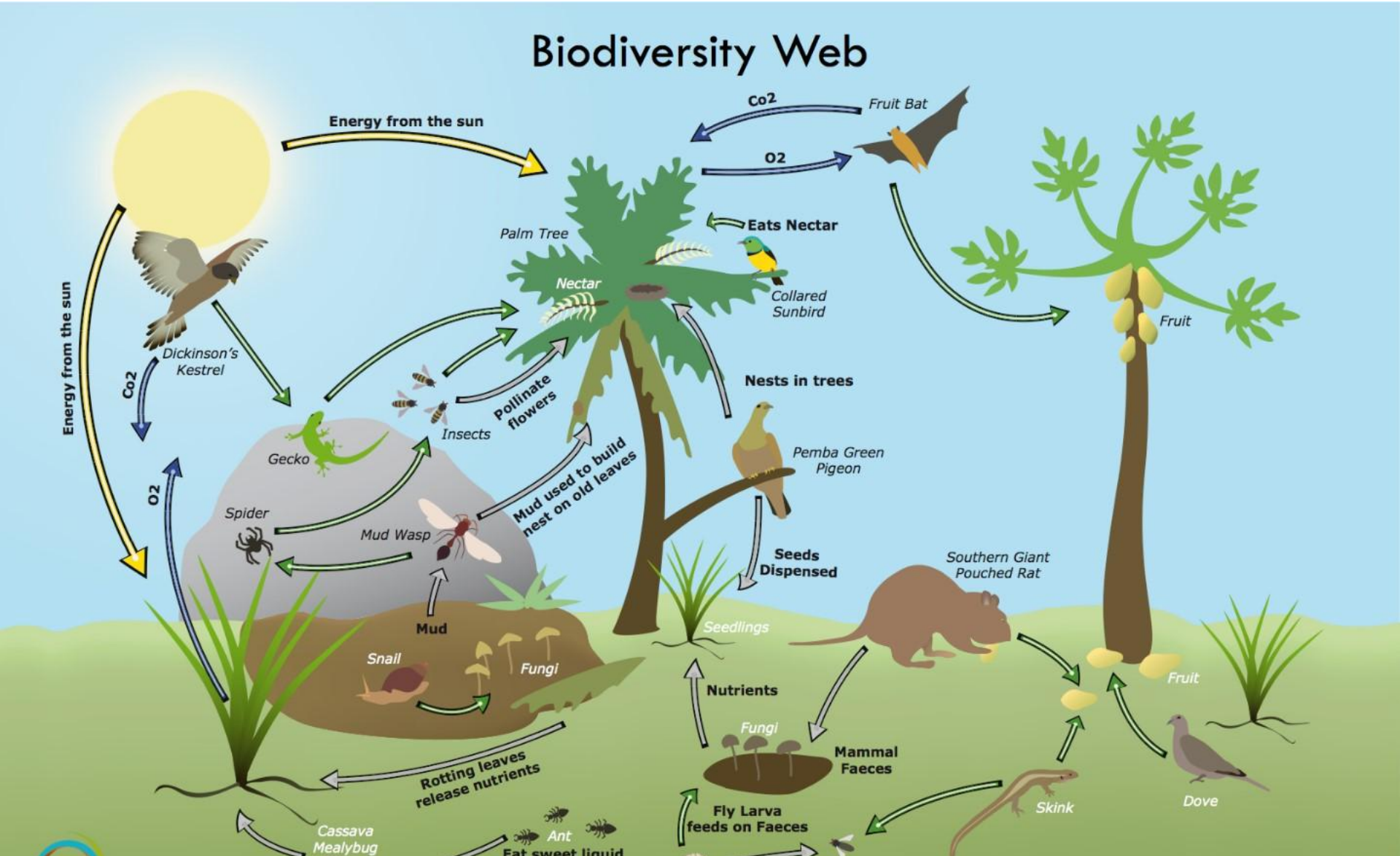
(1) Introduction: Themes in the Study of Life



Overview: Inquiring About Life

- * An organism's **adaptations** to its environment are the results of **evolution**

- Evolution is the process of change that has **transformed** life on earth

BIOLOGY

- The scientific study of life
- Biologists ask
  - How does a **single** cell develop into an organism?
  - How does the human **mind** work?
  - How do living things **interact** in communities?

