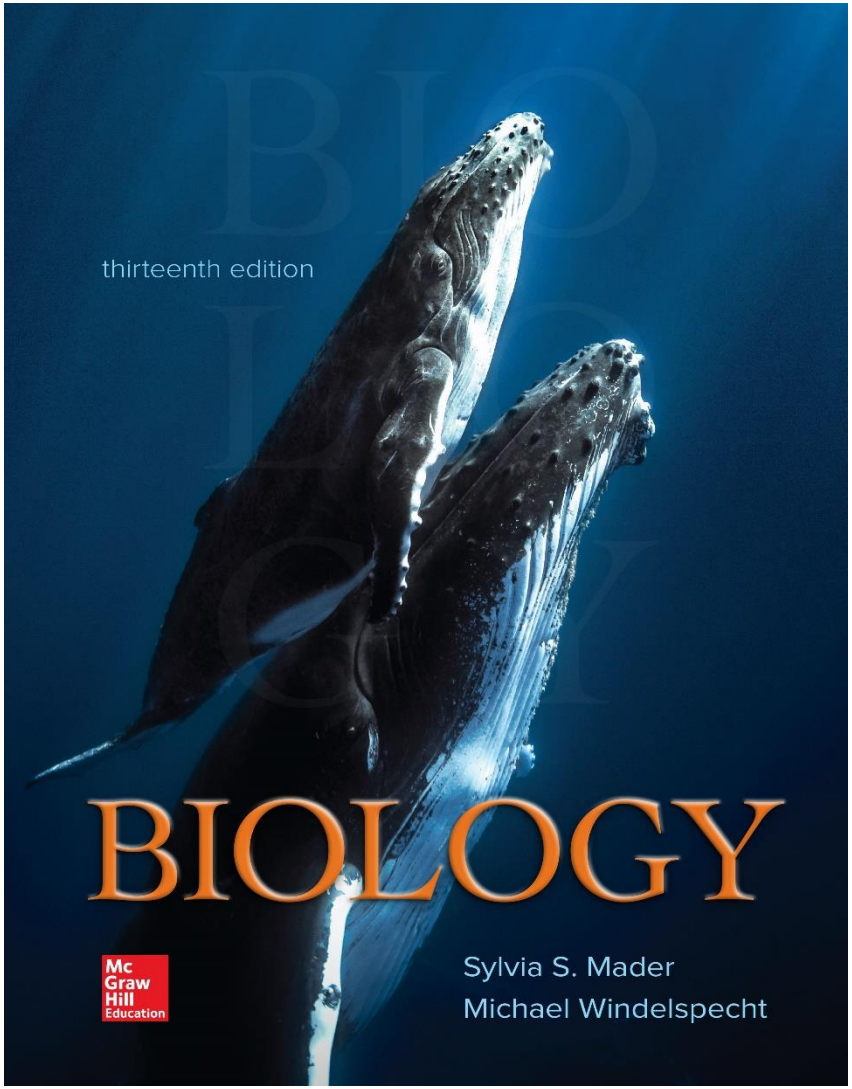


Biology

Sylvia S. Mader
Michael Windelspecht

Chapter 1
A View of Life
Lecture Outline

See separate FlexArt PowerPoint slides for all figures and tables pre-inserted into PowerPoint without notes.

Outline

1.1 The Characteristics of Life

1.2 Evolution and the Classification of Life

1.3 The Process of Science

1.4 Challenges Facing Science

1.1 The Characteristics of Life

Biology is the scientific study of life.

There is great diversity among living things.

Living things

- are composed of the same chemical elements as nonliving things.
- obey the same physical and chemical laws that govern everything in the universe.

Diversity of Life

Bacteria

Paramecium


Morel


Sunflower


Octopus

(bacteria): ©Eye of Science/Science Source; (Paramecium): ©Michael Abbey/Science Source; (morel): ©Carol Wolfe, photographer; (sunflower): ©Mediolmages/Punchstock RF; (octopus): ©Erica S. Leeds

Despite diversity, all living things share the same basic characteristics.

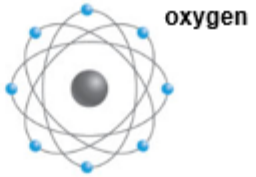
Jump to Diversity of Life Long Description

Characteristics of Life (1)

Living things are organized.

- The levels of biological organization range from atoms to the biosphere.
- The **cell** is the basic unit of structure and function of all living things.
  - Unicellular or multicellular
- Each level of organization is more complex than the level preceding it.
  - As biological complexity increases, each level acquires new, **emergent properties**.

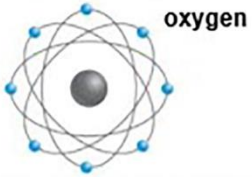
Levels of Biological Organization (1)

Atom **Smallest unit of an element composed of electrons, protons, and neutrons**	

Levels of Biological Organization (2)

Molecule
Union of two or more atoms of the same or different elements

Atom
Smallest unit of an element composed of electrons, protons, and neutrons



Levels of Biological Organization (3)

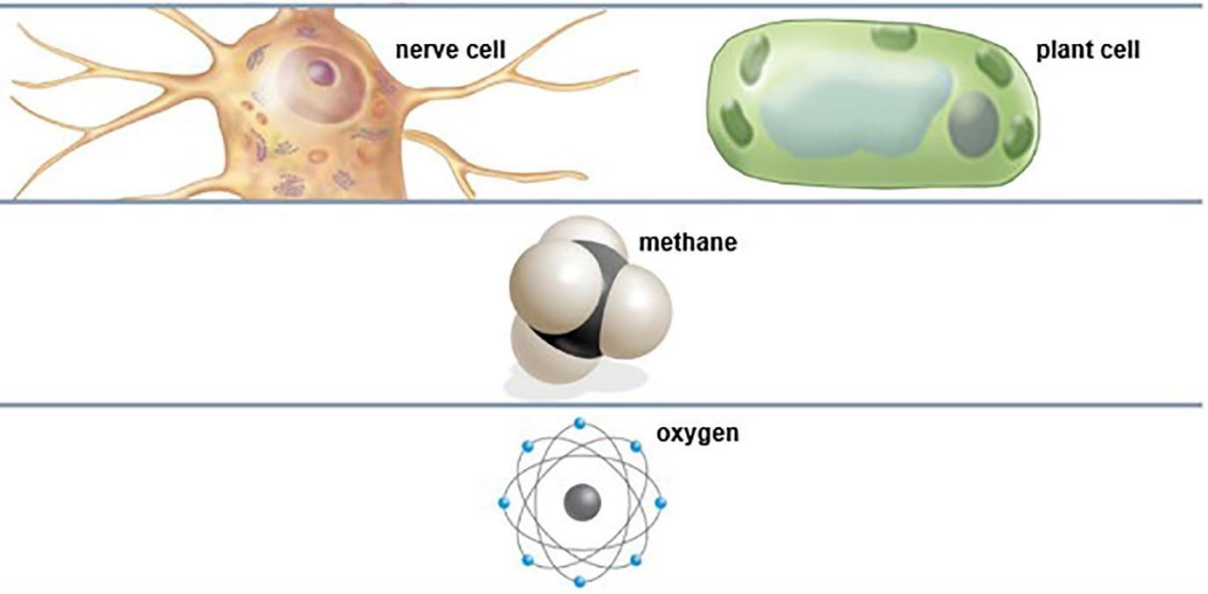
Cell
The structural and functional unit of all living things

↑

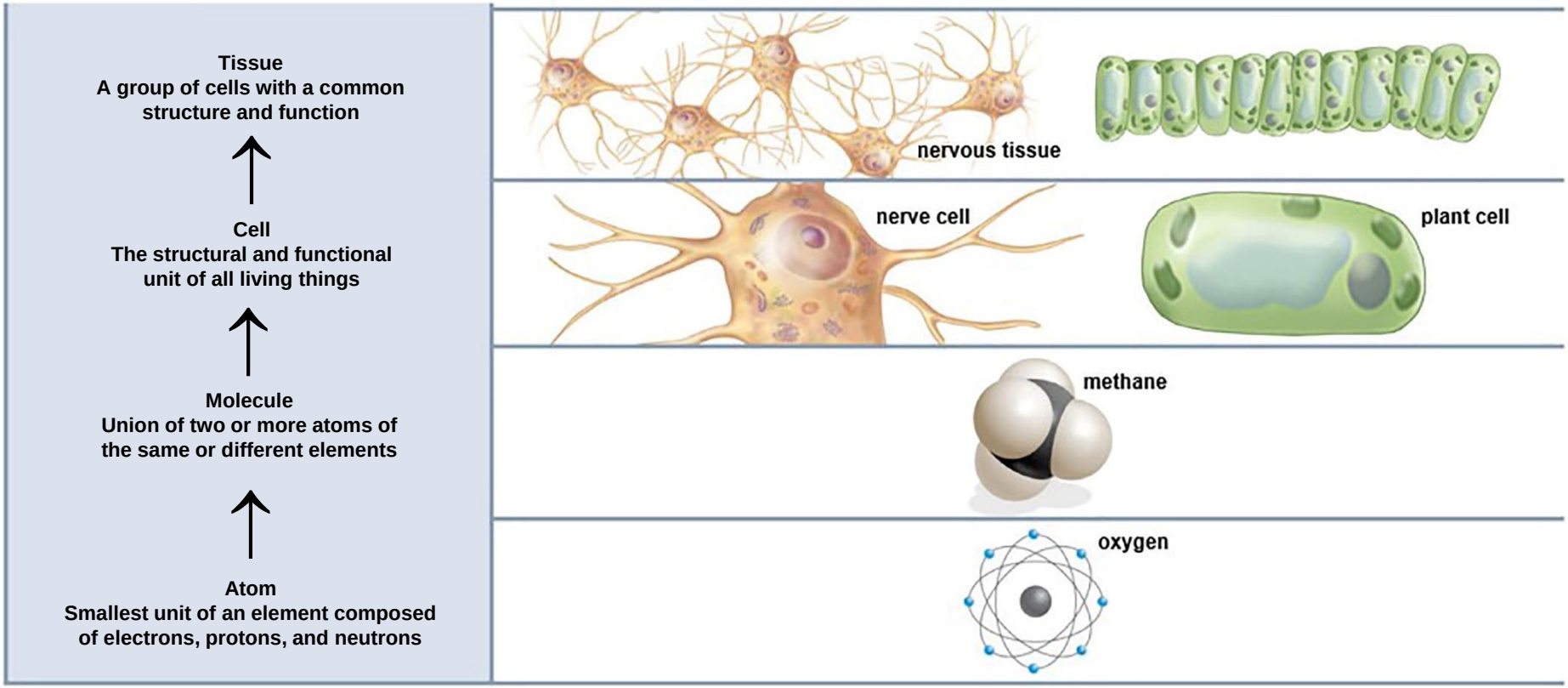
Molecule
Union of two or more atoms of the same or different elements

↑

Atom
Smallest unit of an element composed of electrons, protons, and neutrons



Levels of Biological Organization (4)



Levels of Biological Organization (5)

