

1 _ Exploring Life

Themes in the Study of Biology
Evolution, the Core Theme of Biology
The Process of Science

Key Concepts

- **What is life? How do you define life?**
- **Hierarchy of Life**
- **What is cell? Why is a cell called the functional unit of life?**
- **The 2 forms of cells**
- **Ecosystem – living & non-living factors**
- **Dynamics in an ecosystem**
- **The concept of evolution – Charles Darwin, unity and diversity, descent with modification, natural selection**
- **What is science?**
- **Discovery versus hypothesis-based science**
- **Quantitative vs qualitative data**
- **Inductive vs deductive reasoning**
- **The process of science**
- **Theory vs hypothesis**

All forms of life share common properties

- **Biology** is the scientific study of life
- Life properties are the characteristics shared by all living things
- Properties of life include:
 1. **Order**—the highly ordered structure that typifies life
 2. **Reproduction**—the ability of organisms to reproduce their own kind
 3. **Growth and development**—consistent growth and development controlled by inherited DNA
 4. **Energy processing**—the use of chemical energy to power an organism's activities and chemical reactions
 5. **Regulation**—an ability to control an organism's internal environment within limits that sustain life

6. **Response to the environment**—an ability to respond to environmental stimuli
7. **Evolutionary adaptation**—adaptations evolve over many generations, as individuals with traits best suited to their environments have greater reproductive success and pass their traits to offspring



(1) Order



(2) Reproduction



(3) Growth and development



(4) Energy processing



(5) Regulation



(6) Response to the environment



(7) Evolutionary adaptation

In life's hierarchy of organization, new properties emerge at each level

- **Biological organization** unfolds as follows (from the complex to simple):
 - **Biosphere**—all of the environments on Earth that support life
 - **Ecosystem**—all the organisms living in a particular area and the physical components with which the organisms interact
 - **Community**—the entire array of organisms living in a particular ecosystem
 - **Population**—all the individuals of a species living in a specific area
 - **Organism**—an individual living thing

- **Organ system**—several organs that cooperate in a specific function
- **Organ**—a structure that is composed of tissues
- **Tissue**—a group of similar cells that perform a specific function
- **Cell**—the fundamental unit of life
- **Organelle**—a membrane-enclosed structure that performs a specific function within a cell
- **Molecule**—a cluster of small chemical units called atoms held together by chemical bonds

Emergent properties are new properties that arise in each step upward in the hierarchy of life from the arrangement and interactions among component parts

