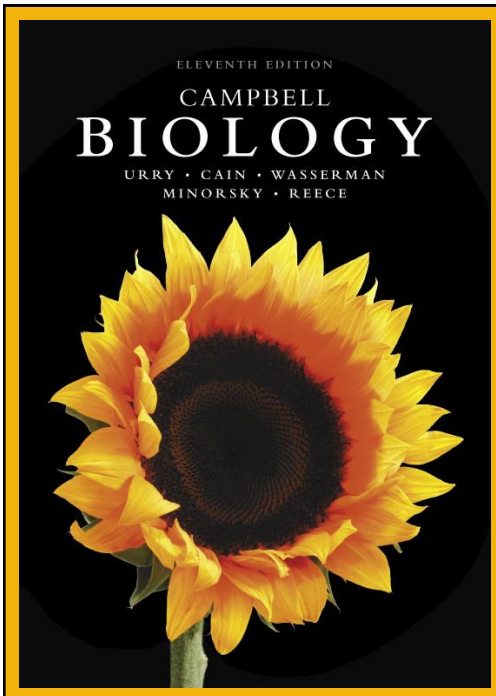

Chapter 1

Evolution, the Themes of Biology, and Scientific Inquiry

Lecture Presentations by
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Inquiring About Life

- An organism's adaptations to its environment are the result of **evolution**
  - For example, the color of the beach mouse has come to be well matched, or **adapted**, to its local background
- ***Evolution is the process of change that has transformed life on Earth***

An inland mouse of the species *Peromyscus polionotus*

- **Biology** is the scientific study of life
- Biologists ask questions, such as: How does a single cell develop into an organism?
- Biology is an ongoing **inquiry** about the nature of life
- Life does not have *a simple, one-sentence definition*
- Life is recognized by **what living things do**

- *Some properties of life are as follows:*

Characteristics of living organisms

Figure 1.2a

Order

Figure 1.2b

Evolutionary adaptation

Figure 1.2c

Regulation

Figure 1.2d

Reproduction

Figure 1.2e

Response to the environment

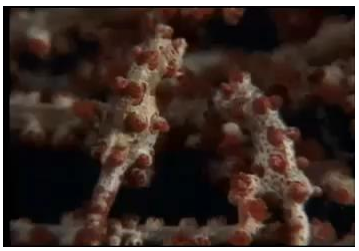
Figure 1.2f

Growth and development

Figure 1.2g

Energy processing

Video: Seahorse Camouflage



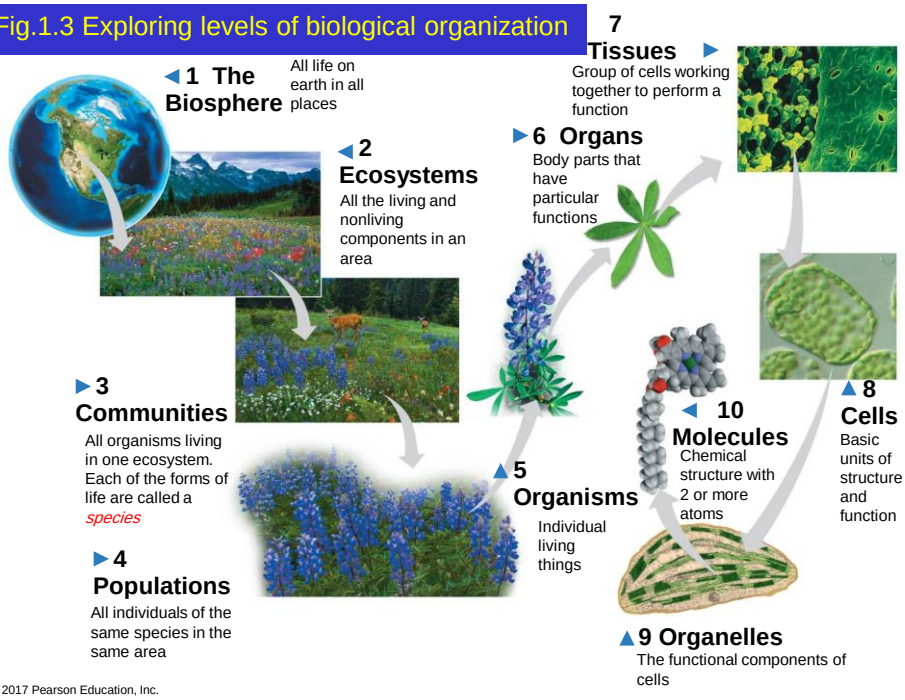
Concept 1.1: The study of life reveals unifying themes