Organ
Composed of tissues functioning together for a specific task

↑

Tissue
A group of cells with a common structure and function

↑

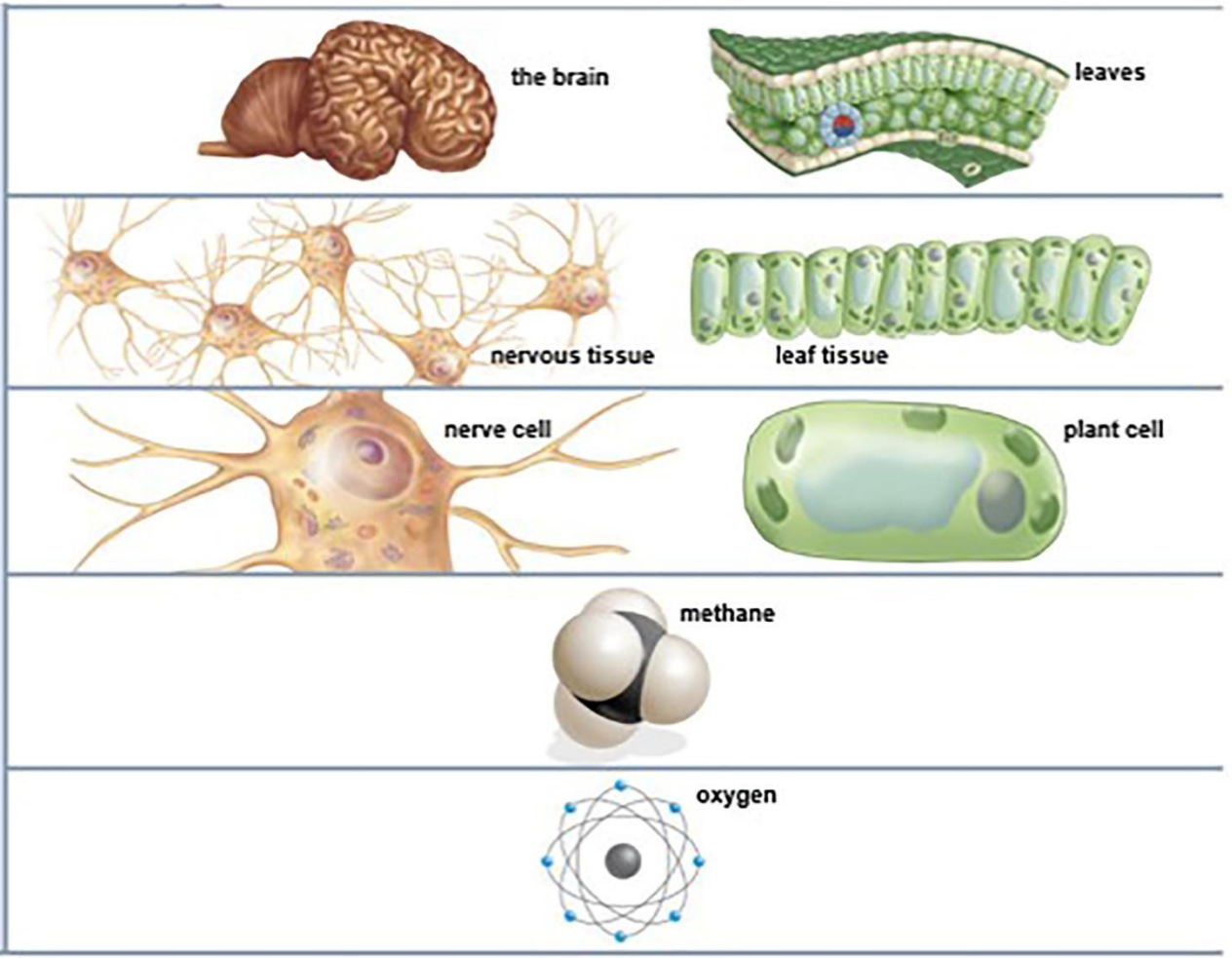
Cell
The structural and functional unit of all living things

↑

Molecule
Union of two or more atoms of the same or different elements

↑

Atom
Smallest unit of an element composed of electrons, protons, and neutrons



Levels of Biological Organization (6)

Organ System
Composed of several organs working together

↑

Organ
Composed of tissues functioning together for a specific task

↑

Tissue
A group of cells with a common structure and function

↑

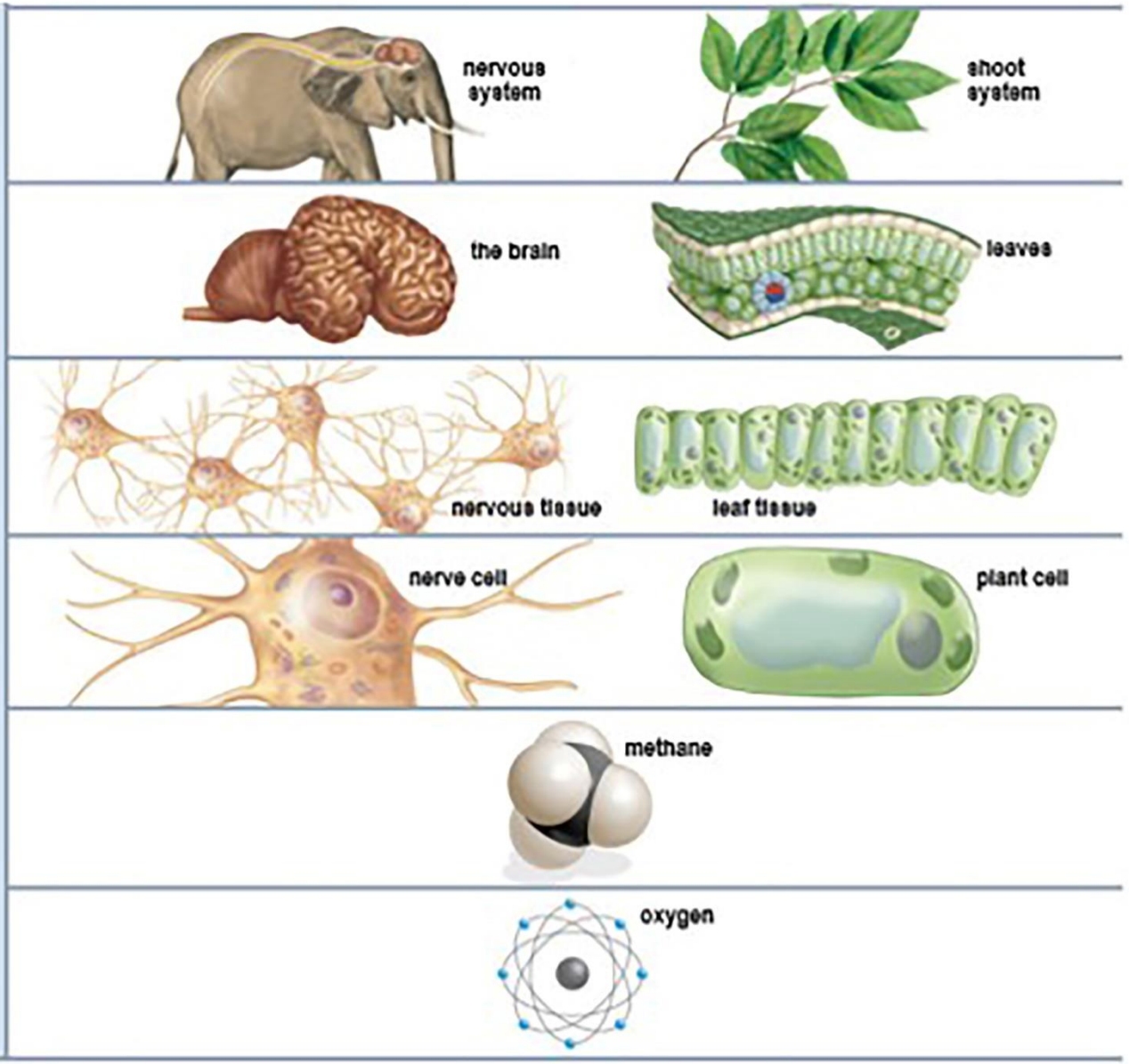
Cell
The structural and functional unit of all living things

↑

Molecule
Union of two or more atoms of the same or different elements

↑

Atom
Smallest unit of an element composed of electrons, protons, and neutrons



Levels of Biological Organization (7)