Figure 1.2-0

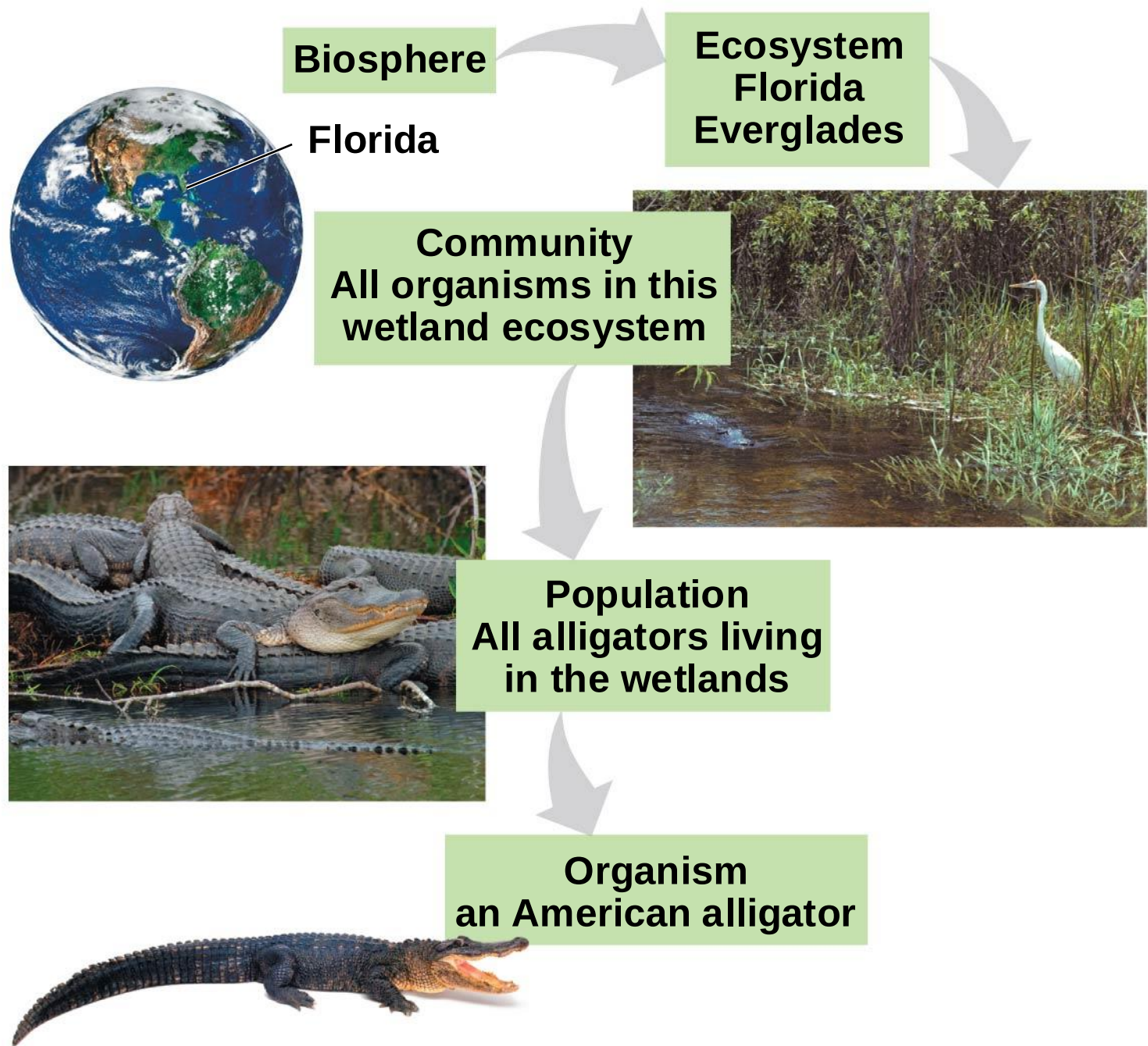
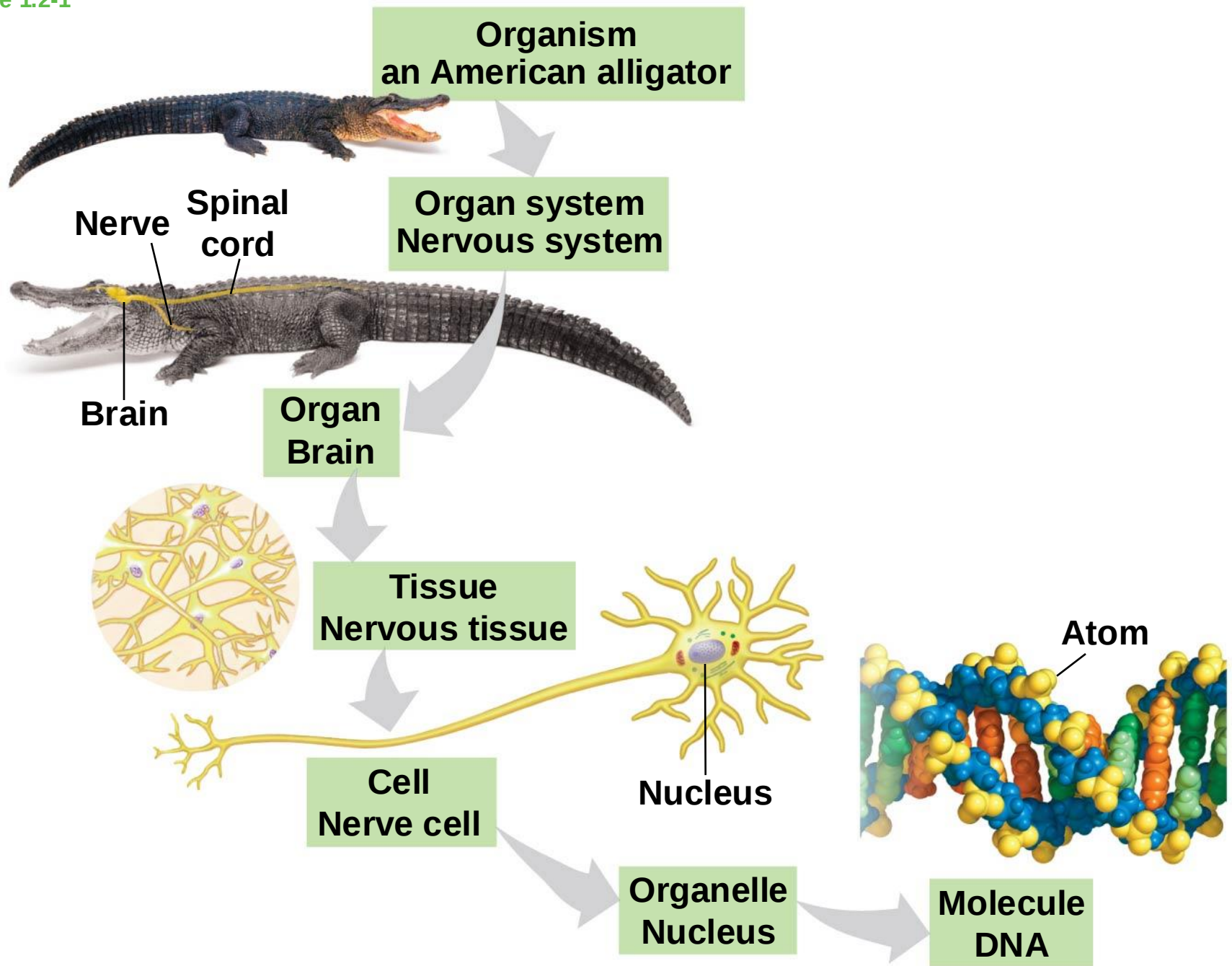


