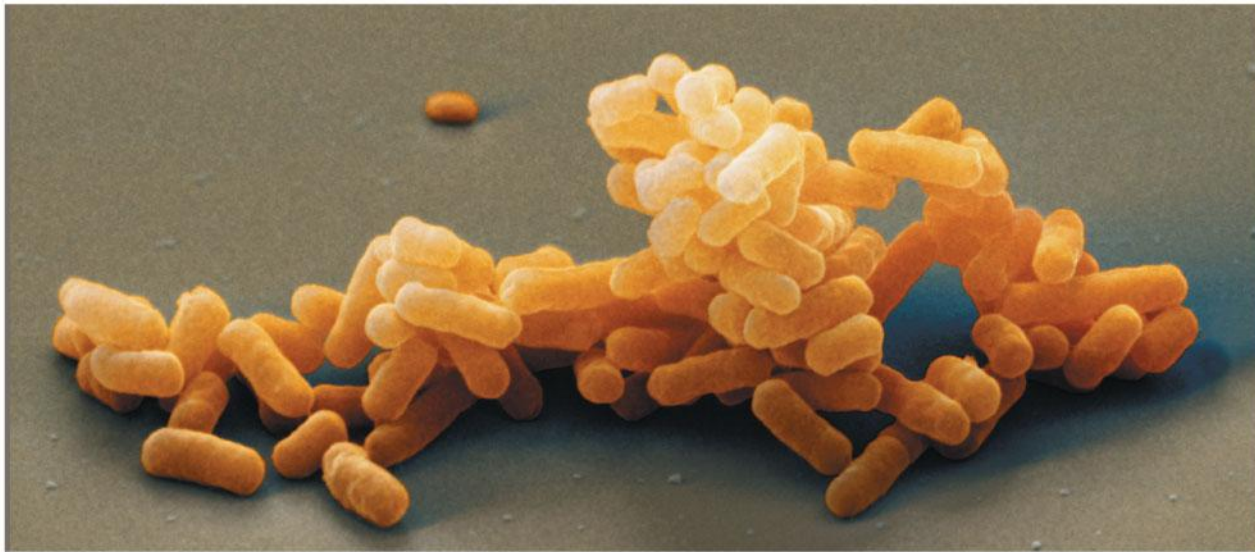


◀ Kingdom Animalia

► Protists



(a) Domain Bacteria



2 μm

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(b) Domain Archaea



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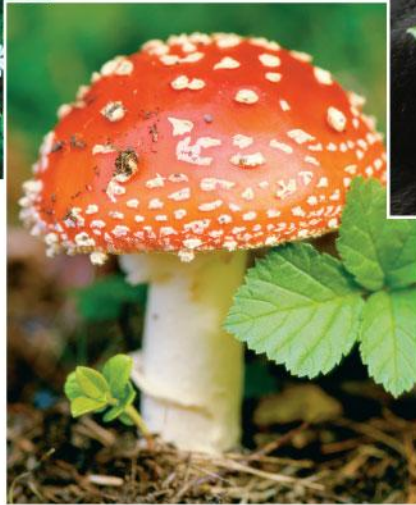
- Domain **Eukarya** includes all eukaryotic organisms
- Domain Eukarya includes three multicellular kingdoms
 - Plants, which produce their own food by photosynthesis
 - Fungi, which absorb nutrients
 - Animals, which ingest their food

- Other eukaryotic organisms were formerly grouped into the Protist kingdom, though these are now often grouped into many separate groups