Organism
An individual; complex individuals contain organ systems

↑

Organ System
Composed of several organs working together

↑

Organ
Composed of tissues functioning together for a specific task

↑

Tissue
A group of cells with a common structure and function

↑

Cell
The structural and functional unit of all living things

↑

Molecule
Union of two or more atoms of the same or different elements

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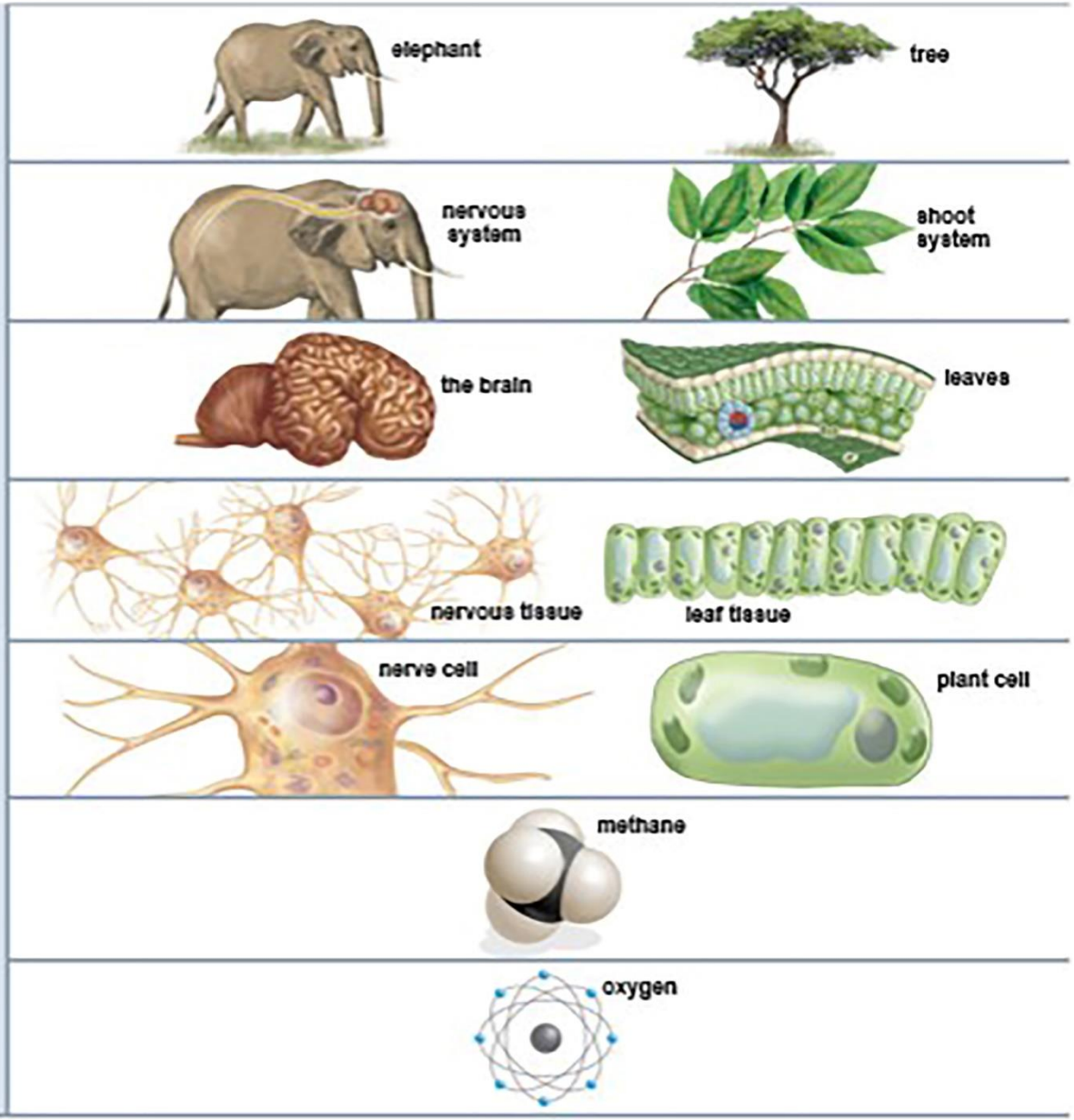
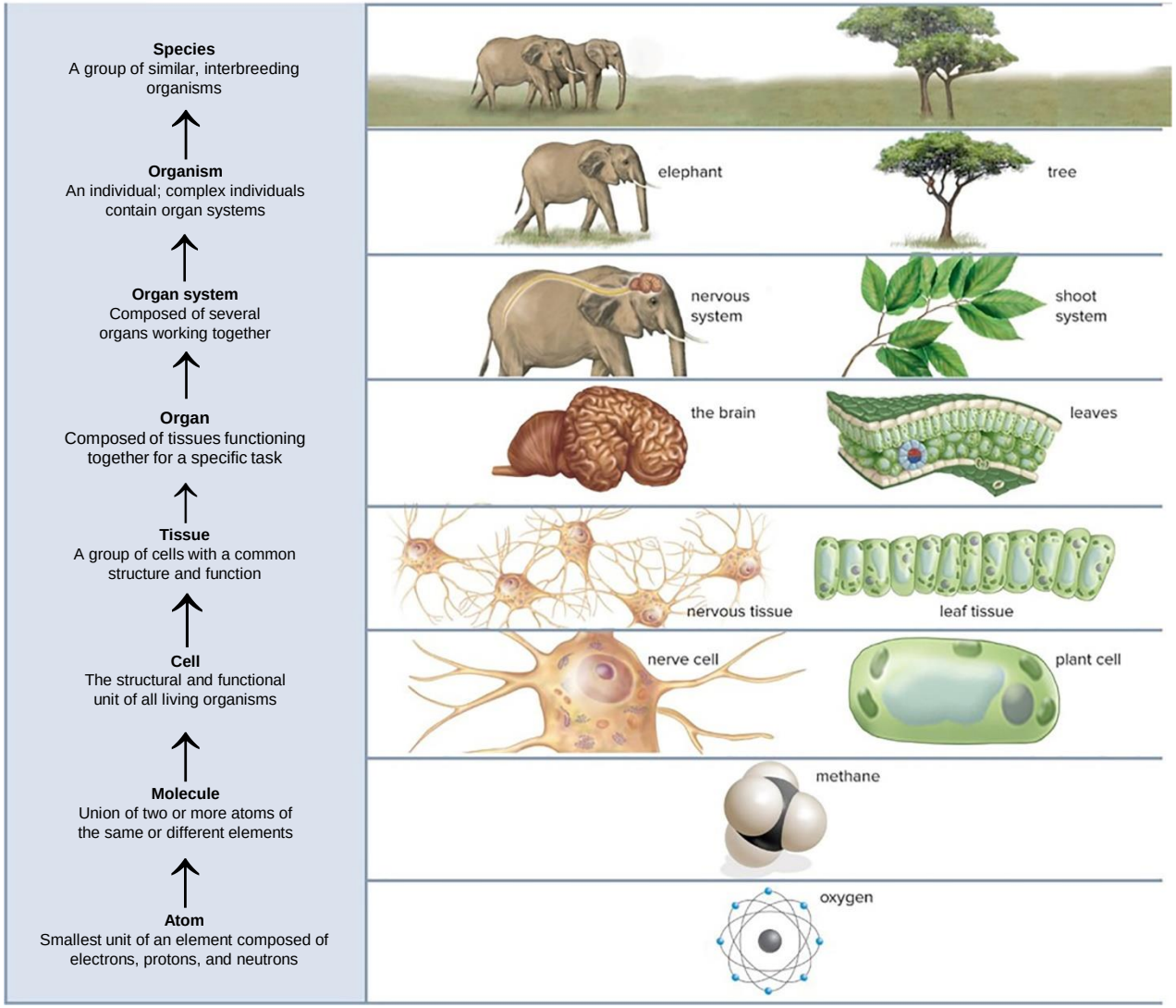
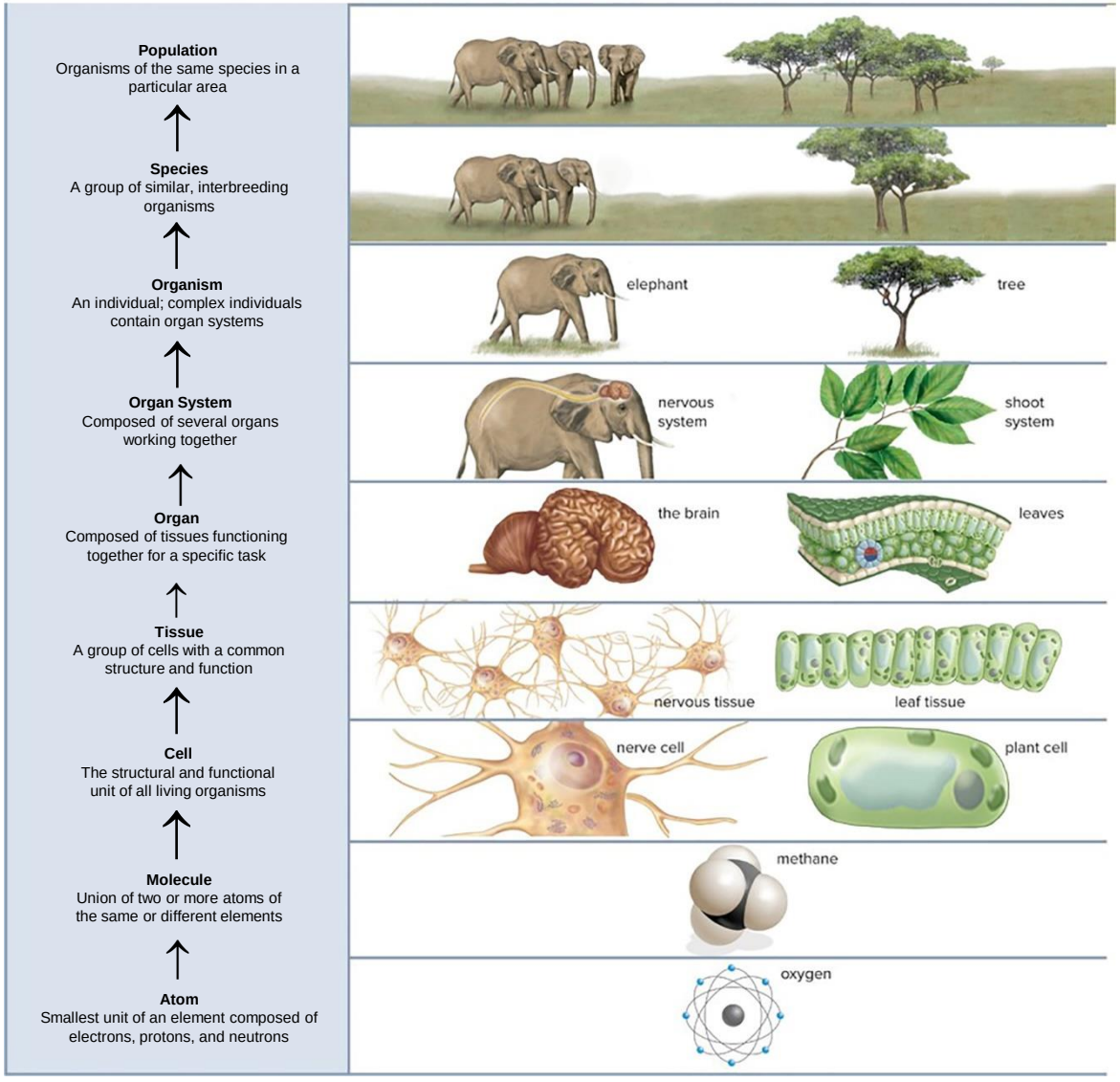
Atom
Smallest unit of an element composed of electrons, protons, and neutrons



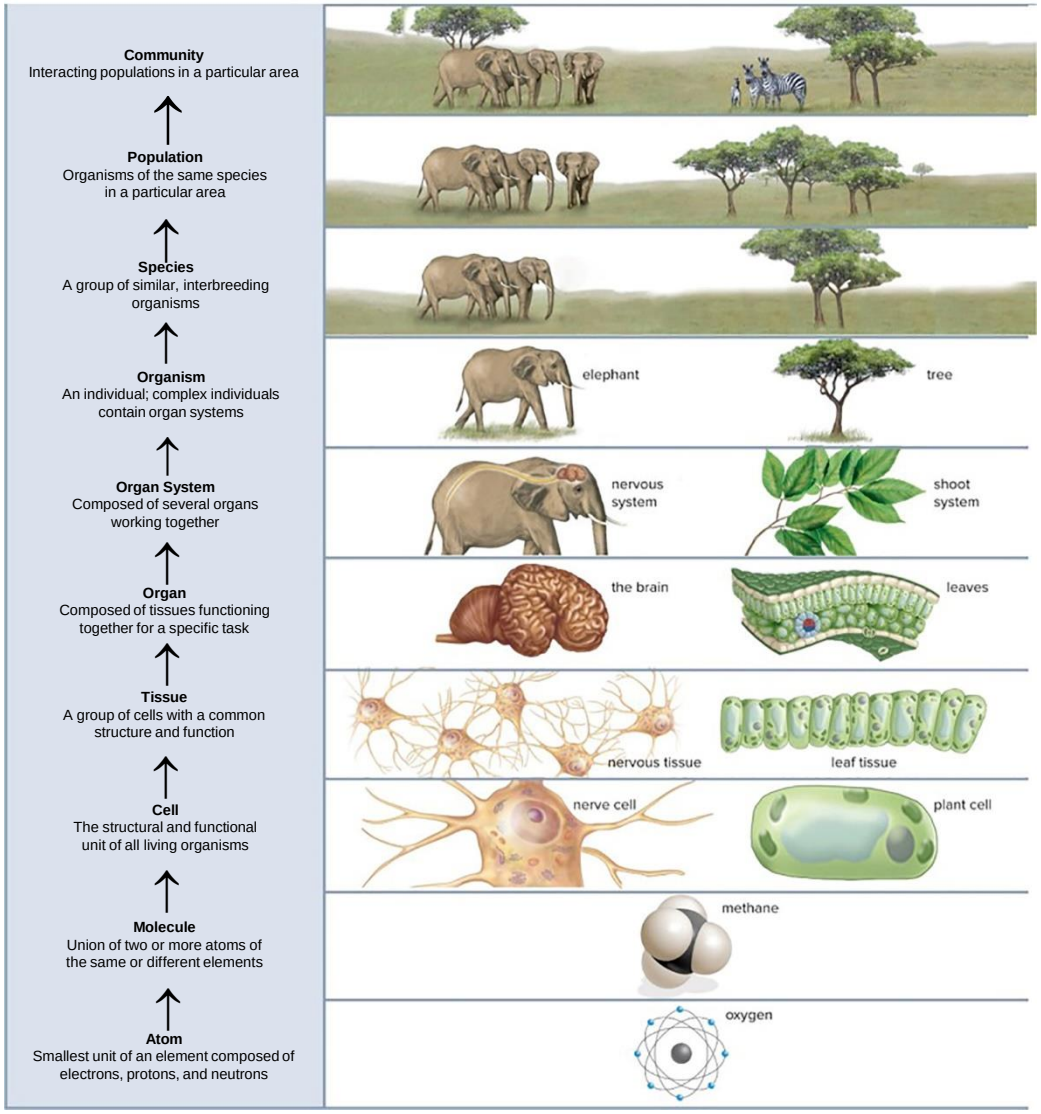
Levels of Biological Organization (8)



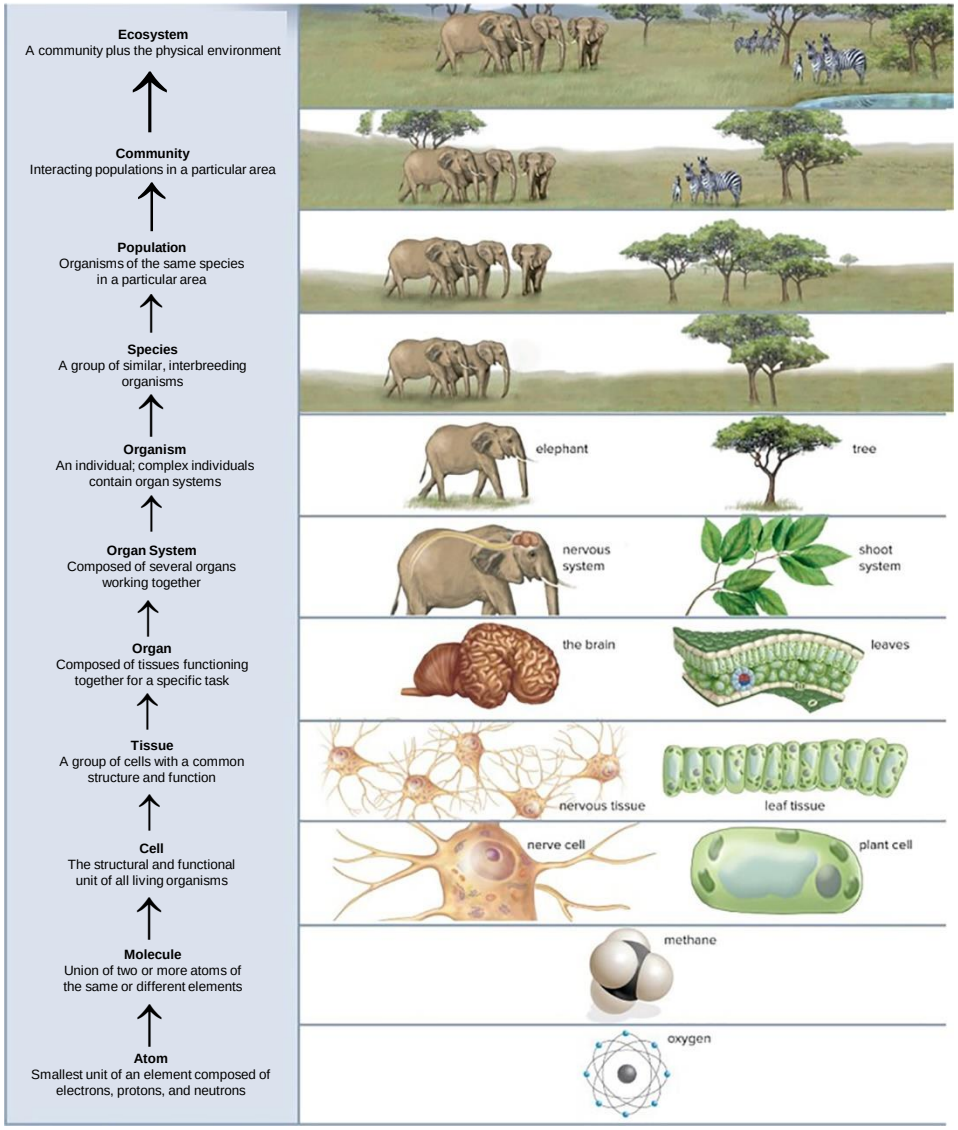
Levels of Biological Organization (9)