Figure 1.2-1



Cells are the structural and functional units of life

- **Cells** are the level at which the properties of life emerge – **basic unit of life**
- A cell can:
 - regulate its internal environment
 - take in and use energy
 - respond to its environment
 - develop and maintain its complex organization
 - give rise to new cells
- **All cells:**
 - are enclosed by a membrane that regulates the passage of materials between the cell and its surroundings
 - use DNA as their genetic information

Two basic forms of cells:

There are **two basic forms** of cells

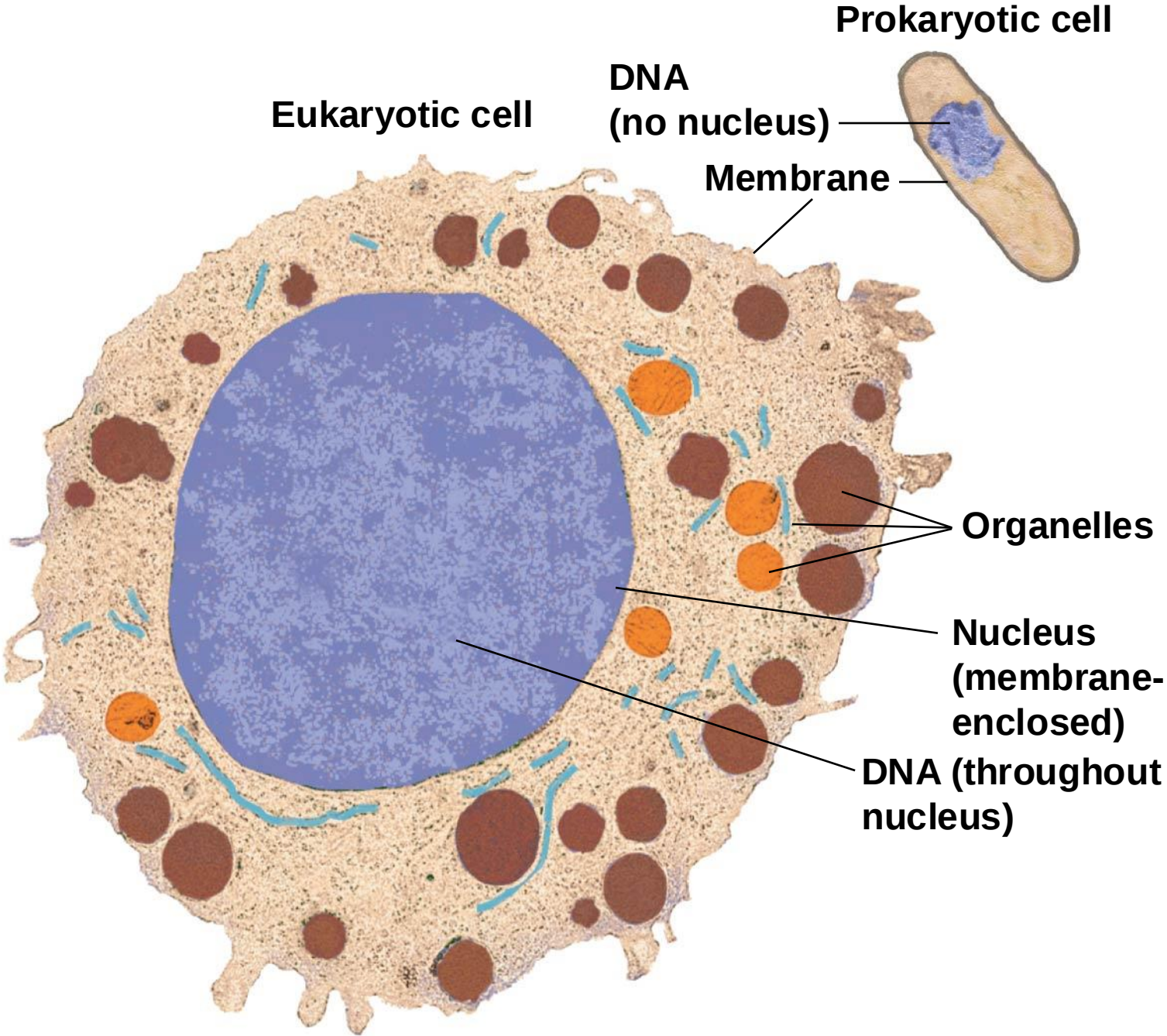
1. Prokaryotic cells

- were the first to evolve
- are found in bacteria and archaea
- are simpler
- are usually smaller than eukaryotic cells

2. Eukaryotic cells

- are found in plants, animals, fungi, and protists
- are subdivided by membranes into various functional compartments, or organelles, including a nucleus that houses the DNA

Figure 1.3



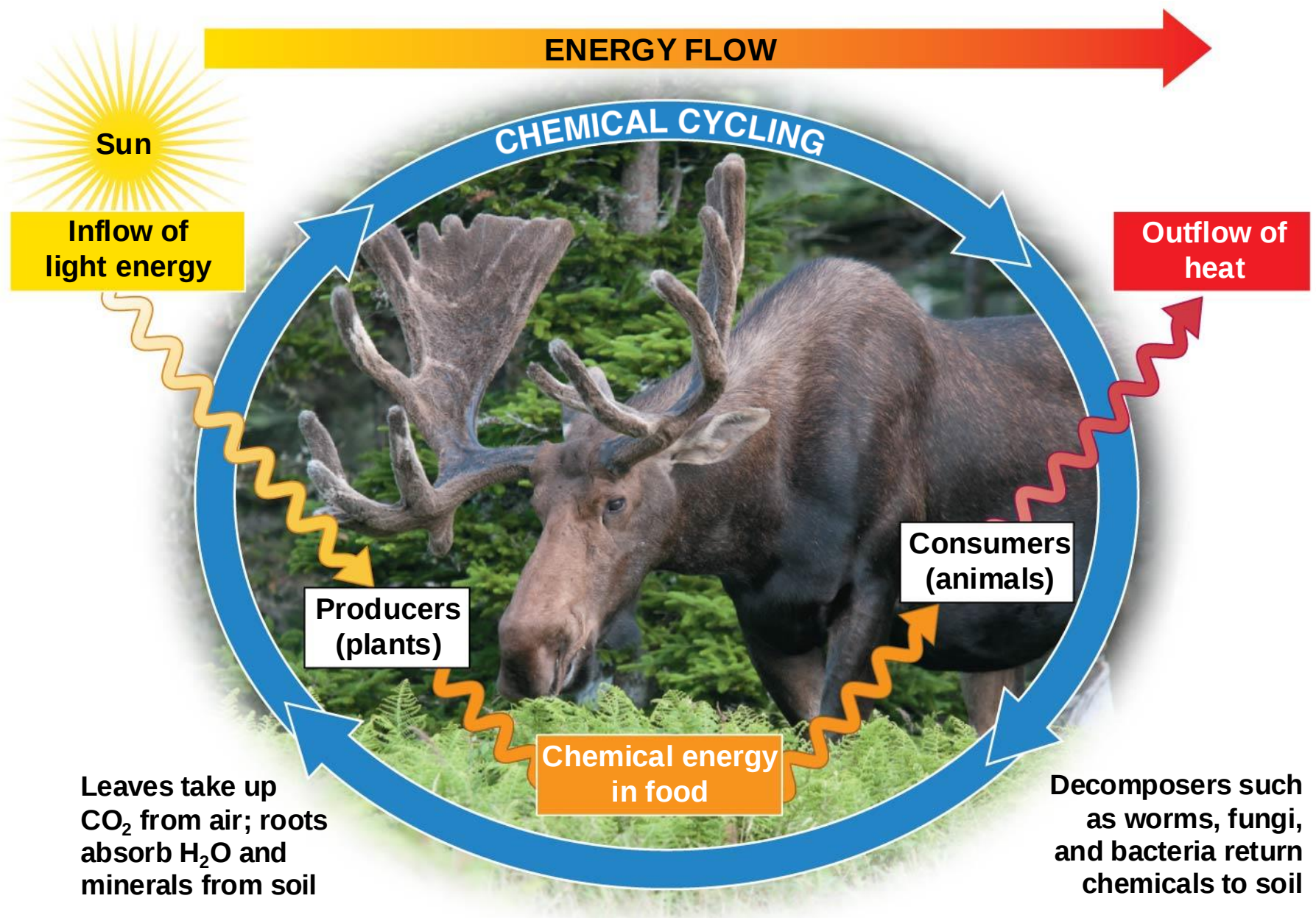
Organisms interact with their environment, exchanging matter and energy