1.1 All forms of life share common properties

- 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,

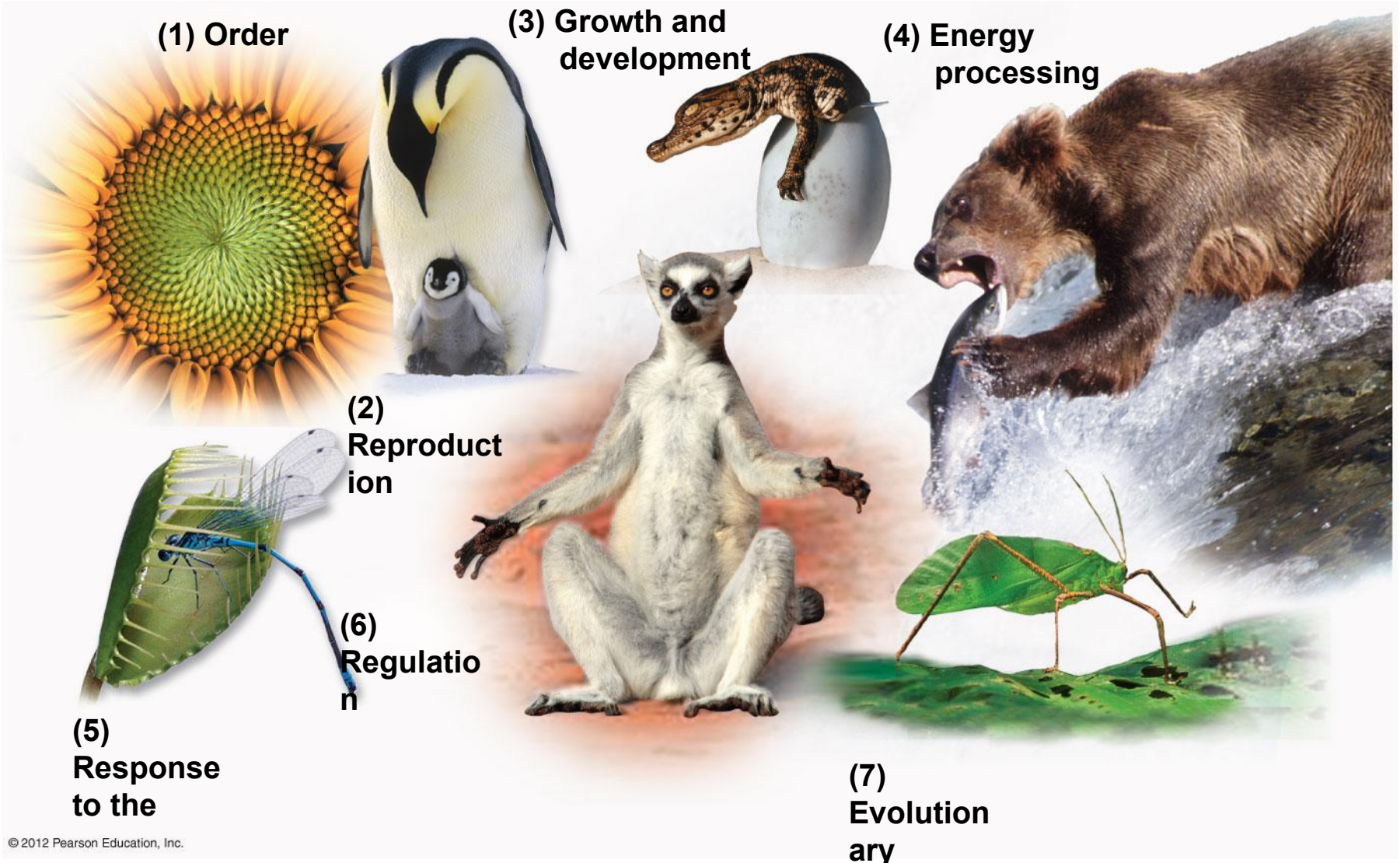
1.1 All forms of life share common properties

5. **Response to the environment**—an ability to **respond** to environmental stimuli,

6. **Regulation**—an ability to control an organism's **internal** environment within limits that sustain life, and

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.

Figure 1.1


(1) Order
(3) Growth and development
(4) Energy processing
(2) Reproduction
(6) Regulation
(5) Response to the environment
(7) Evolutionary adaptation
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New Properties Emerge at Each Level in the Biological Hierarchy

Life is studies at different levels

- **Molecules to Entire Living Planet**

► levels of *Biological Organizations*

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

- **Biological organization:**
  - ***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,**

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

- ***Organism***—an individual living thing,
- ***Organ system***—several organs that cooperate in a specific function,
- ***Organ***—a structure that is composed of tissues and that provides a specific function for the organism,
- ***Tissues***—a group of similar cells that perform a specific function,
- ***Cells***—the fundamental unit of life,

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

- ***Organelle***—a membrane-bound structure that performs a specific function in a cell, and
- ***Molecule***—a cluster of small chemical units called atoms held together by chemical bonds.