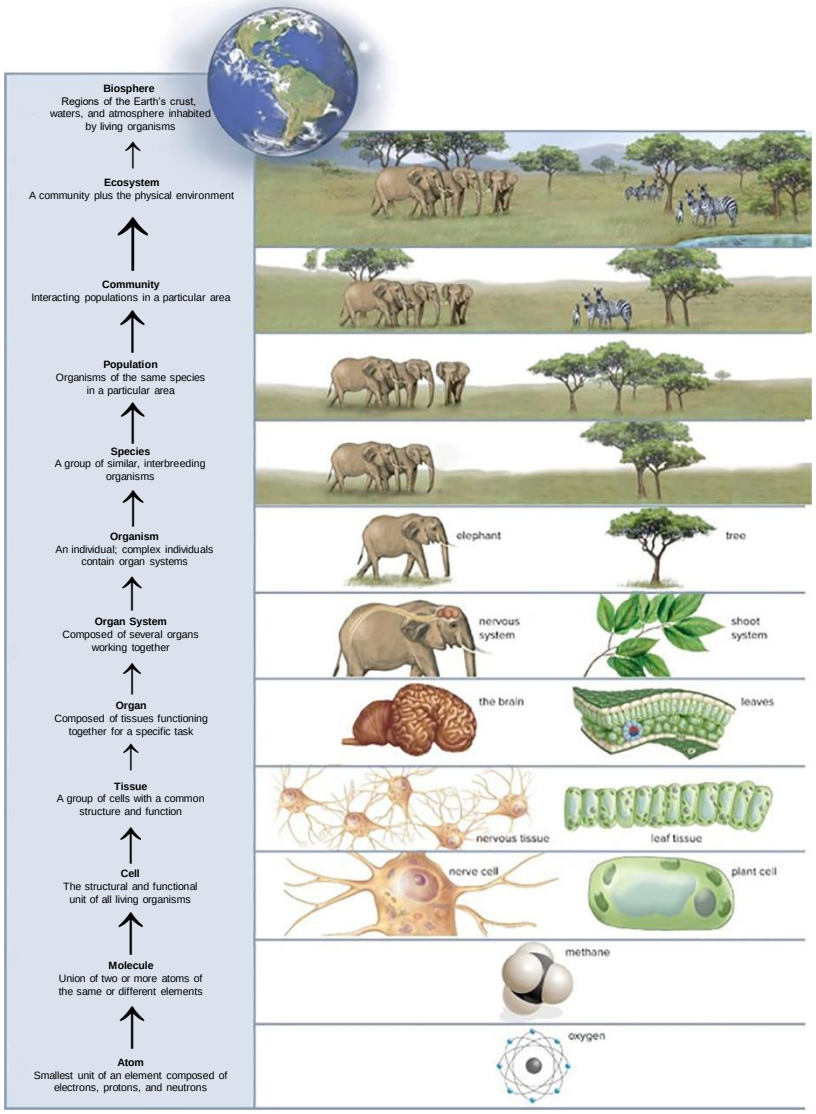
Levels of Biological Organization (10)



Levels of Biological Organization (11)



Levels of Biological Organization (12)



How the Biosphere Is Organized (1)

The **biosphere** is the zone of air, land, and water where organisms exist.

An **ecosystem** is a community plus its physical environment.

A **community** is a collection of interacting populations within the same environment.

A **population** is all the members of a species within an area.

A **species** is a group of similar, interbreeding organisms.

How the Biosphere Is Organized (2)

An **organism** is formed when organ systems are joined together.

Organs work together to form **organ systems**.

Tissues make up **organs**.

Similar cells combine together to form **tissues**.

Molecules join to form larger molecules within a **cell**.

Atoms combine to form **molecules**.

The organization of life begins with **atoms**.

Characteristics of Life (2)

Life requires materials and energy.

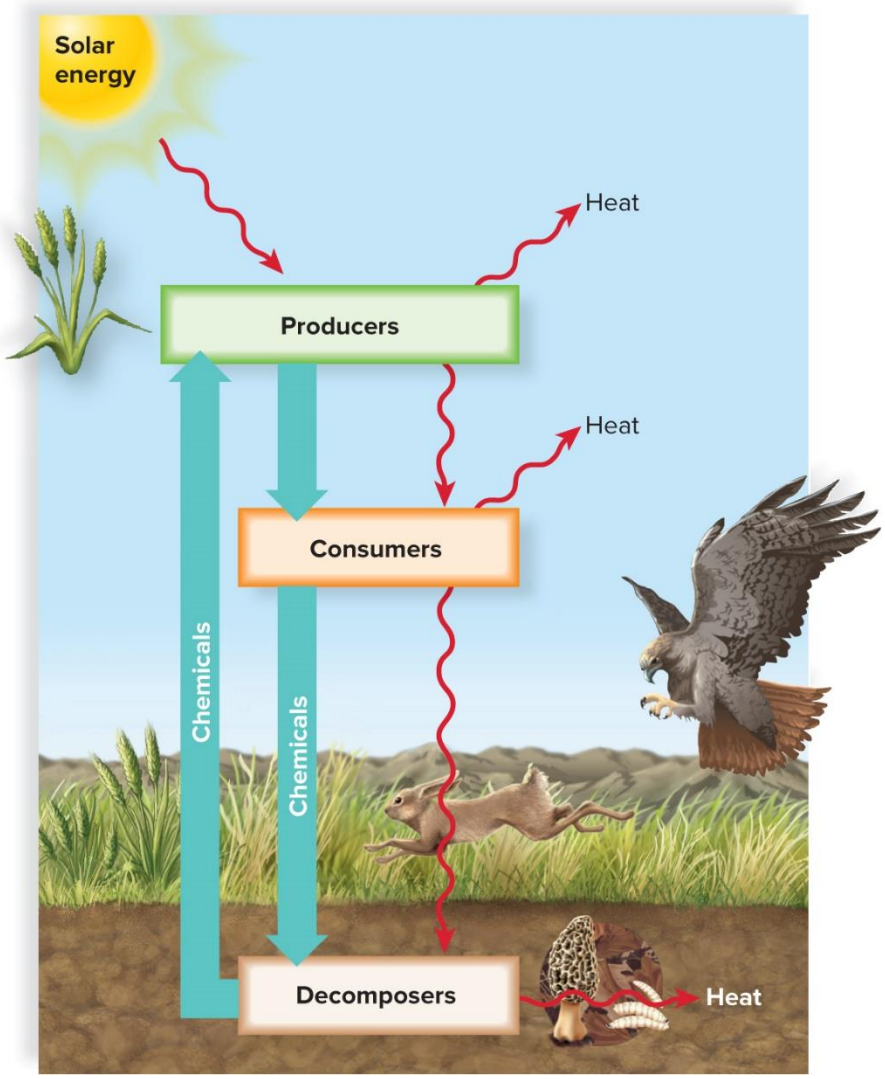
- **Energy** is the capacity to do work.
  - Energy is required to maintain organization and conduct life-sustaining processes such as chemical reactions.
    - **Metabolism** is all the chemical reactions that occur in a cell.
  - The sun is the ultimate source of energy for nearly all life on Earth.
    - Plants, algae, and some other organisms capture solar energy and perform photosynthesis.
    - **Photosynthesis** is a process that converts solar energy into the chemical energy of carbohydrates.

Ecosystems (1)

Ecosystems are characterized by chemical cycling and energy flow.

- Chemicals are not used up when organisms die.
  - Chemicals move from one population to another in a food chain.
  - Example: Chemicals move from producers to consumers to decomposers.
  - As a result of death and decomposition, chemicals are returned to living plants.
- Energy from the sun flows through plants and other members of the food chain as one population feeds on another.
  - Therefore, there must be a constant input of solar energy.

Ecosystems (2)



Jump to Ecosystems (2) Long Description

Characteristics of Life (3)

Living things maintain homeostasis.

- **Homeostasis** is the maintenance of internal conditions within certain boundaries.
  - It is imperative than an organism maintain a state of biological balance.
  - Feedback systems monitor internal conditions and make adjustments.

Living things respond to stimuli.

- Living things interact with the environment and respond to changes in the environment.
  - The ability to respond often produces movement.

Characteristics of Life (4)

Living things reproduce and develop.

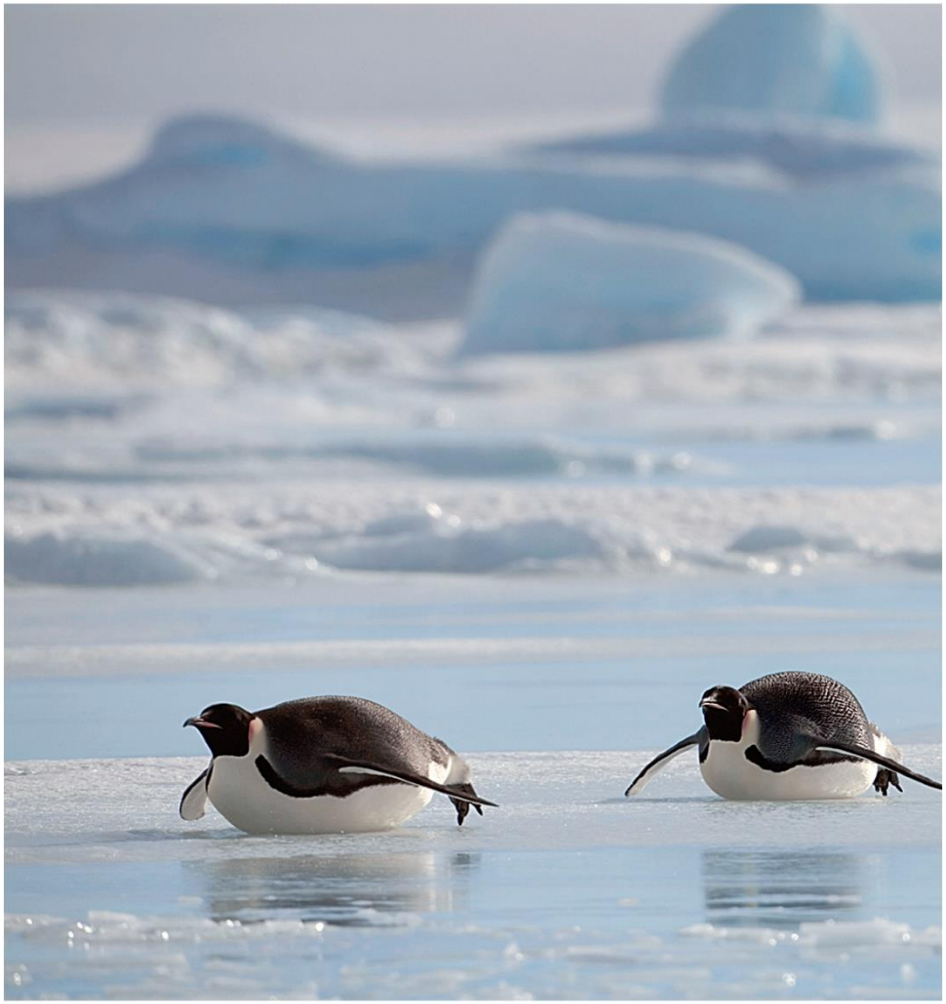
- All living organisms must reproduce to maintain a population.
- The manner of reproduction varies among different organisms.
- When organisms reproduce, they pass on copies of their genetic information (**genes**) to the next generation.
  - Genes determine the characteristics of an organism.
  - Genes are composed of DNA (deoxyribonucleic acid).