(c) Domain Eukarya



▲ **Kingdom Plantae**



► **Kingdom Fungi**



◀ **Kingdom Animalia**

► **Protists**



100 μm

Figure 1.15ca



Kingdom Plantae

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Kingdom Fungi

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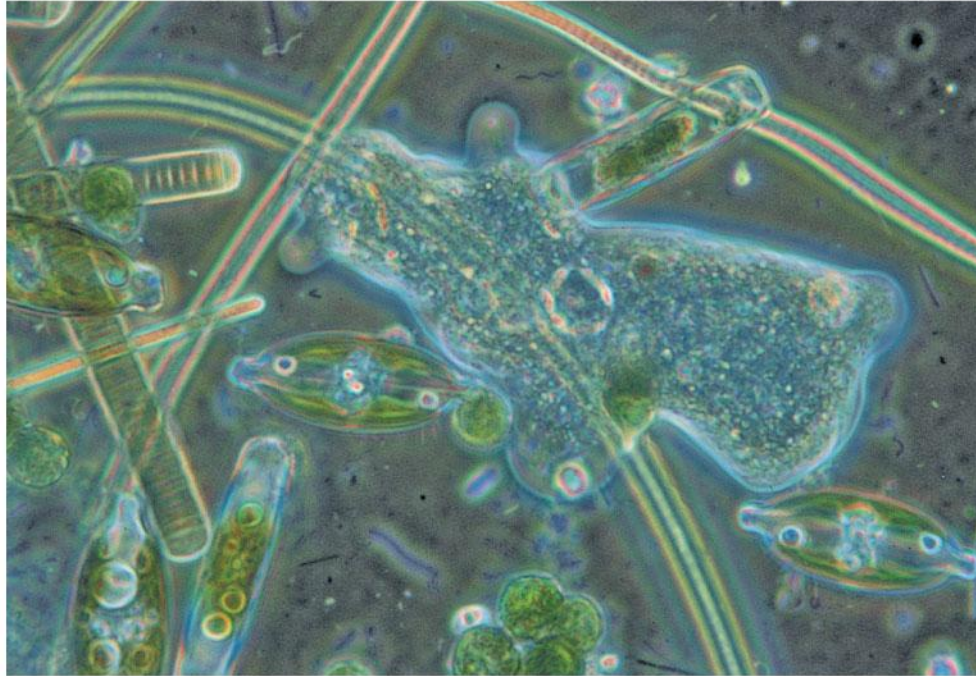


Kingdom Animalia

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Figure 1.15cd

100 μm



Protists

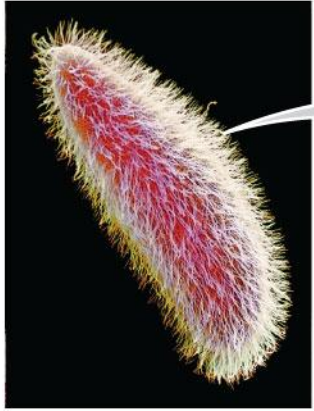
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Unity in the Diversity of Life

- A striking unity underlies the diversity of life; for example
 - DNA is the universal genetic language common to all organisms
 - Unity is evident in many features of cell structure