- Living organisms interact with their environments, which include
 - other organisms
 - physical factors
- In most ecosystems,
 - plants are the “**producers**” that provide the food
 - animals are “**consumers**” that eat plants & other animals
 - “**decomposers**” act as recyclers, changing complex matter into simpler chemicals that plants can absorb and use

Dynamics of ecosystems

- The dynamics of ecosystems include **two major processes**:
 1. the **recycling of chemical nutrients** from the atmosphere and soil through producers, consumers, and decomposers back to the air and soil
 2. the **one-way flow of energy through an ecosystem**, entering as sunlight and exiting as heat

Figure 1.4



Evolution, the Core Theme of Biology

- **The Unity and Diversity of Life**
- **Natural Selection leads to Evolution**

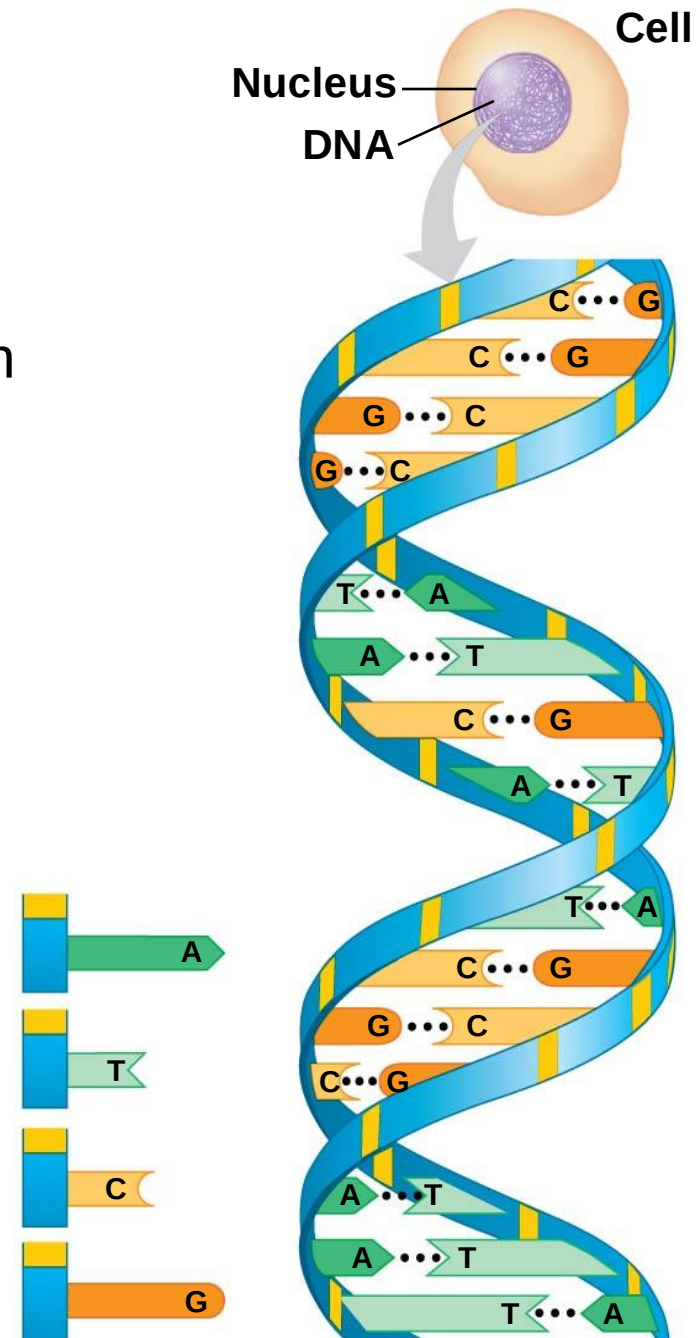
The unity of life is based on DNA and a common genetic code