Characteristics of Life (5)

Living things have adaptations.

- An **adaptation** is any modification that makes an organism better able to function in a particular environment.
- The diversity of life exists because over long periods of time, organisms respond to changing environments by developing new adaptations.
- **Evolution** is the change in a population of organisms over time to become more suited to the environment.

Characteristics of Life (6)



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Jump to Characteristics of Life (6) Long Description

1.2 Evolution and the Classification of Life

The theory of evolution explains the diversity and unity of life.

- The theory of evolution suggests how all living things descended from a common ancestor.
- Common descent with modification

Natural Selection (1)

Natural selection is the evolutionary mechanism proposed by **Charles Darwin.**

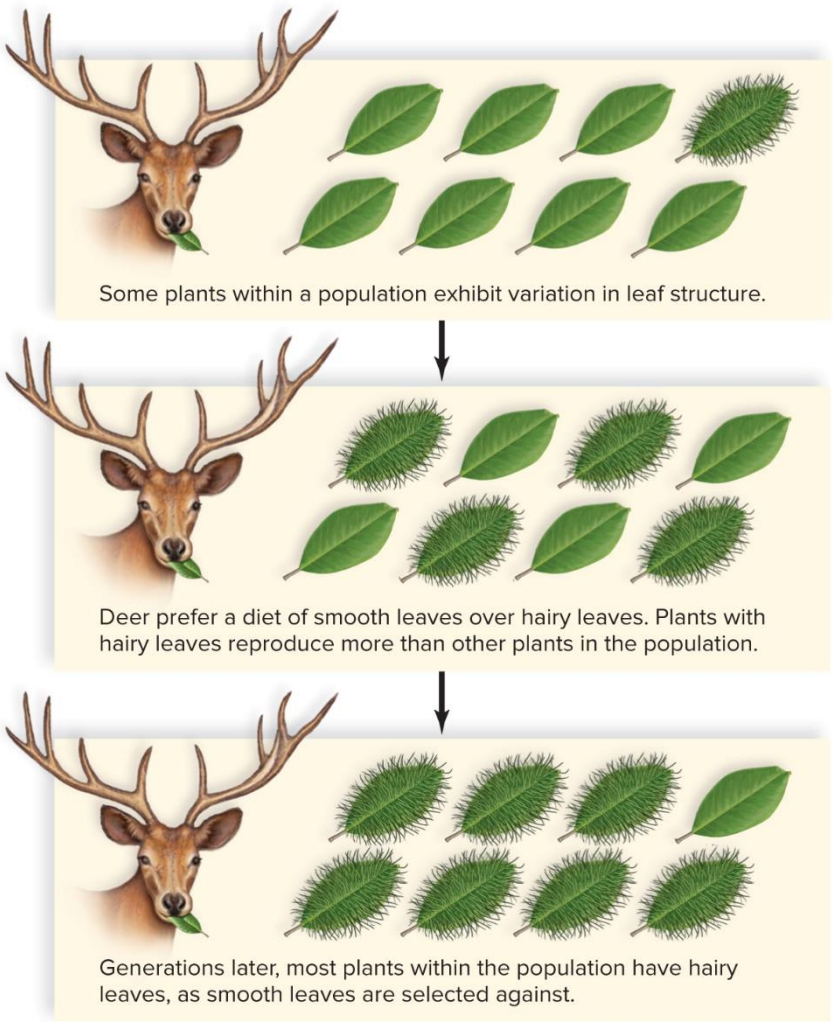
Some aspect of the environment selects which traits are more apt to be passed on to the next generation.

- Individuals with the favorable traits produce the greater number of offspring that survive and reproduce.
- This increases the frequency of those favorable traits in population.

Mutations fuel natural selection.

- It introduces variations among members of a population.

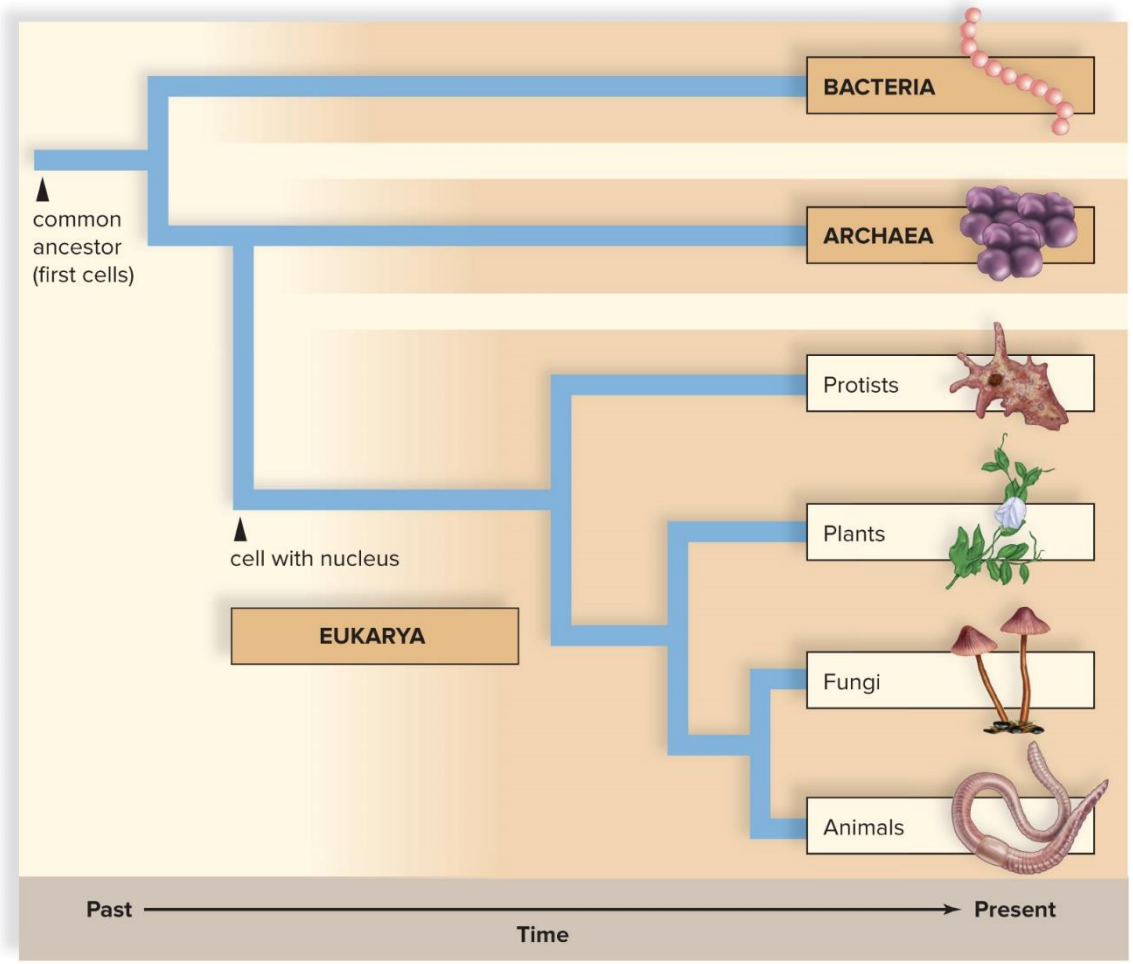
Natural Selection (2)



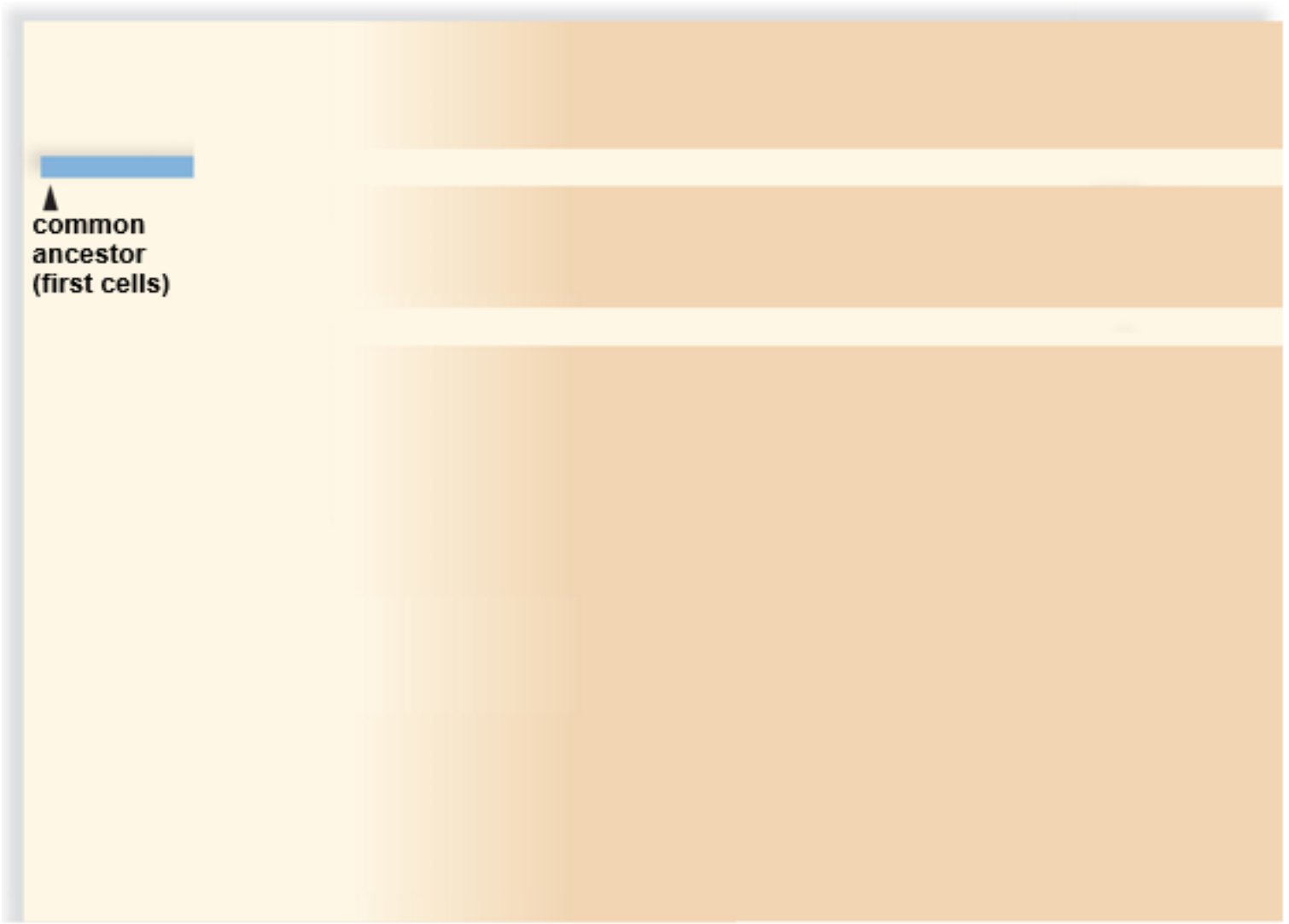
Jump to Natural Selection (2) Long Description

Evolutionary Tree of Life (1)