Figure 1.16

15 μm

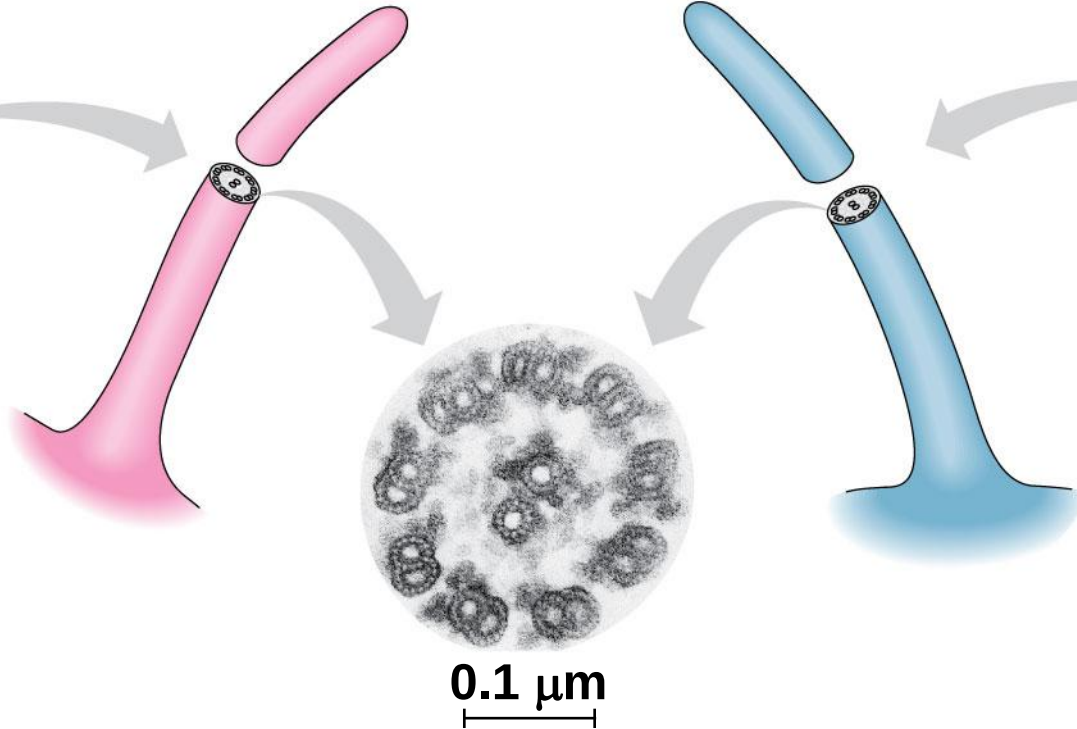


Cilia of
Paramecium

5 μm

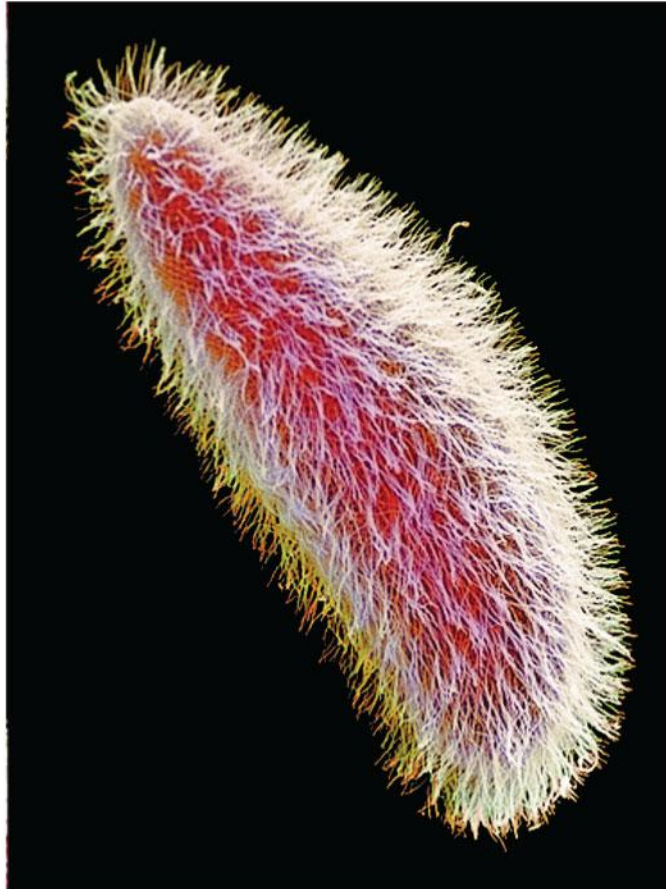


Cilia of
windpipe
cells



Cross section of a cilium, as viewed
with an electron microscope

15 μm



Cilia of *Paramecium*

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5 μm



Cilia of windpipe cells

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0.1 μm

**Cross section of a cilium, as viewed
with an electron microscope**

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Charles Darwin and the Theory of Natural Selection