Figure 1.2

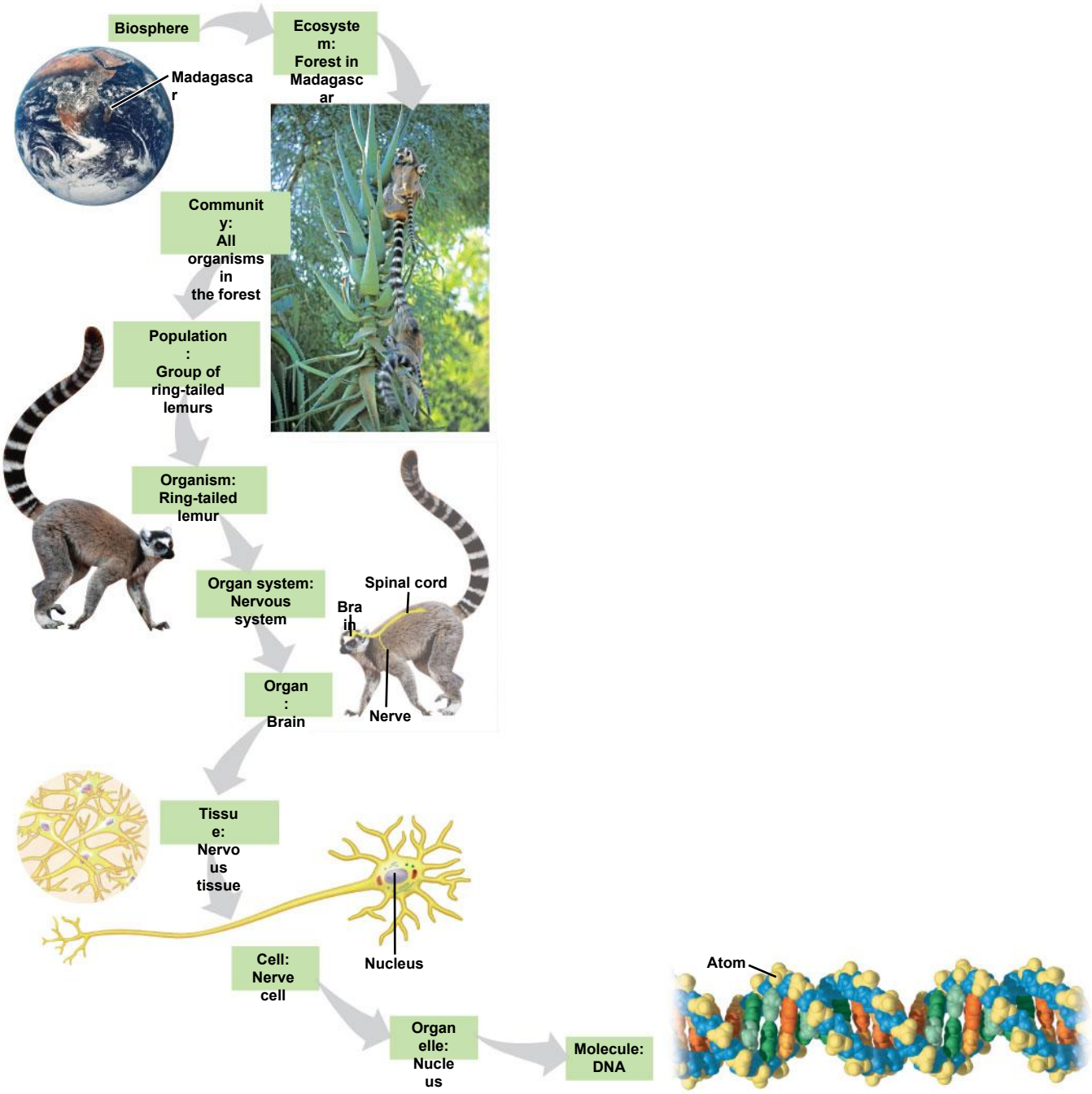

Figure 1.2_1

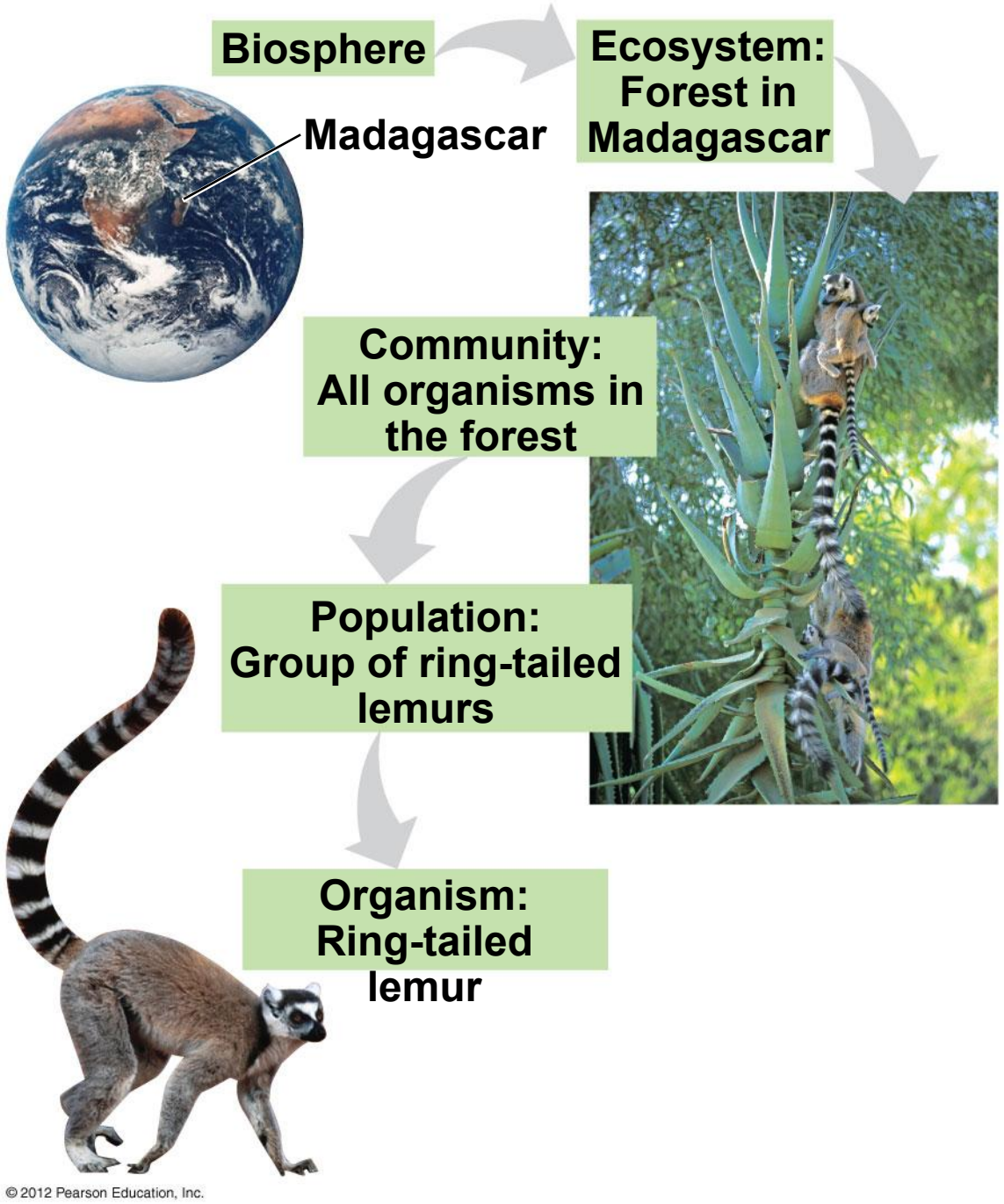
Biosphere
Madagascar