- All cells have **DNA**, the chemical substance of genes

Genes:

- are the **unit of inheritance** that transmit information from parents to offspring
- are grouped into very long DNA molecules called chromosomes
- control the activities of a cell

- A species' genes are coded in the sequences of the four kinds of building blocks making up DNA's double helix.
 - All forms of life use essentially the same code to translate the information stored in DNA into proteins
 - **The diversity of life arises from differences in DNA sequences**
- The entire “library” of genetic instructions that an organism inherits is called its **genome**
- In recent years, scientists have determined the entire sequence of nucleotides in the human genome
(~ 3 billions base pairs)



Taxonomy – classification of diverse life form

Taxonomy is the branch of biology that

- names species
- classifies species into a hierarchy of broader groups: genus, family, order, class, phylum, and kingdom

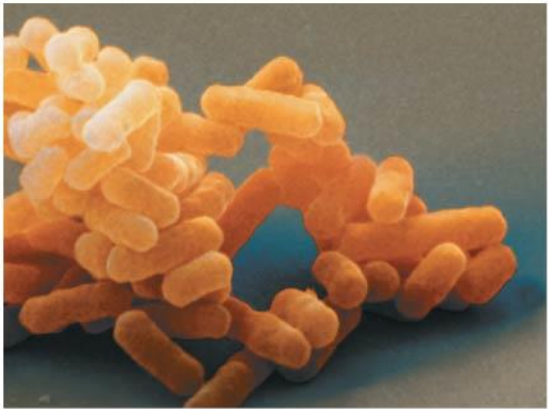
The members increase from the “genus” group to the “kingdom” group

The diversity of life can be arranged into three domains

- **The diversity of life** can be arranged into three higher levels called **domains**
 1. **Bacteria** are the most diverse and widespread prokaryotes
 2. **Archaea** are prokaryotes that often live in Earth's extreme environments
 3. **Eukarya** have eukaryotic cells and include
 - single-celled protists
 - multicellular fungi, animals, and plants.

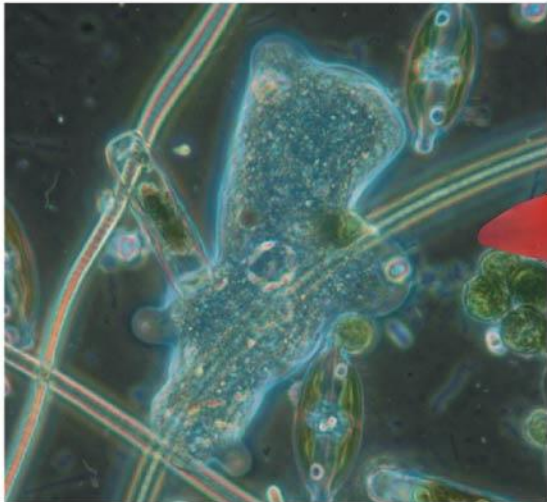
Figure 1.6

Domain Bacteria



Bacteria

Domain Eukarya



**Protists
(multiple kingdoms)**



Kingdom Plantae

Domain Archaea



Archaea



Kingdom Fungi



Kingdom Animalia

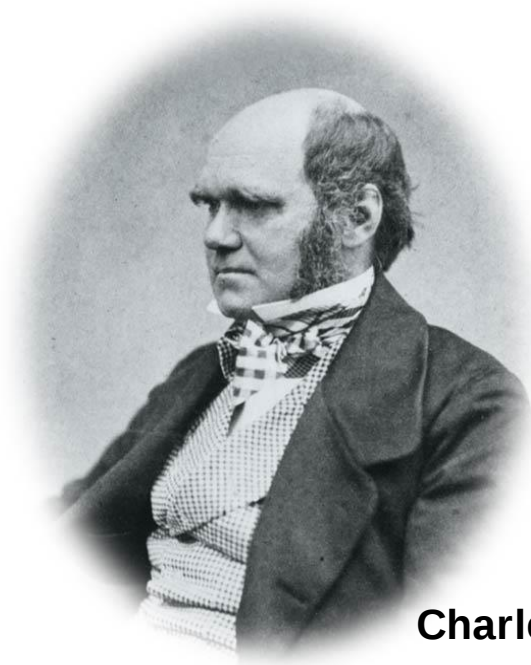
Evolution explains the unity and diversity of life