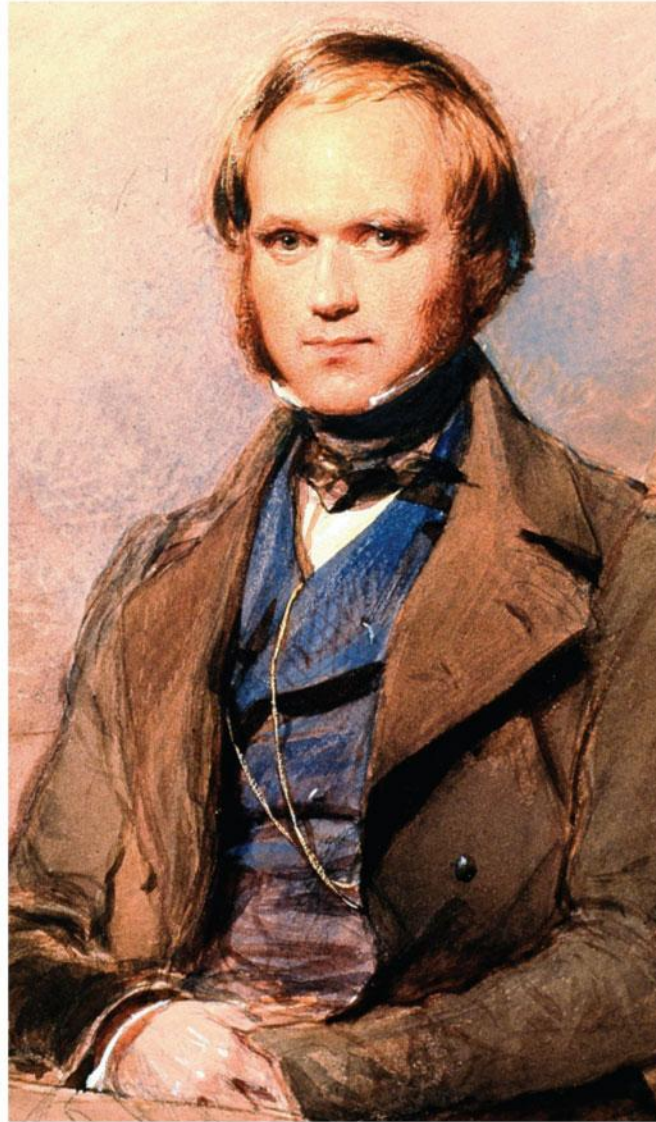
- Fossils and other evidence document the evolution of life on Earth over billions of years

Figure 1.17



- Charles Darwin published *On the Origin of Species by Means of Natural Selection* in 1859
- Darwin made two main points
 - Species showed evidence of “descent with modification” from common ancestors
 - Natural selection is the mechanism behind “descent with modification”
- Darwin’s theory explained the duality of unity and diversity

Figure 1.18



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Figure 1.19



Figure 1.19a



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Figure 1.19b



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- Darwin observed that
 - Individuals in a population vary in their traits, many of which are heritable
 - More offspring are produced than survive, and competition is inevitable
 - Species generally suit their environment

- Darwin inferred that
 - Individuals that are best suited to their environment are more likely to survive and reproduce
 - Over time, more individuals in a population will have the advantageous traits
- Evolution occurs as the unequal reproductive success of individuals

- In other words, the environment “selects” for the propagation of beneficial traits
- Darwin called this process **natural selection**

Figure 1.20



1 Population with varied inherited traits



2 Elimination of individuals with certain traits



3 Reproduction of survivors



4 Increasing frequency of traits that enhance survival and reproductive success

- Natural selection results in the adaptation of organisms to their environment
 - For example, bat wings are an example of adaptation