- Biology is a *very large* subject
- Memorizing facts is not the way to learn it
- There are five general **unifying themes**
  - Organization
  - Information
  - Energy and Matter
  - Interactions
  - Evolution

Theme: New Properties Emerge at Successive Levels of Biological Organization

- Life can be studied at different levels, from molecules to the entire living planet
- This very large range **can be divided into different levels of biological organization**

Fig.1.3 Exploring levels of biological organization



Emergent Properties

- **Emergent properties** result from the arrangement and interaction of parts within a system
- Emergent properties characterize non-biological entities as well
  - For example, a functioning bicycle emerges only when all of the necessary parts connect in the correct way
  - Table salt (NaCl) is made from toxic components (Na + Cl)

Structure and Function

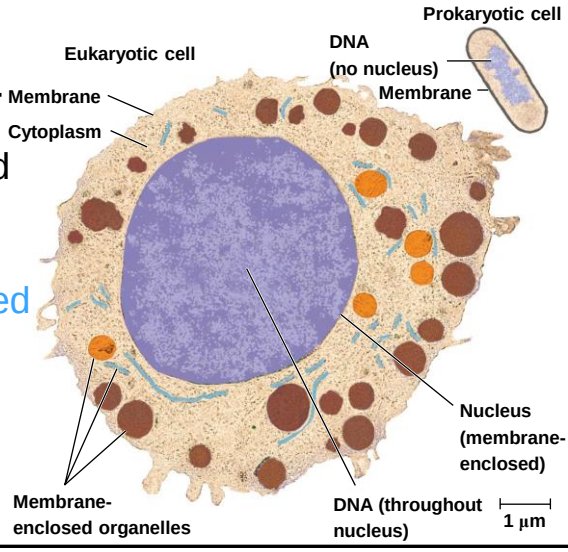
- At each level of the **biological hierarchy** we find a correlation between structure and function
- Analyzing a biological structure gives us clues about what it does and how it works
- Also, knowing the function of something may give indications of its structure and organization

The Cell: An Organism's Basic Unit of Structure and Function

- The cell is the **smallest unit of organization** that can **perform all activities required for life**
- Every cell is enclosed by a **membrane** that regulates passage of materials between the cell and its environment
- The cells of bacteria and archaea are ***prokaryotic***, while all other forms of life are composed of ***eukaryotic*** cells

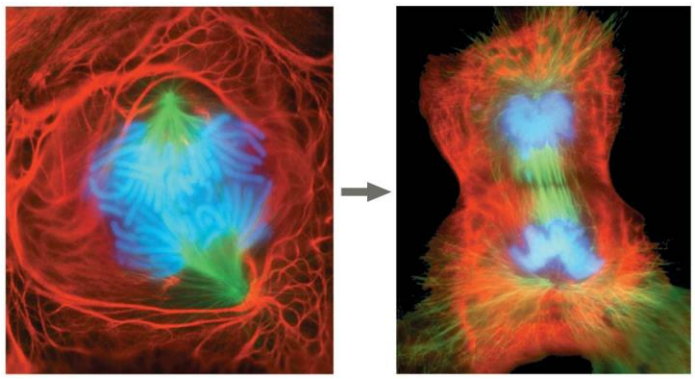
- A **eukaryotic cell** has membrane-enclosed **organelles**, the largest of which is usually the **nucleus**