- **Evolution** can be defined as the process of change that has transformed life on Earth from its earliest beginnings to the diversity of organisms living today
- The fossil record tells us
 - ❑ that life has been evolving on Earth for billions of years
 - ❑ the pattern of ancestry



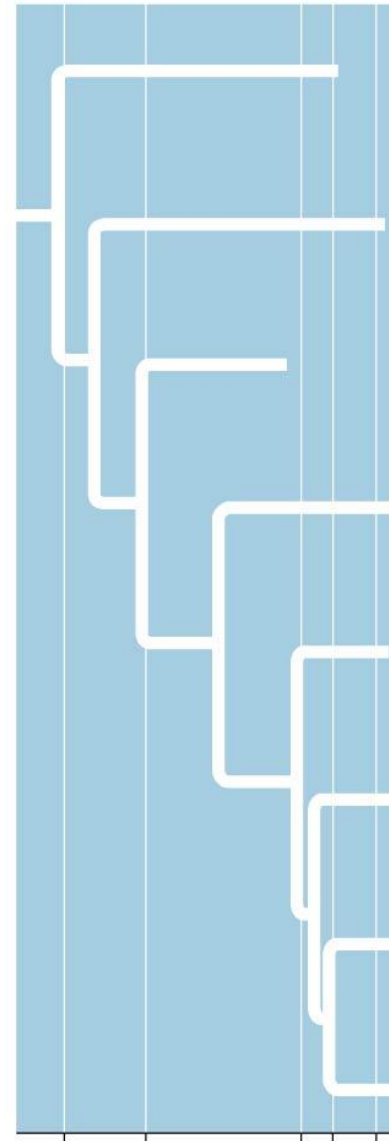
Excavation of fossilized mammoth bones

- In 1859, Charles Darwin published the book “*On the Origin of Species by Means of Natural Selection*”, which explained two main points:
 1. Species living today descended from ancestral species - “**descent with modification**”
 2. **Natural selection** is a mechanism for evolution



Charles Darwin in 1859

- Darwin realized that numerous small changes in populations as a result of natural selection could eventually lead to major alterations of species.
- The fossil record provides evidence of such diversification of species from ancestral species.



An evolutionary tree of elephants

The Process of Science

- Scientific Approaches
- Scientific Thinking

Scientific Approaches

- The word “**SCIENCE**” is derived from a Latin verb meaning “**to know**”
- Science is a way of knowing that stems from our curiosity about ourselves and the world around us
- Science is based upon inquiry, the search for information and explanations of natural phenomena
- Scientists typically
 - make observations
 - form **hypotheses** by proposing explanations for a set of observations, and test them

Scientists uses **two forms of inquiry**

1. Discovery Science which is mostly about **describing nature**

- Verifiable observations and measurements are the data of discovery science
- In biology, discovery science describe life at its many levels, from ecosystems down to cells and molecules

2. Hypothesis-based Science which is mostly about **explaining nature**

- The observations of discovery science stimulate us to seek natural causes and explanations for those observations