Figure 1.21



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The Tree of Life

- “Unity in diversity” arises from “descent with modification”
 - For example, the forelimb of the bat, human, and horse and the whale flipper all share a common skeletal architecture
- Fossils provide additional evidence of anatomical unity from descent with modification

- Darwin proposed that natural selection could cause an ancestral species to give rise to two or more descendent species
 - For example, the finch species of the Galápagos Islands are descended from a common ancestor
- Evolutionary relationships are often illustrated with treelike diagrams that show ancestors and their descendants

Figure 1.22

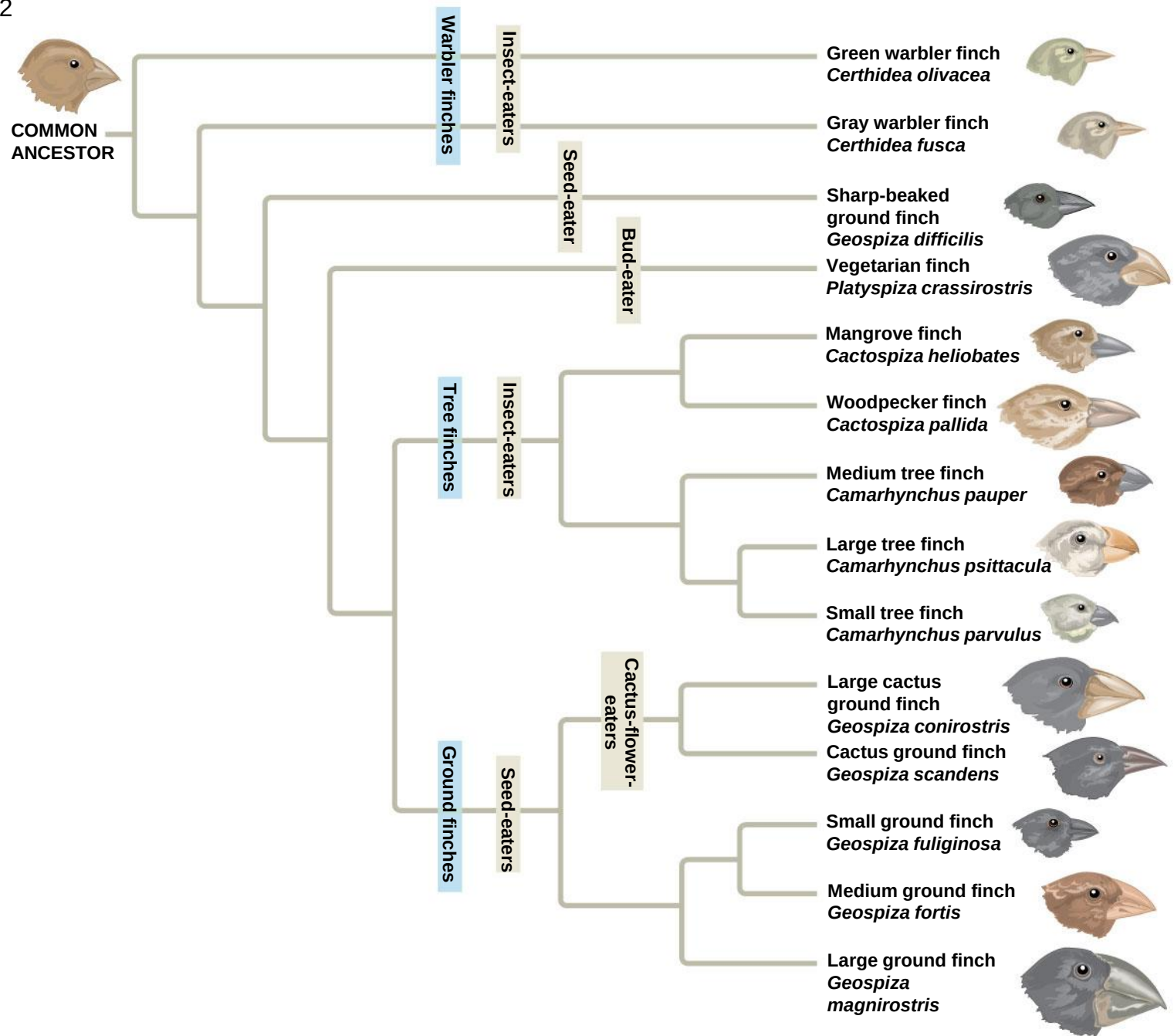


Figure 1.22a

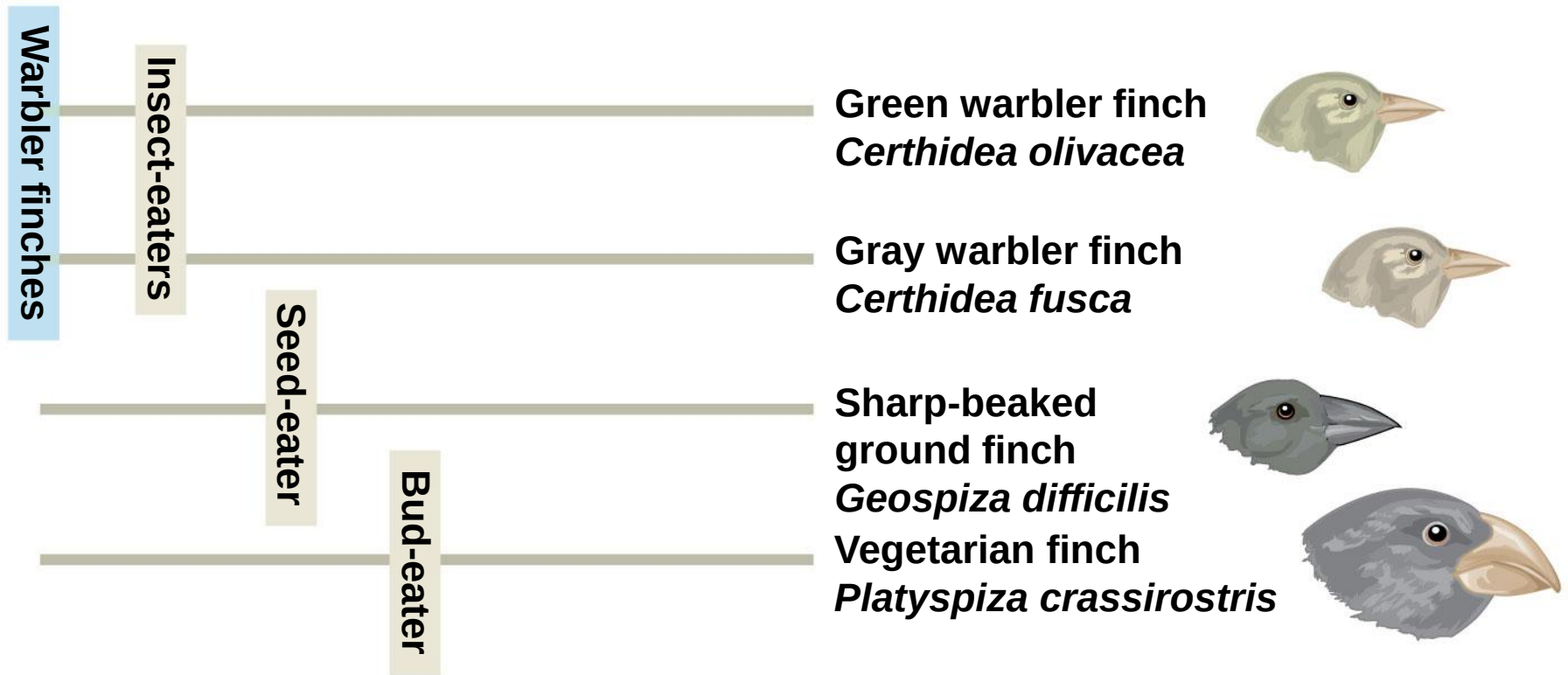
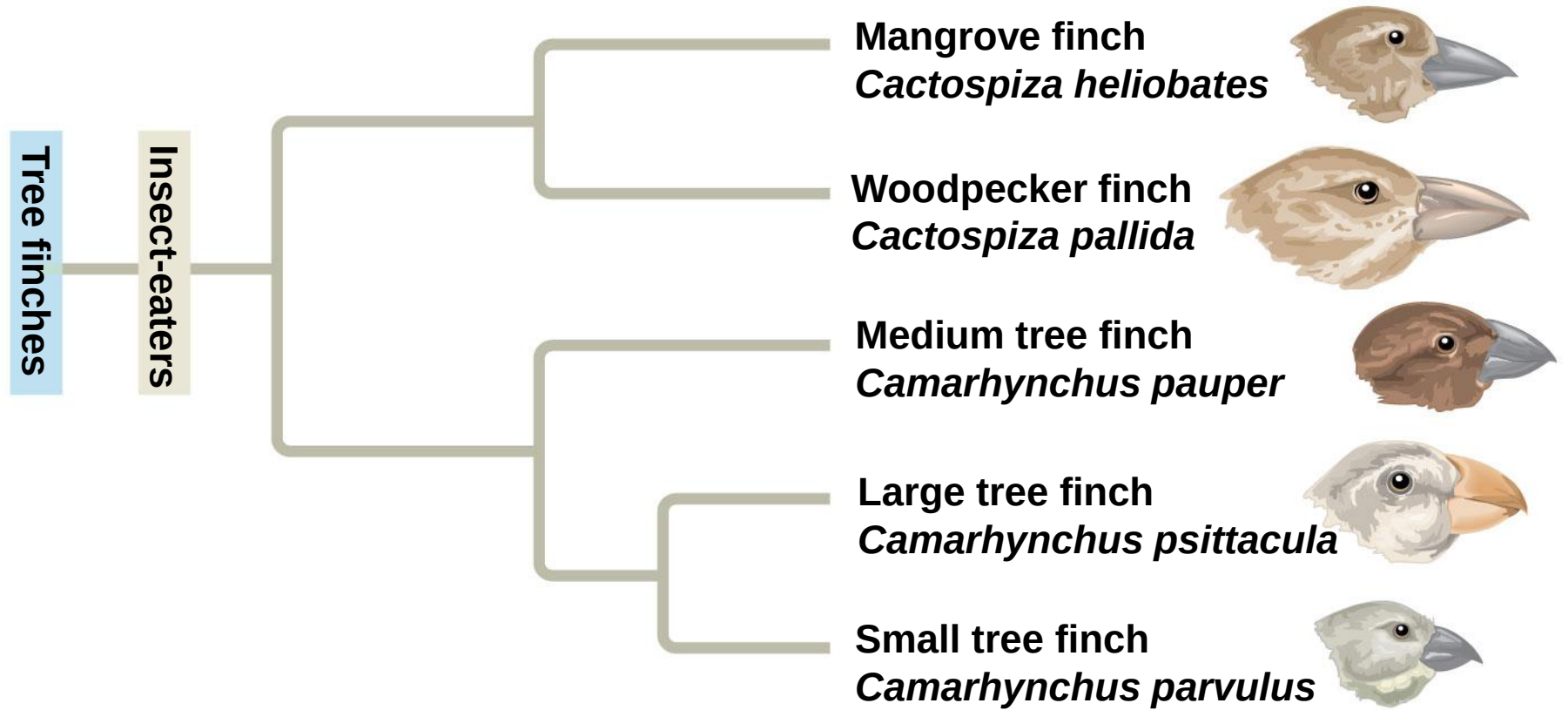


Figure 1.22b



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Figure 1.22c