Ecosystem: Forest in Madagascar
Community: All organisms in the forest
Population: Group of ring-tailed lemurs
Organism: Ring-tailed lemur
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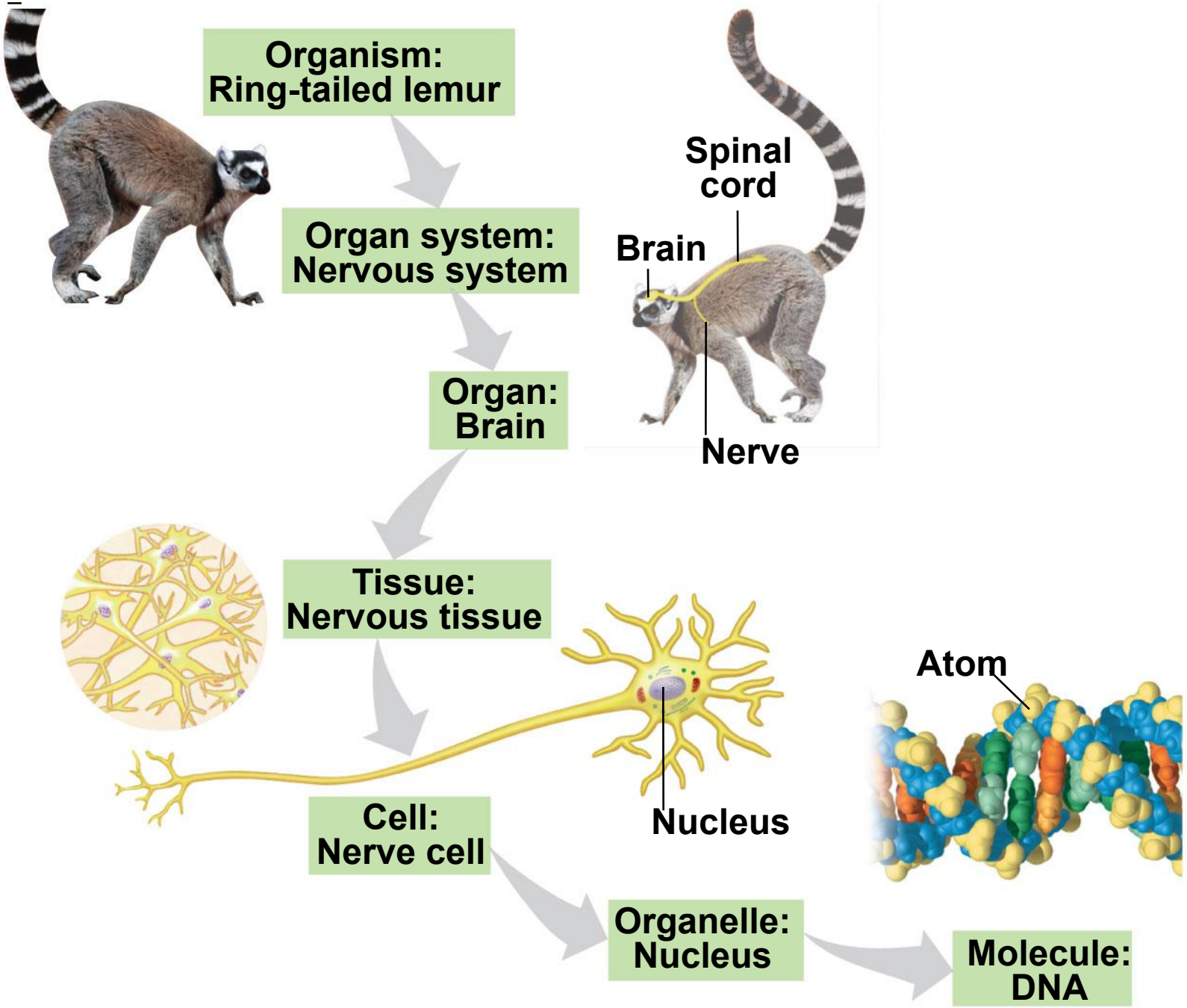
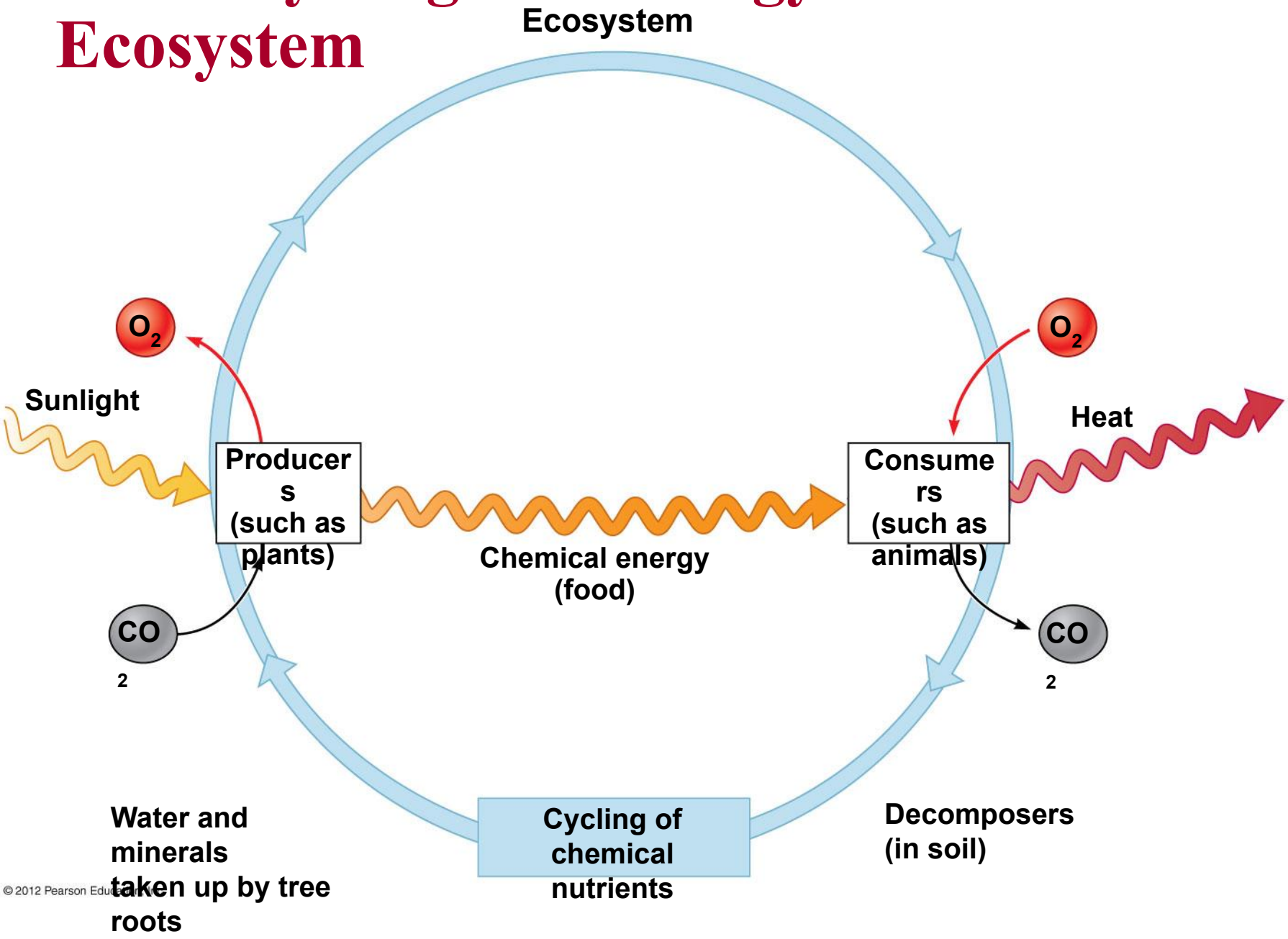
Figure 1.2_2