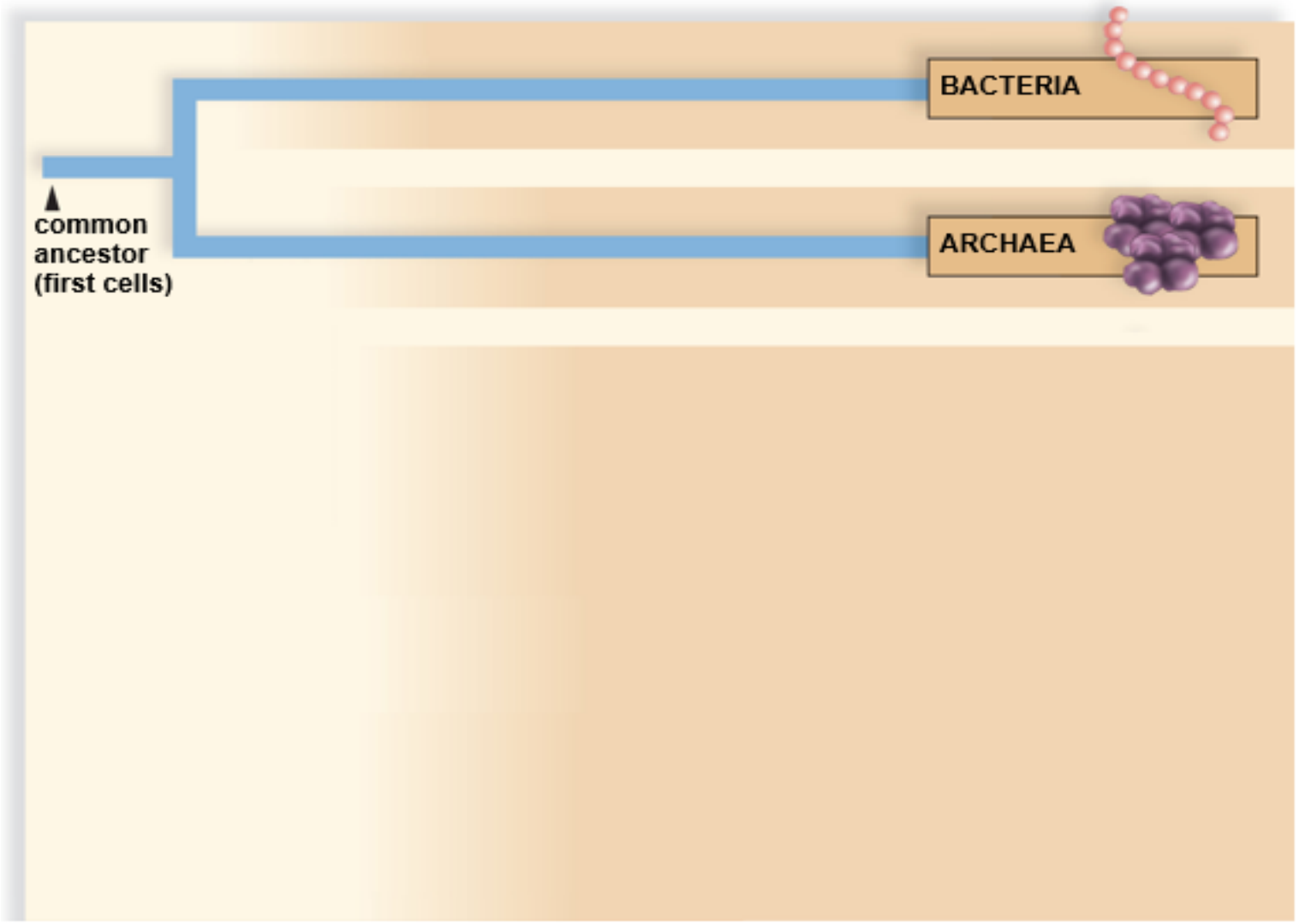
An evolutionary tree is like a family tree. An evolutionary tree traces the ancestry of life on Earth to a common ancestor.



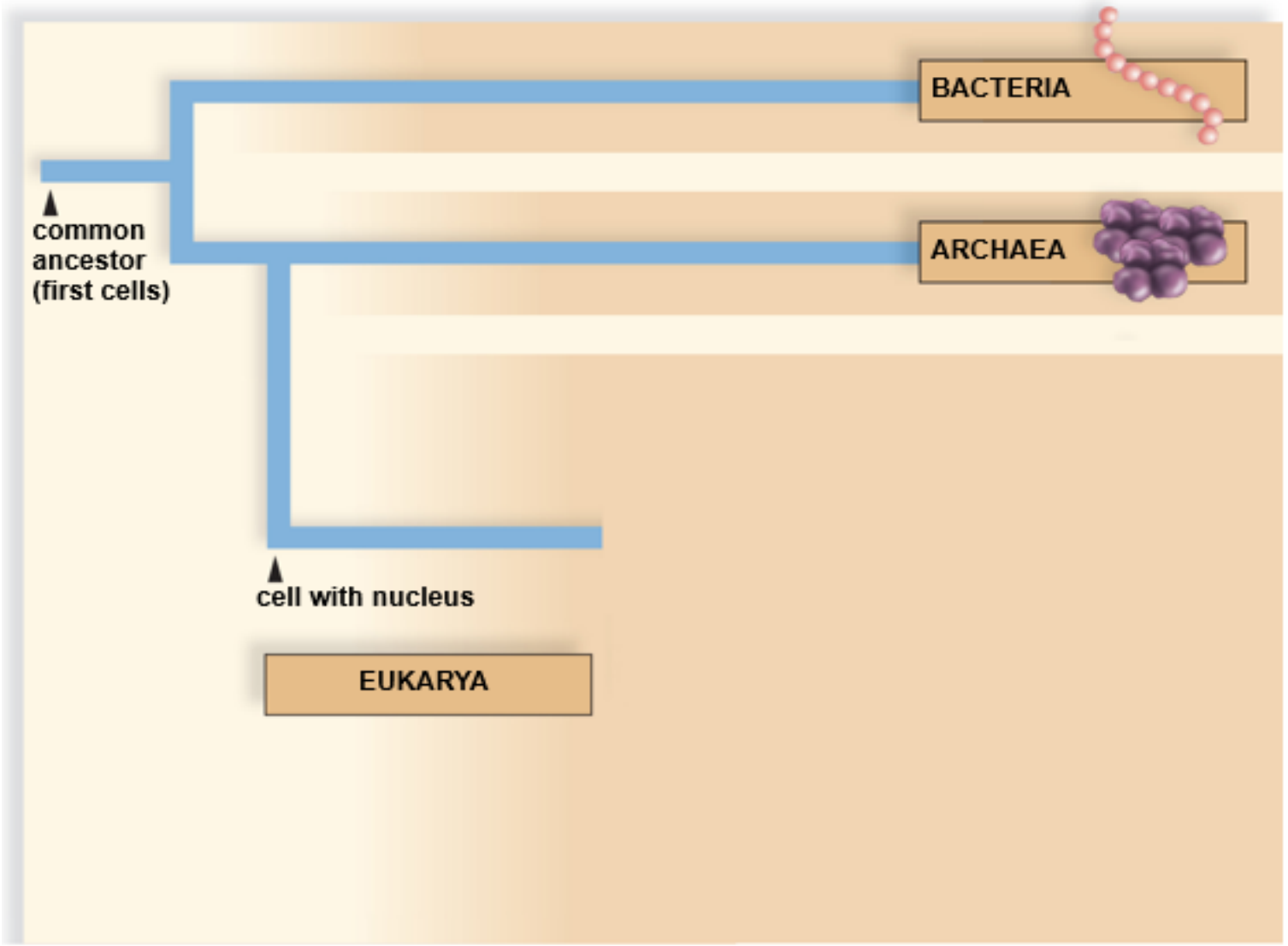
Evolutionary Tree of Life (2)



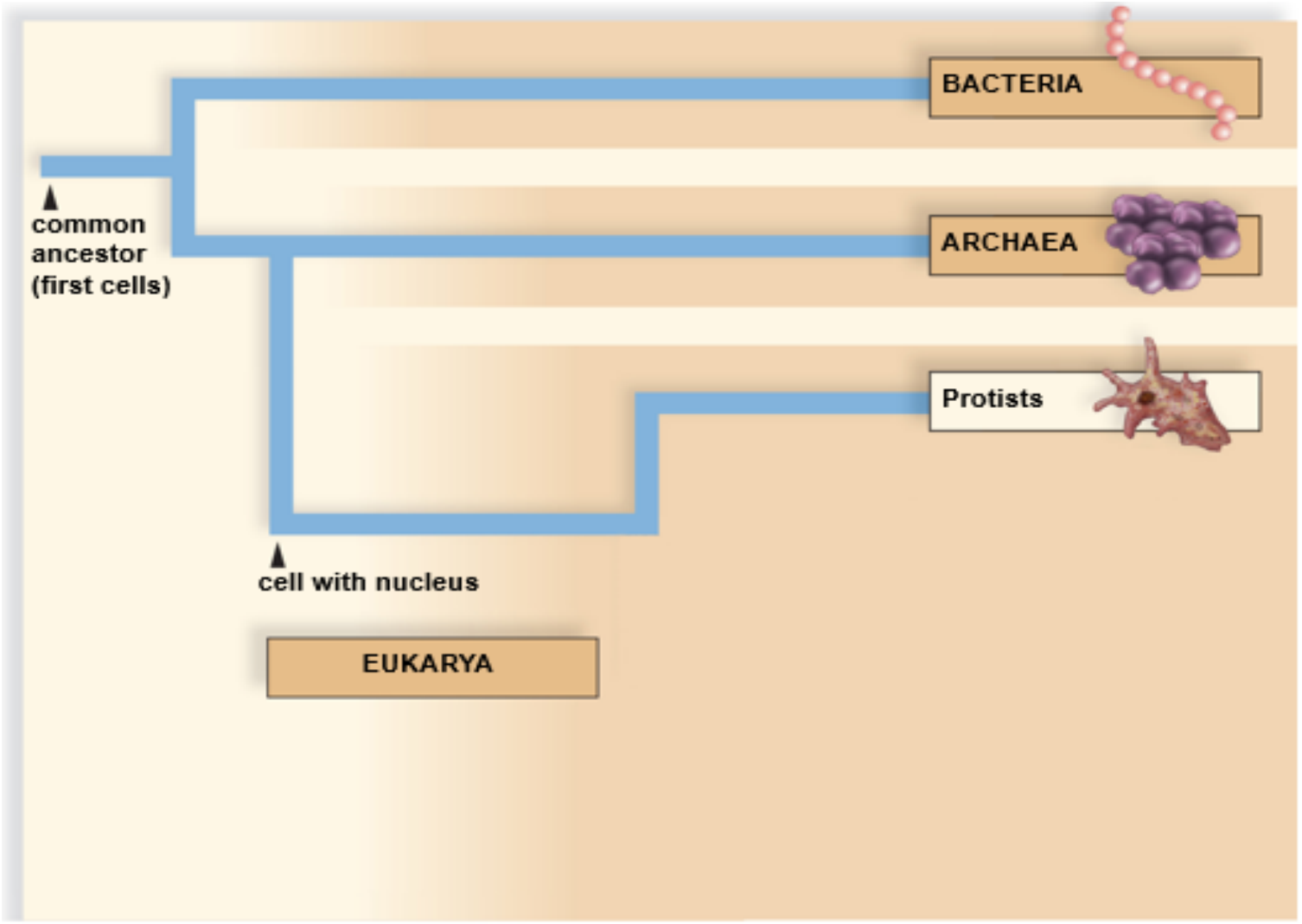
Evolutionary Tree of Life (3)