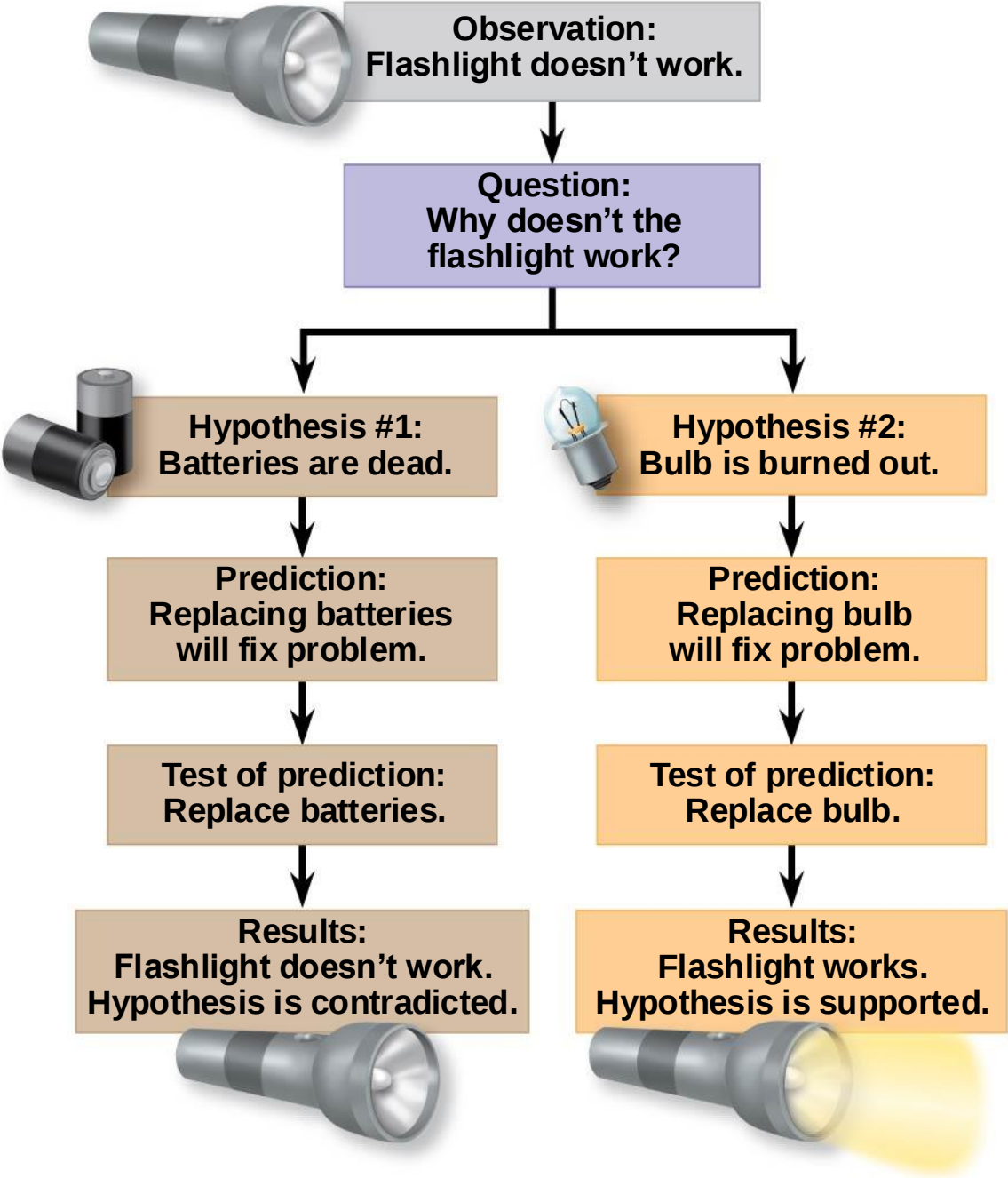
- **Two types of data** are frequently collected in scientific investigations
 1. **Qualitative** data is “descriptive”
 2. **Quantitative** data includes “numerical measurements”
- Scientists use **two types of reasoning**
 1. **Inductive reasoning** makes generalizations based on collecting and analyzing a large number of specific observations
 2. **Deductive reasoning** flows from general premises to predicted and specific results

In studying nature, scientists make observations, then form and test hypotheses

We solve everyday problems by using hypotheses

- A common example would be the reasoning we use to answer the question, “Why doesn’t a flashlight work?”
- Two reasonable hypotheses are that
 1. the batteries are dead
 2. the bulb is burned out

Figure 1.8 An everyday example of forming and testing hypotheses



- A **scientific theory** is
 - ☐ much broader in scope than a hypothesis
 - ☐ supported by a large and usually growing body of evidence
- Science is a social activity in which scientists
 - ☐ work in teams
 - ☐ share information through peer-reviewed publications, meetings, and personal communication
 - ☐ build on and confirm each other's work

- [SCIENCE 7: LEVELS OF BIOLOGICAL ORGANIZATIONS, THE SPECTRUM OF BIOLOGICAL ORGANIZATION – YouTube](#)
- [Evolution by Natural Selection - Darwin's Finches | Evolution | Biology | FuseSchool - YouTube](#)