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

- **Emergent properties are**
  - **new properties that arise in each step upward in the hierarchy of life,**
  - **result from the arrangement and *interactions* of parts within a system**

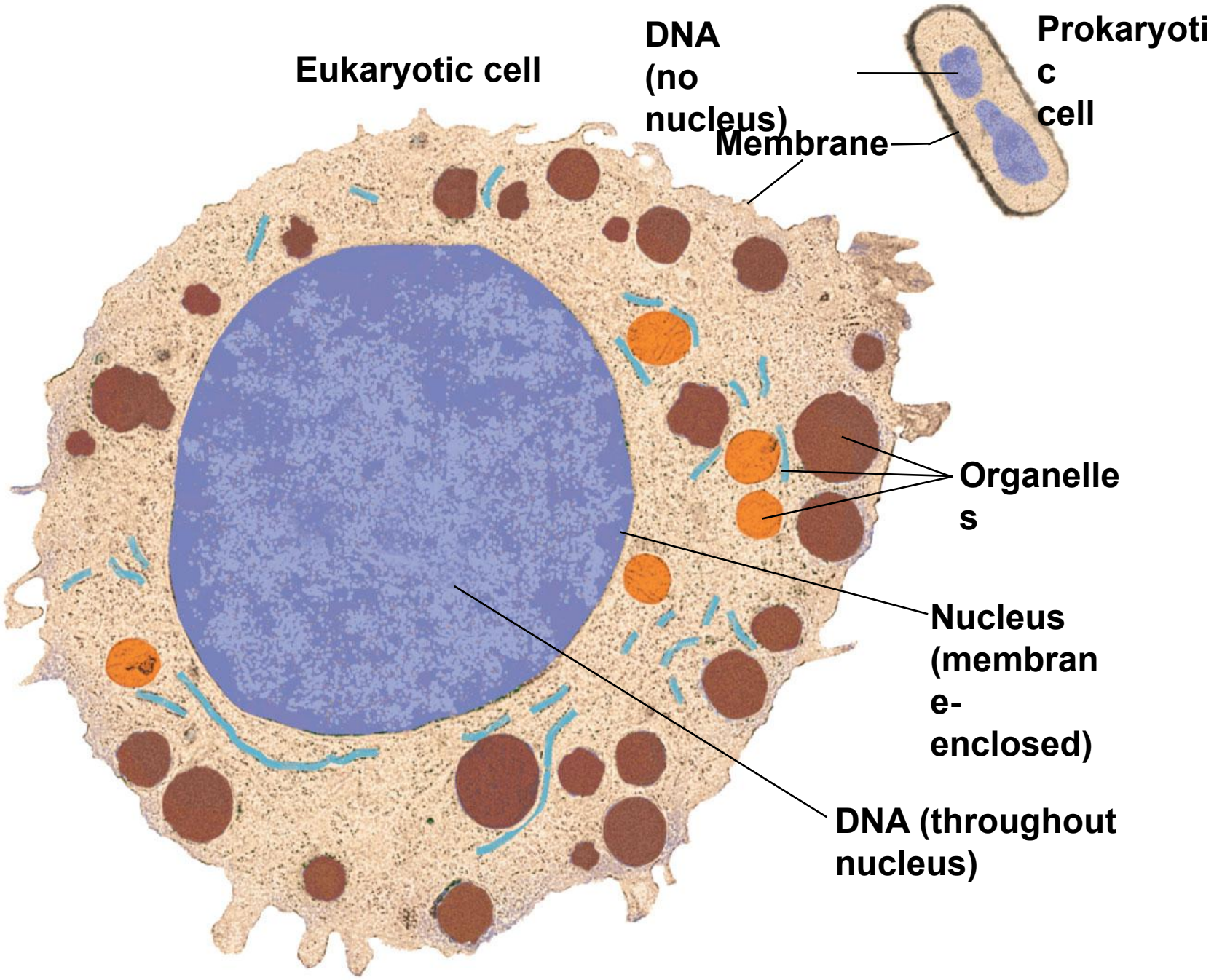
Nutrient Cycling and Energy Flow in an Ecosystem