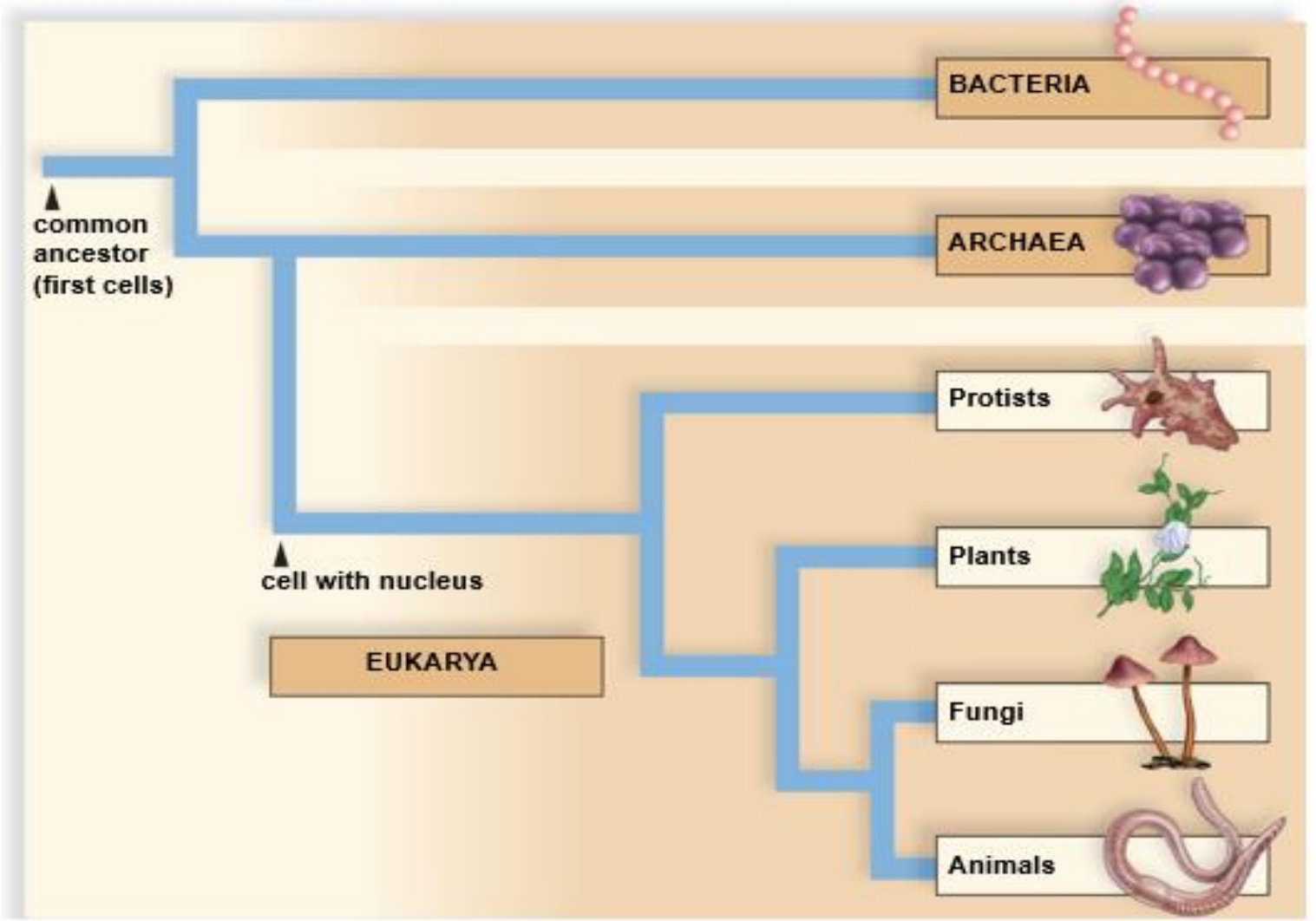
Evolutionary Tree of Life (4)



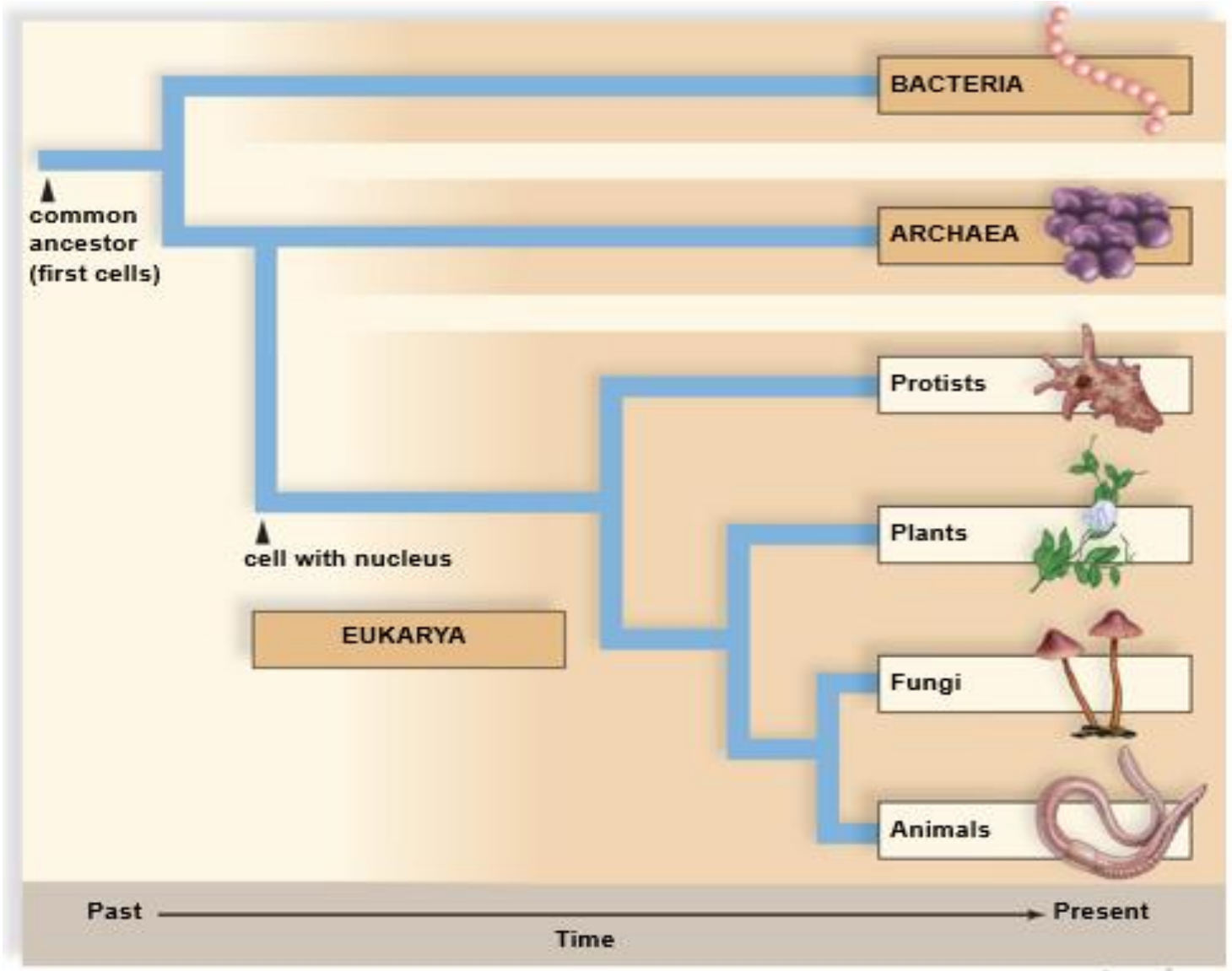
Evolutionary Tree of Life (5)



Evolutionary Tree of Life (6)



Evolutionary Tree of Life (7)



Jump to Evolutionary Tree of Life (7) Long Description

Organizing Diversity

Taxonomy is the discipline of biology that identifies, names, and classifies organisms according to certain rules.

Systematics is the study of evolutionary relationships between organisms.

Classification categories

- From least inclusive category (species) to most inclusive category (domain):
  - Species, genus, family, order, class, phylum, kingdom, and domain
  - Each successive category above species includes more types of organisms than the preceding one.

Levels of Classification

Table 1.1 Levels of Classification

Category	Human	Corn
Domain	Eukarya	Eukarya
Kingdom	Animalia	Plantae
Phylum	Chordata	Anthophyta
Class	Mammalia	Monocotyledones
Order	Primates	Commelinales
Family	Hominidae	Poaceae
Genus	Homo	*Zea*
Species*	H. *sapiens*	*Z. mays*

**To specify an organism, you must use the full binomial name, such as Homo sapiens.*

Domains

Domain Archaea

- Contains unicellular prokaryotes that live in extreme environments probably similar to the primitive earth
  - **Prokaryotes** lack a membrane-bound nucleus.

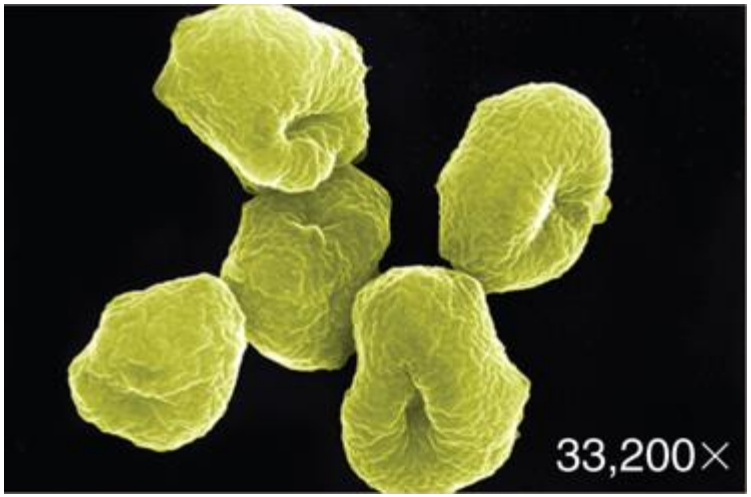
Domain Bacteria

- Contains unicellular prokaryotes that live in all environments including on our skin and in our mouths and intestines

Domain Eukarya

- Contains unicellular and multicellular eukaryotes
  - **Eukaryotes** contain a membrane-bound nucleus.

Domains Archaea



Sulfolobus, an archaean

- Prokaryotic cells of various shapes
- Adaptations to extreme environments
- Absorb or chemosynthesize food
- Unique chemical characteristics

Domain Bacteria

***Escherichia coli,* a bacterium**

Prokaryotic cells
of various shapes

Adaptations to
all environments

Absorb, photosynthesize,
or chemosynthesize food

Unique chemical
characteristics

Domain Eukarya

Domain Eukarya: Kingdom Protista

- Algae, protozoans, slime molds, and water molds
- Complex single cell (sometimes filaments, colonies, or even multicellular)
- Absorb, photosynthesize, or ingest food

Paramecium, a single-celled protozoan

Domain Eukarya: Kingdom Fungi

- Molds, mushrooms, yeasts, and ringworms
- Mostly multicellular filaments with specialized, complex cells
- Absorb food

Amanita, a mushroom

Domain Eukarya: Kingdom Plantae

- Certain algae, mosses, ferns, conifers, and flowering plants
- Multicellular, usually with specialized tissues, containing complex cells
- Photosynthesize food

Phalaenopsis, orchid, a flowering plant

Domain Eukarya: Kingdom Animalia

- Sponges, worms, insects, fishes, frogs, turtles, birds, and mammals
- Multicellular with specialized tissues containing complex cells
- Ingest food

Vulpes, a red fox

Kingdoms

Domain Archaea – kingdom designations are being determined

Domain Bacteria – kingdom designations are being determined

Domain Eukarya – kingdoms are designated, but new taxonomic supergroups are being determined

- **Protists** (composed of several kingdoms)
- **Kingdom Fungi**
- **Kingdom Plantae**
- **Kingdom Animalia**