- A **prokaryotic cell** is simpler and usually smaller and does not contain a nucleus or other membrane-enclosed organelles



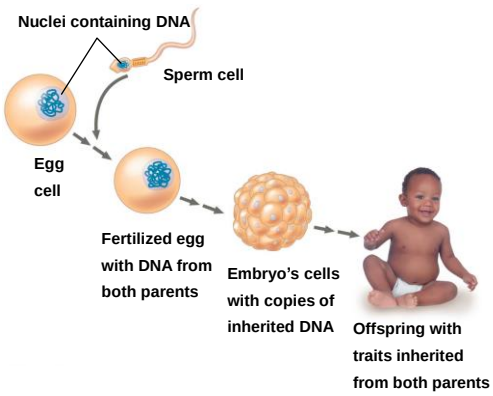
Theme: Life's Processes Involve the Expression and Transmission of Genetic Information

- Within cells, structures called **chromosomes** contain **genetic material** in the form of **DNA (deoxyribonucleic acid)**



DNA, the Genetic Material

- Each chromosome contains one long DNA molecule with hundreds or thousands of genes
- **Genes** are the *units of inheritance*
- They encode information for building the molecules synthesized within the cell
- The genetic information encoded by DNA directs the development of an organism



- The molecular structure of DNA accounts for its ability to store information
- Each DNA molecule is made up of **two long chains arranged in a double helix**
- Each chain is made up of four kinds of chemical building blocks called **nucleotides** (A, G, C, and T)
- The sequence of nucleotides has the information for making a protein
- DNA is **transcribed** into **RNA**, which is then **translated** into a **protein**
- **Gene expression** is the process of converting information from gene to cellular product

Figure 1.7

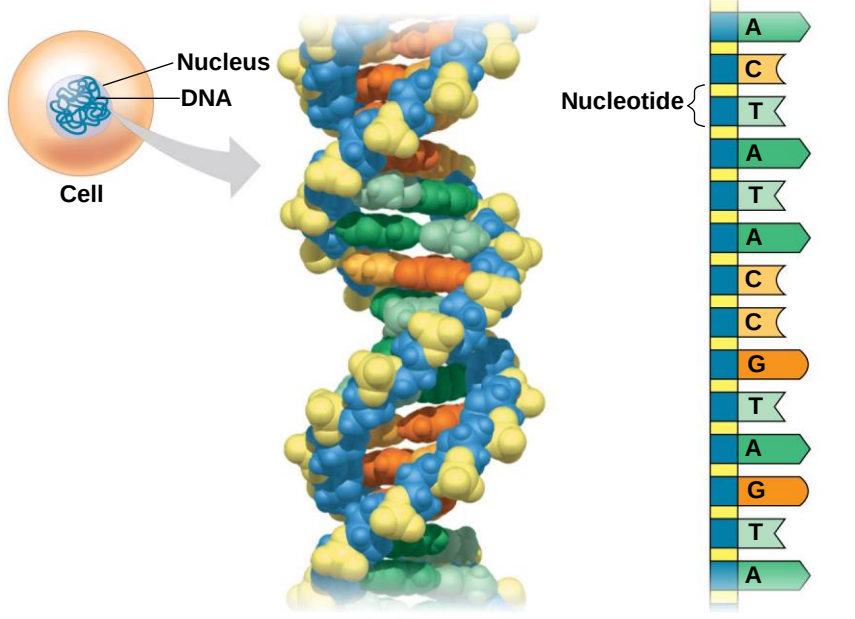
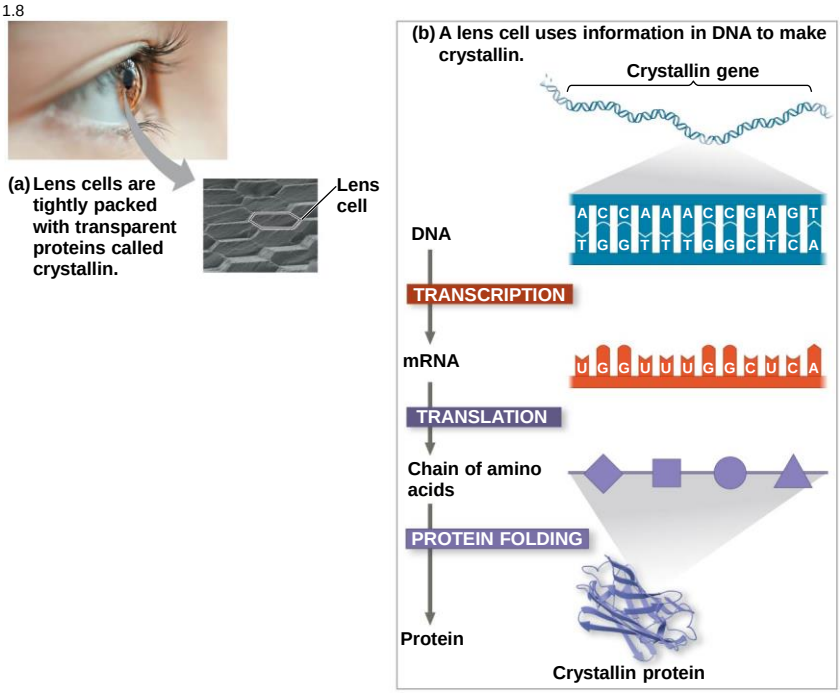