Cells are the structural and functional units of life

- ***Systems biology*** **models the complex interactions of biological systems, ranging**
  - **from the functioning of the biosphere**
  - **to the complex molecular machinery of a cell.**

Figure 1.3



1.3 Cells are the structural and functional units of life

Structure is related to function at all levels of biological organization

Two basic types of cells

1. ***Prokaryotic cells***

   - **first to evolve,**
   - **are simpler, and are usually smaller.**

2. ***Eukaryotic cells***

   - **contain membrane-enclosed organelles, including a nucleus containing DNA, and**
   - **found in plants, animals, and fungi.**

Life Requires Energy Transfer and Transformation

Light Energy ► Chemical Energy ► Kinetic Energy

((Energy flows through an Ecosystem (*entering as light* and *exiting as heat*)))

Humans have modified our environment

Human activities ► higher levels of

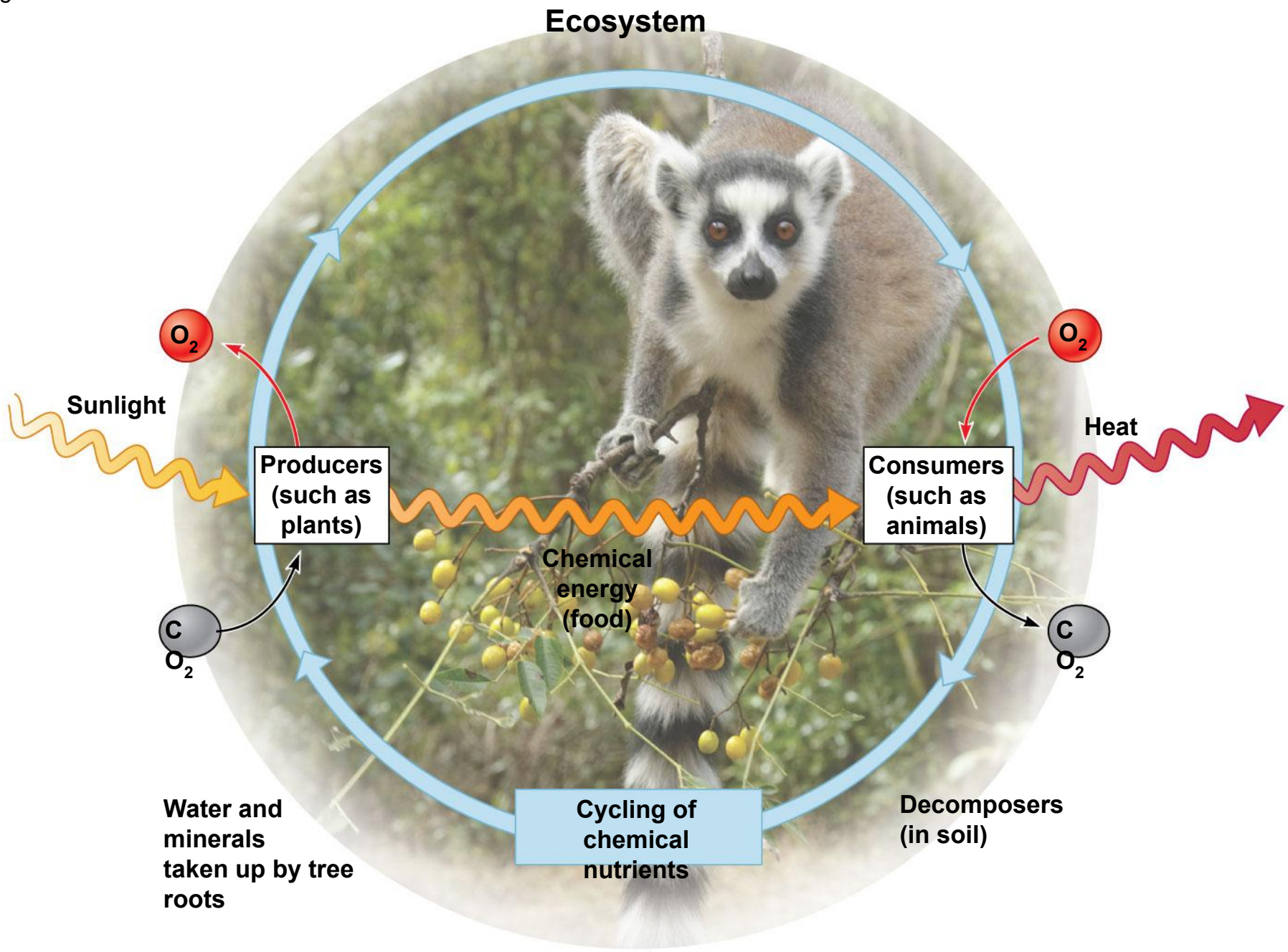
CO_2 in the atmosphere ► GLOBAL

warming ► Global Climate Change

Living organisms interact with their environment, exchanging matter and energy

- In most ecosystems
  - plants are the ***producers*** that provide the food,
  - ***consumers*** eat plants and other animals, and
  - ***decomposers*** act as recyclers, changing complex matter into simpler mineral nutrients.

Figure 1.4



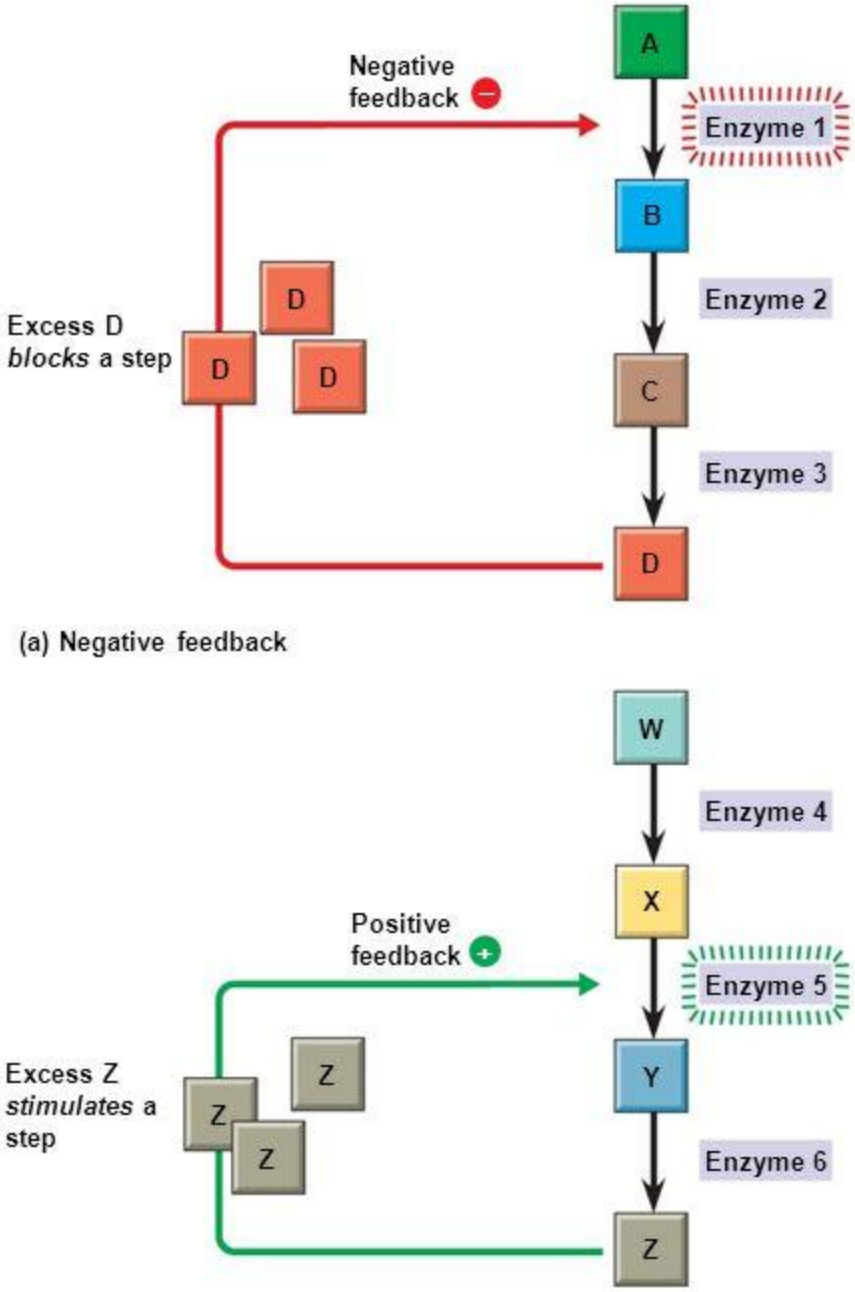
Feedback Mechanisms Regulate Biological Systems

- **Allow Biological Systems to <u>self-regulate</u>**

- **<u>Negative feedback:</u> as more of a product accumulate, the process that creates it slows**