Scientific Names

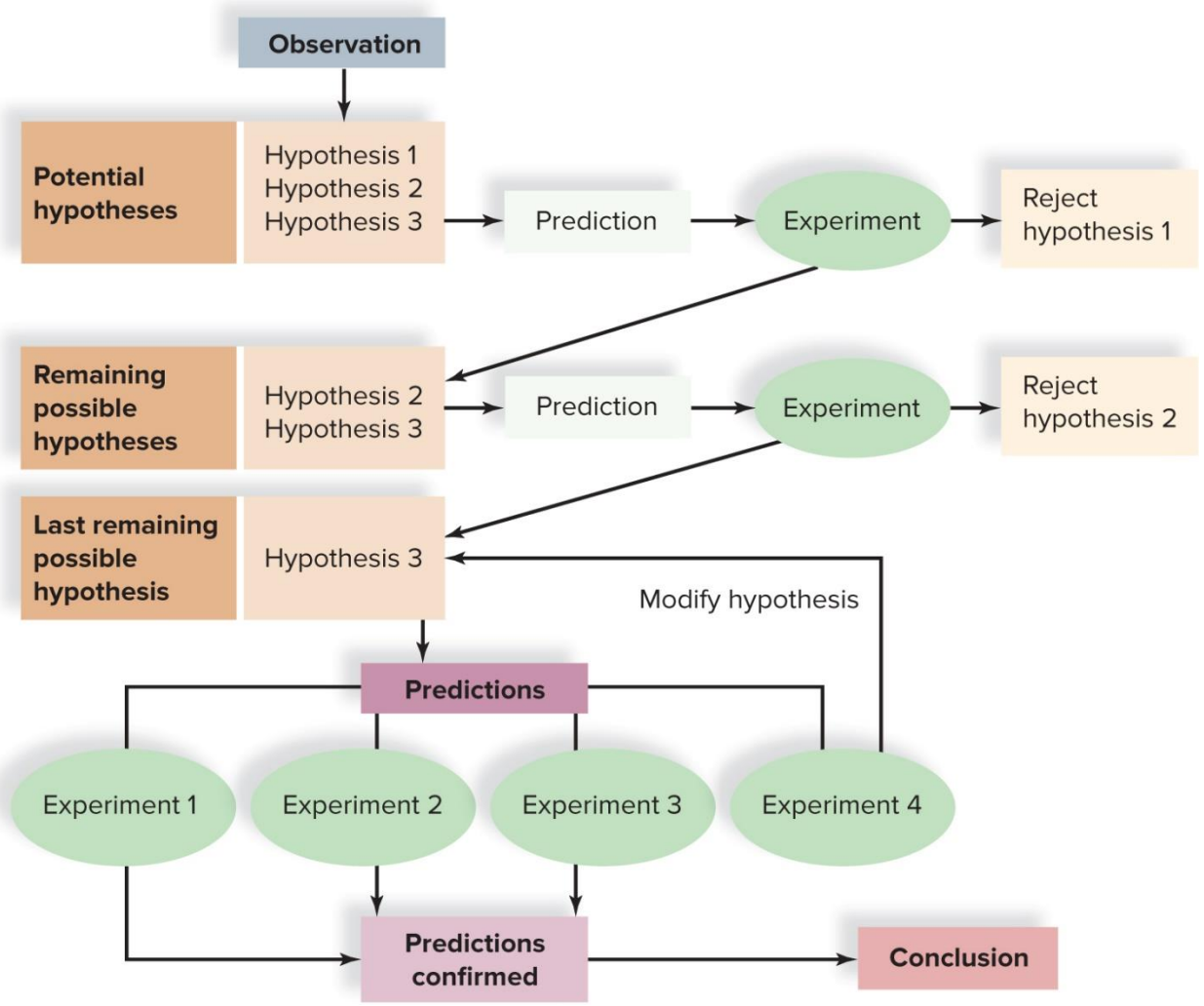
Universal

Latin-based

Binomial nomenclature

- Two-part name
- First word is the genus.
  - Always capitalized
- Second word is the species designation (or specific epithet).
  - Written in lowercase
- Both words are italicized.
- Examples: *Homo sapiens* (humans), *Zea mays* (corn)

1.3 The Process of Science (1)



Jump to 1.3 The Process of Science (1) Long Description

1.3 The Process of Science (2)

The **scientific method** is a standard series of steps used in gaining new knowledge through research.

- The scientific method can be divided into five steps:
  - **Observation**
  - **Hypothesis**
  - **Predictions and Experiments**
  - **Data Collection with Statistical Analysis**
  - **Conclusion**

The Scientific Method (1)

Observation

- Scientists use their senses to gather information about a **phenomenon** or natural event.

Hypothesis

- A **hypothesis** is a tentative explanation for what was observed.
  - An example is the discovery of the antibiotic penicillin.
- It is developed through inductive reasoning.
- It is testable.

The Scientific Method (2)

Predictions and Experiments

- An **experiment** is a series of procedures designed to test a hypothesis.
  - It utilizes deductive reasoning to make a **prediction** or expected outcome.
- The manner in which a scientist conducts an experiment is called the **experimental design**.
  - A good experimental design ensures that the scientist is examining the contribution of a specific factor, called the **experimental (independent) variable,** to the observation.
    - The experimental variable is the factor being tested.

The Scientific Method (3)

Experiments

- A **test group** is exposed to the experimental variable.
- A **control group** goes through all aspects of the experiment but is not exposed to the experimental variable.
- If the control and test groups show the same results, the hypothesis is not supported

Data

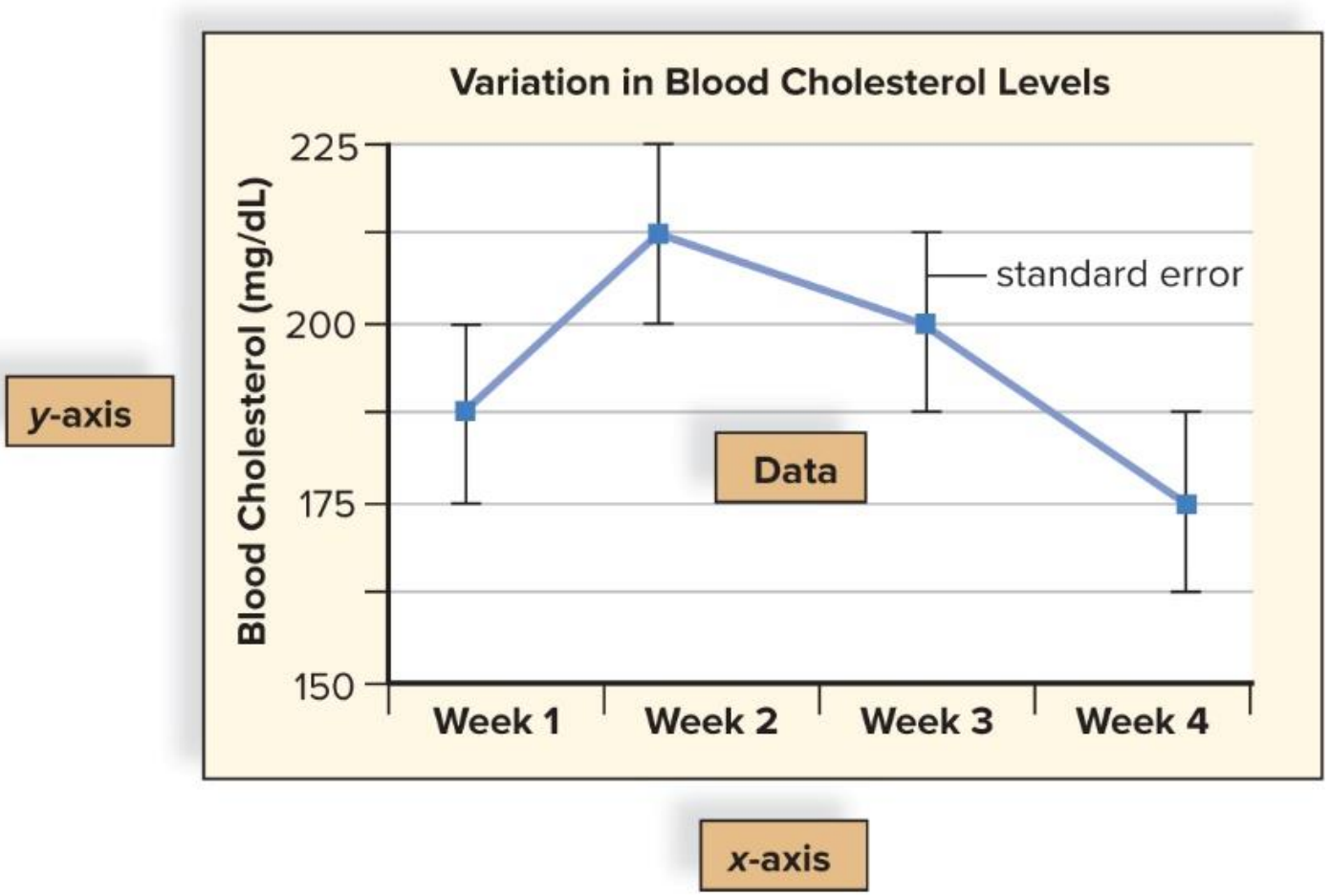
- The **data** are the results of an experiment.
  - Results should be observable and objective.

The Scientific Method (4)

Data

- Tables and graphs are two possible formats for data.
- Data are analyzed using statistics.
- Measures of variation
  - Standard error: How far off the average of the data is
- Statistical significance
  - Probability value (p)
    - Less than 5% is acceptable ($p<0.05$)
    - The lower the p value, the greater the confidence in the results
    - Not due to chance alone

The Scientific Method (5)



Jump to The Scientific Method (5) Long Description

The Scientific Method (6)

Conclusion

- The data are interpreted to determine whether the hypothesis is supported or not.
  - If prediction happens, hypothesis is supported.
  - If not, hypothesis is rejected.
- Findings are reported in scientific journals.
- Peers review the findings.
- Other scientists then attempt to duplicate or dismiss the published findings.

The Scientific Method (7)

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Jump to The Scientific Method (7) Long Description

Scientific Theory

Scientific Theory:

- Concepts that join together two or more well-supported and related hypotheses
- Supported by broad range of observations, experiments, and data

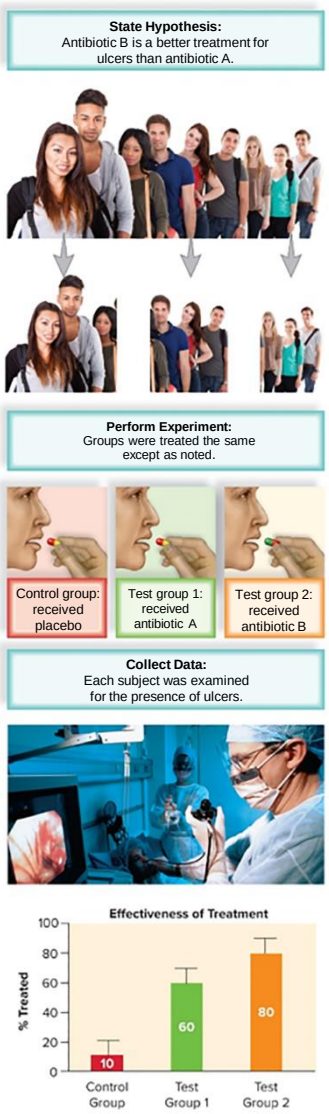
Scientific Principle / Law:

- Widely accepted set of theories
- No serious challenges to validity

Basic Theories of Biology (1)

Theory	*Concept*
Cell	All organisms are composed of cells, and new cells come only from preexisting cells.
Homeostasis	The internal environment of an organism stays relatively constant—within a range that is protective of life.
Evolution	All living organisms have a common ancestor, but each is adapted to a particular way of life.

Basic Theories of Biology (2)



(students): ©Andrey Popov/Shutterstock RF; (surgery): ©Phanie/Science Source

Jump to Basic Theories of Biology (2) Long Description

Experimental Design (1)

Hypothesis:

Newly discovered antibiotic B is a better treatment for ulcers than antibiotic A, in current use.

Experimental Design:

One control group includes subjects with ulcers who are untreated by antibiotics.

Two test groups are subjects with ulcers who are treated with either antibiotic A or B.

Experimental Design (2)

Results and Conclusion:

An endoscopy (a procedure that allows doctors to examine the linings of the throat, stomach, and upper small intestine to check for ulcers) is performed on all subjects.

The investigators then use statistics to determine the effectiveness of the various treatments.

On the basis of the data, the investigators conclude that their hypothesis has been supported.

1.4 Challenges Facing Science

Science is a systematic way of acquiring knowledge about the natural world.

Technology is the application of scientific knowledge to the interests of humans.

Examples: cell phone, new drug, others?

Biodiversity and Habitat Loss

Biodiversity is the total number and relative abundance of species, the variability of their genes, and the ecosystems in which they live.

- Estimated to be as high as 8.7 million species
  - Less than 2.3 million have been named and identified

Extinction is the death of the last member of a species or larger classification category.

- Estimated to be losing hundreds of species every year due to human activities

Biologically Diverse Ecosystems Are in Danger

Tropical rain forests and coral reef ecosystems are home to many organisms.

Both ecosystems are threatened by human activities.

The canopy of the tropical rain forest supports orchids, insects, and monkeys, among other organisms.

Coral reefs provide habitats for jellyfish, sponges, crabs, lobsters, sea turtles, moray eels, and fishes.

Destruction of Healthy Ecosystems Has Unintended Consequences

Humans depend upon healthy ecosystems for:

- Food
- Medicines
- Raw materials

Draining of wetlands of Mississippi and Ohio Rivers:

- Worsened flooding
- Ruined farmland

Destruction of South American rain forests:

- Killed species
- Decreased availability of lumber

Emerging Diseases

Over the past decade several new diseases have been in the news:

- H5N1
- H7N9
- SARS
- Ebola

Where do emerging diseases come from?

- New or increased exposure to insects or animals
- Changes in behavior
- Use of technology (Legionnaires' disease)
- Globalization
- Pathogens mutating and changing hosts (avian flu)

Climate Change

Changes in the normal cycles of the Earth's climate attributable to human activities

Due to imbalance in chemical cycling of carbon

- More carbon is being released than removed.
  - Burning of fossil fuels
  - Destruction of forests and replacement by farmland
- Increase in CO_2 causes temperature increases, called global warming.
  - Produced by greenhouse effect
  - Global warming is changing Earth's ecosystems.