Figure 1.8



Genomics: Large-Scale Analysis of DNA Sequences

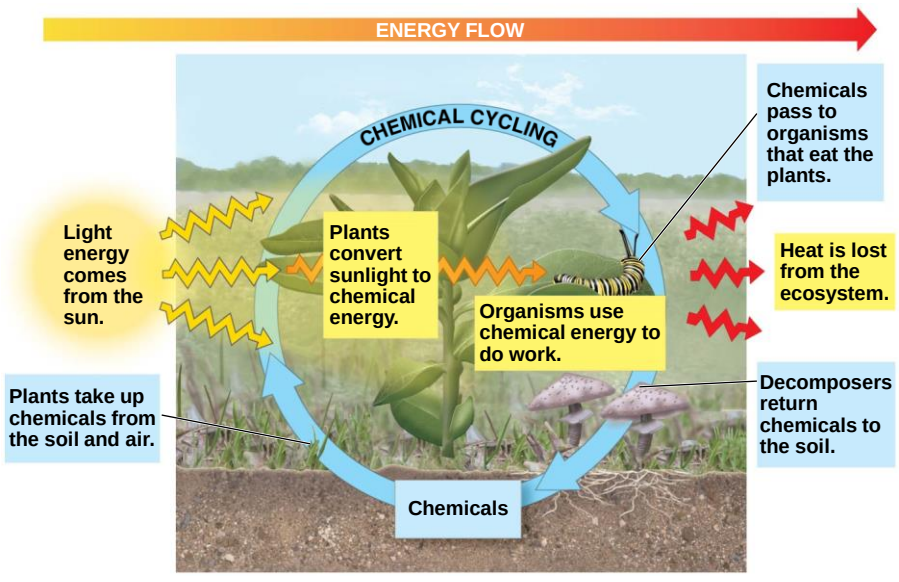
- An organism's **genome** is its entire "library" of genetic instructions
- **Genomics** is the study of sets of genes in one or more species
- **Proteomics** is the study of whole sets of proteins and their properties
- The entire set of proteins expressed by a given cell, tissue, or organ is called a **proteome**