- **<u>Positive feedback:</u> more product, the process speeds up**

Fig. 1-13



(a) Negative feedback

(b) Positive feedback

EVOLUTION

THE CORE THEME OF BIOLOGY

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

* All cells have DNA

** Gene

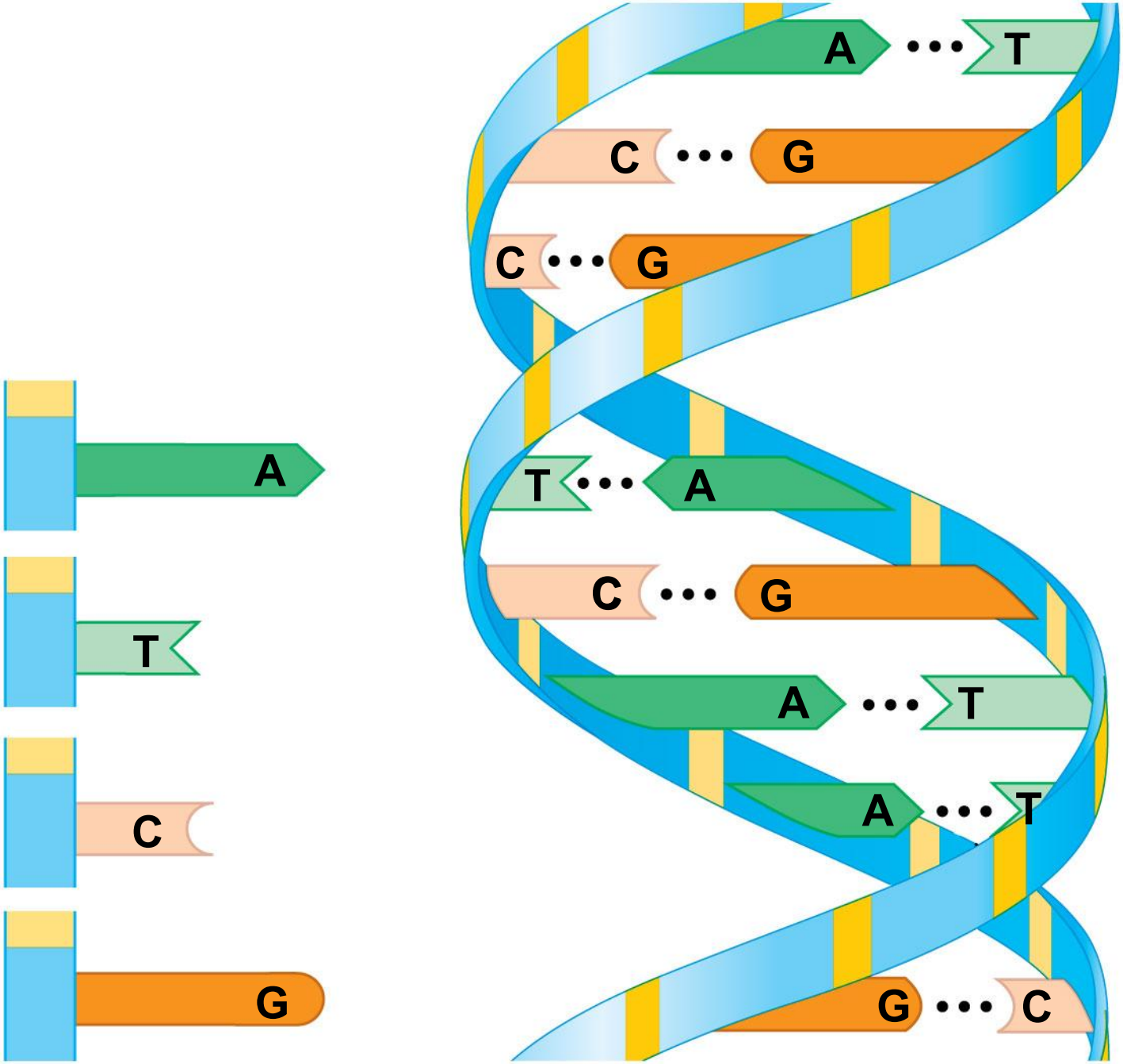
- unit of inheritance
- DNA molecules (chromosomes) have large number of genes

– control the activities of a cell.

- All forms of life use essentially the same code (four building blocks) to translate the information stored in DNA into proteins.

- The diversity of life arises from differences in DNA sequences.

Figure 1.5



- **Diversity is the hallmark of life.**
  - **Biologists have identified about 1.8 million species.**
  - **Estimates of the actual number of species ranges from 10 to 100 million.**

-Taxonomy names species and classifies them into a system of broader groups.

Domains of Life

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 (e.g. multicellular fungi, animals, and plants).

Figure 1.6

Domain Bacteria

Bacteria

Domain Archaea

Archaea

Domain Eukarya

Protists
(multiple kingdoms)

Kingdom Plantae

Kingdom Fungi

Kingdom
Animalia

Evolution explains the unity and diversity of life

- The history of life, as documented by fossils, is a saga of a changing Earth
  - billions of years old and
  - inhabited by an evolving cast of life forms.

- Evolution accounts for life's dual nature of
  - ***Kinship (relatedness) and diversity.***

Evolution explains the unity and diversity of life

- In 1859, Charles Darwin published the book *On the Origin of Species by Means of Natural Selection,* which articulated two main points.

1. A large amount of evidence supports the idea of evolution, that species living today are descendants of ancestral species in what Darwin called "***descent with modification***"

2. ***Natural selection*** is a mechanism for evolution.

Natural selection

1. Individuals in a population vary in their traits, many of which are passed on from parents to offspring.

2. A population can produce far more offspring than the environment can support.

Figure 1.7C

1 Population with varied inherited traits

2 Elimination of individuals with certain traits

3 Reproduction of survivors

Evolution explains the unity and diversity of life

- Darwin inferred that
  - those individuals with heritable traits best suited to the environment are more likely to survive and reproduce than less well-suited individuals,

Evolution explains the unity and diversity of life

- **Darwin inferred that**
  - **as a result of this *unequal reproductive success over many generations*, an increasing proportion of individuals will have the advantageous traits, and**

Evolution explains the unity and diversity of life

- Darwin inferred that
  - the ***result will be evolutionary adaptation, the accumulation of favorable traits*** in a population over time.

Figure 1.UN01