- The genomics approach depends on
  - "High-throughput" technology, which yields very large amounts of **data**
  - ***Bioinformatics***, which is the use of *computational* tools to process a large volume of data
  - ***Interdisciplinary research teams***, especially computer scientists, physicists and biologists

Theme: Life Requires the Transfer and Transformation of Energy and Matter

- The input of energy from the sun and the transformation of energy from one form to another make life possible
- The chemical energy generated by plants and other photosynthetic organisms (**producers**) is passed along to consumers
- **Consumers** are organisms that feed on other organisms or their remains

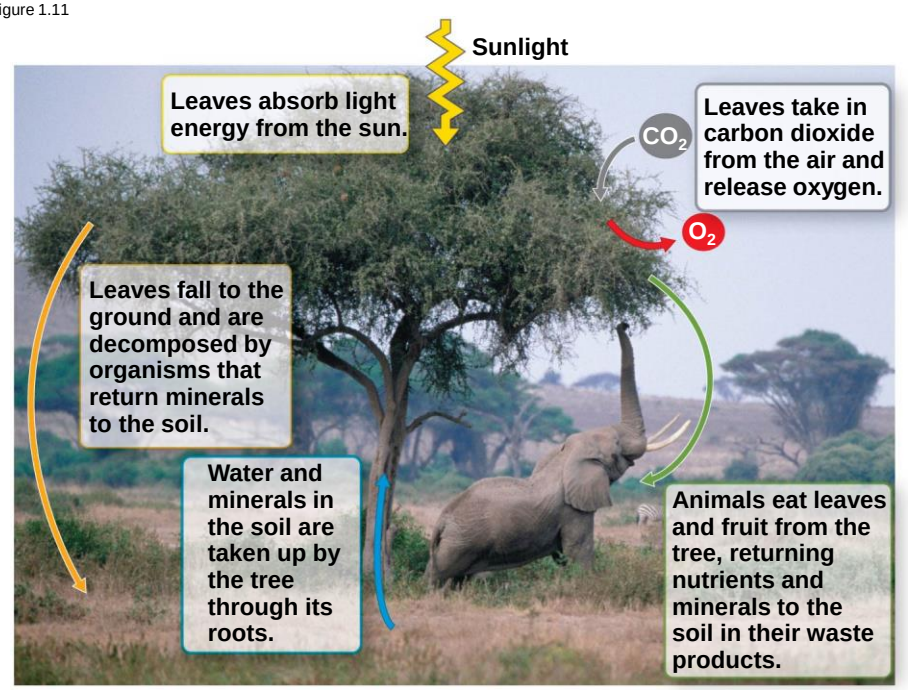
Figure 1.9



Ecosystems: An Organism's Interactions with Other Organisms and the Physical Environment

- At the ecosystem level, each organism **interacts** with other organisms
- These interactions may be *beneficial* or *harmful* to one or both of the organisms
- Organisms also interact continuously with the physical factors in their environment, and the environment is affected by the organisms living there

Figure 1.11



- Each organism interacts continuously with physical factors in its environment
- Humans interact with our environment, sometimes with very bad consequences
- Over the past 150 years, humans have greatly increased the burning of **fossil fuels** and the release of carbon dioxide (CO_2) into the atmosphere
- The resulting global warming is just one aspect of **climate change**

- Wind and rain patterns are also changing
- Extreme weather events such as storms and droughts are happening more often
- As habitats deteriorate, plant and animal species shift their ranges to more suitable locations
- *Populations of many species are shrinking in size or even disappearing*

Threatened by global warming

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

- Evolution is the one idea that makes logical sense of everything we know about living organisms
- *"Nothing in biology makes sense except in the light of evolution"—Theodosius Dobzhansky*
- The scientific explanation for both the *unity* and *diversity* of organisms is **evolution**, the concept that living organisms are modified descendants of **common ancestors**
- An abundance of evidence supports the occurrence of evolution

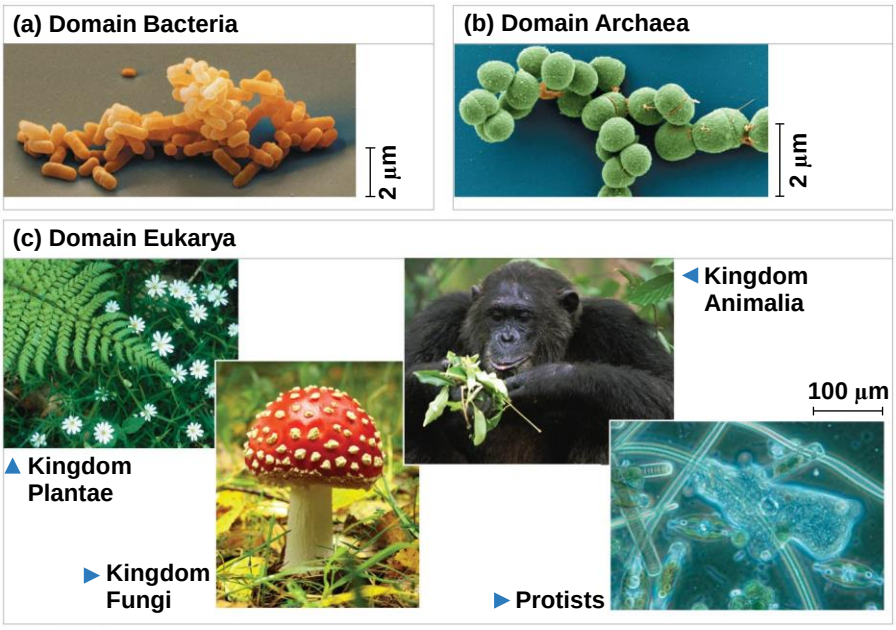
Classifying the Diversity of Life

- Approximately 1.8 million species have been identified and named to date
- Each species is given a two-part name: The ***genus***, to which the species belongs, and a ***species*** name unique to that species
- E.g., *Homo sapiens (H. sapiens)*, the name of our species
- Other examples: *Escherichia coli (E. coli)*
- Estimates of the total number of species that actually exist range from 10 million to over 100 million

The Three Domains of Life

- Organisms are currently divided into three **domains**: Bacteria, Archaea, and Eukarya
- **Bacteria** and **Archaea** are *prokaryotes*
- Domain **Eukarya** includes all eukaryotic organisms
- Domain Eukarya includes the *protists* and three *kingdoms*
  - **Plants**, which produce their own food by photosynthesis
  - **Fungi**, which absorb nutrients
  - **Animals**, which ingest their food

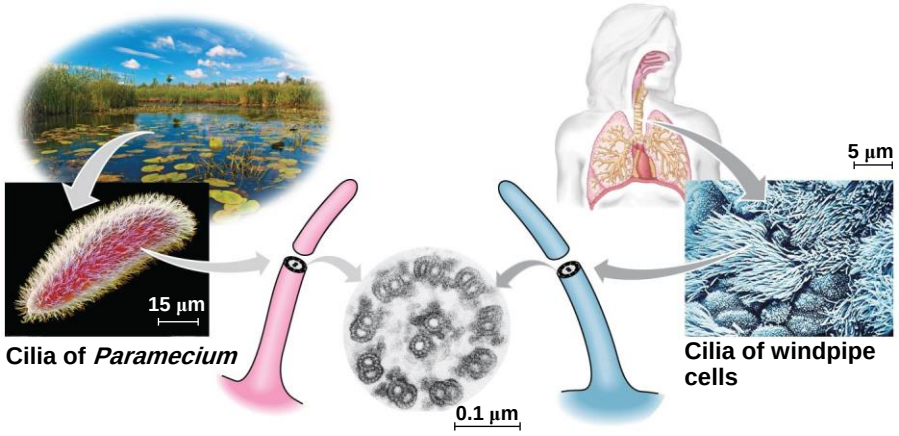
Figure 1.13



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 (e.g., all cells have membranes)

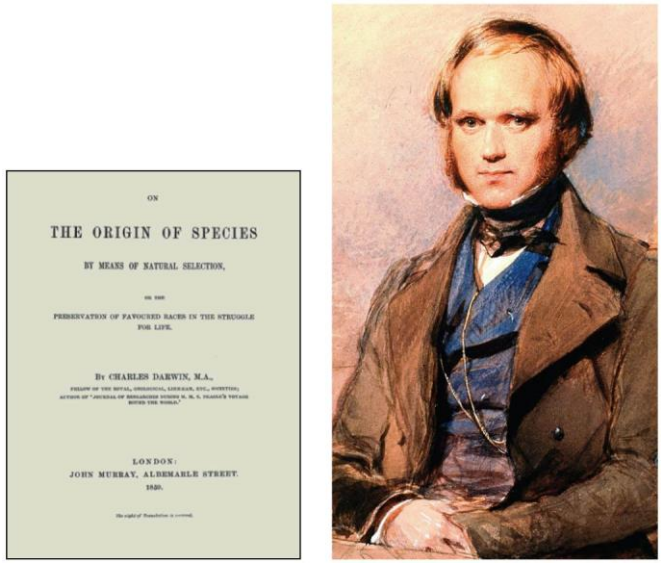
Figure 1.14



Charles Darwin and the Theory of Natural Selection

- 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
  (*decent* – unity; *modification* – modification)

Figure 1.16



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

- Darwin reasoned 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
- The natural environment "selects" for the propagation of beneficial traits
- Darwin called this process **natural selection**

Figure 1.18_1

1 Population with varied inherited traits

Figure 1.18_2

1 Population with varied inherited traits

2 Elimination of individuals with certain traits

Figure 1.18_3

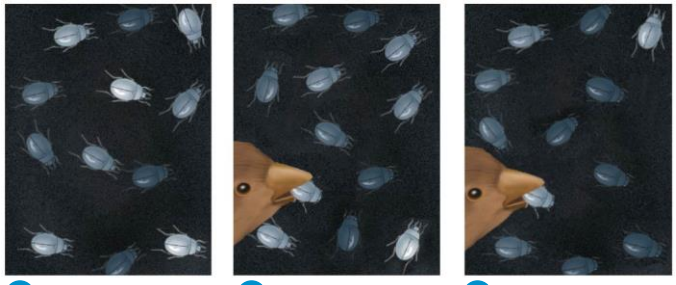
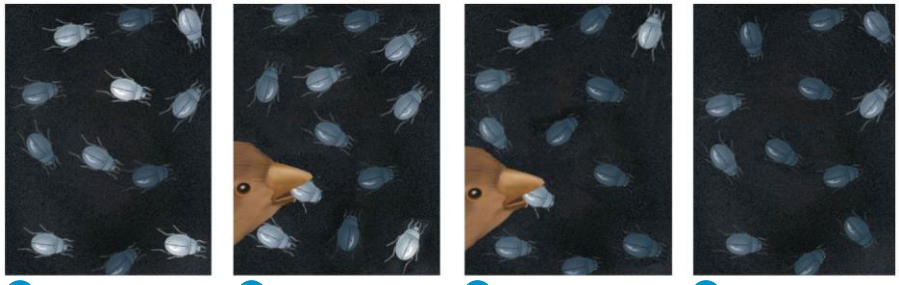


Figure 1.18_4



- Natural selection results in the **adaptation** of organisms to the circumstances of their way of life and their environment
- For example, bat wings are an example of adaptation (the only mammal to be able to fly; has webbings between long fingers)

The Tree of Life

- The shared anatomy of mammalian limbs (أطراف) reflects the inheritance of the limb structure from a common ancestor
- **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 1.20