LECTURE PRESENTATIONS
For CAMPBELL BIOLOGY, NINTH EDITION
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Chapter 1

Introduction: Themes in the Study of Life

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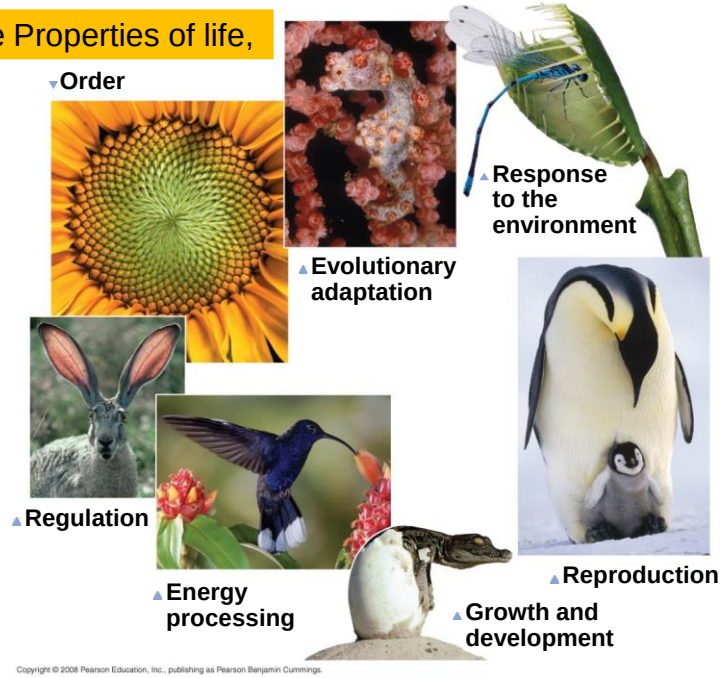
Overview: Inquiring About Life

- 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*

- **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

Some Properties of life,



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

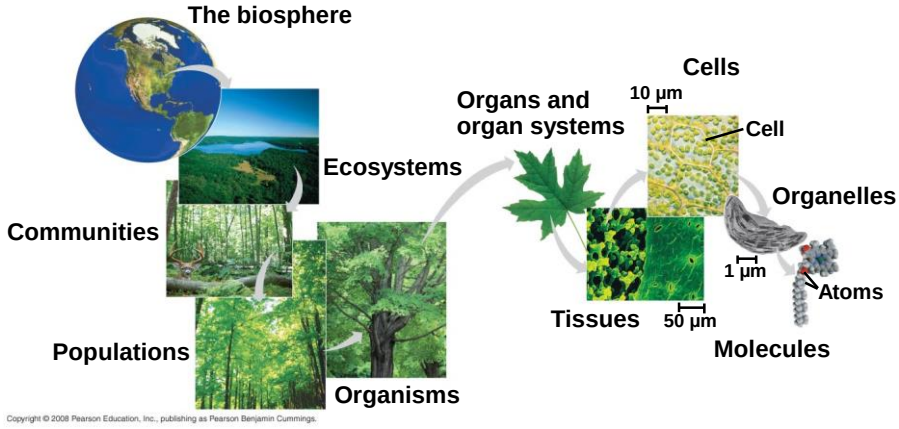
- Biology consists of more than memorizing factual details
- Themes help to organize biological information

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

Fig. 1-4

Levels of biological organization



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

Systems Biology

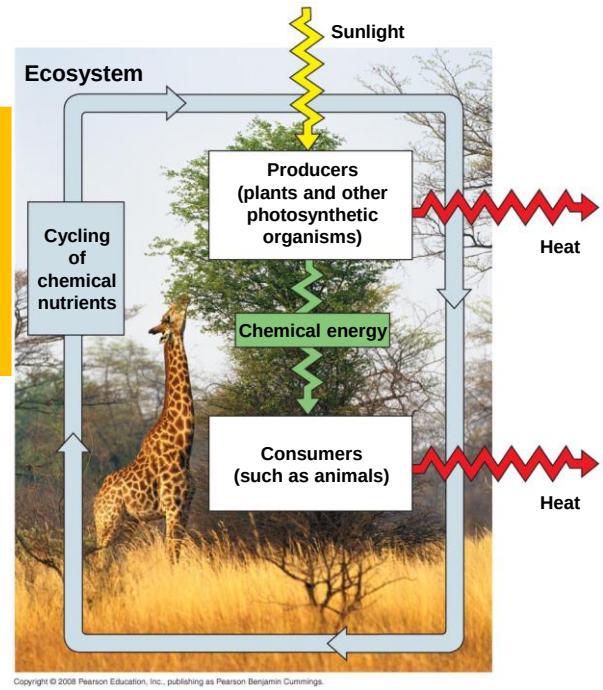
- **A system** *is a combination of components that function together*
- **Systems biology** constructs models for the dynamic behavior of whole biological systems
- The systems approach **poses questions** such as
  - How does a drug for blood pressure affect other organs?
  - How does increasing CO_2 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

Fig. 1-5

Nutrient cycling and energy flow in an ecosystem



- **Humans have modified our environment**
  - For example, half the human-generated CO_2 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

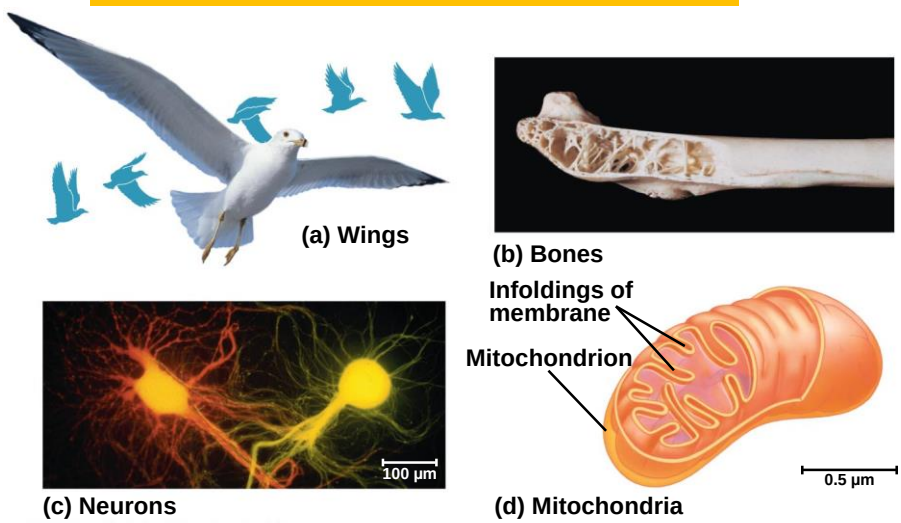
- A fundamental characteristic of living organisms is their use of energy to carry out life's activities
- **Work**, including moving, growing, and reproducing, requires a **source of energy**
- Living organisms transform energy from one form to another
  - For example, **light energy** is converted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

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

Fig. 1-6

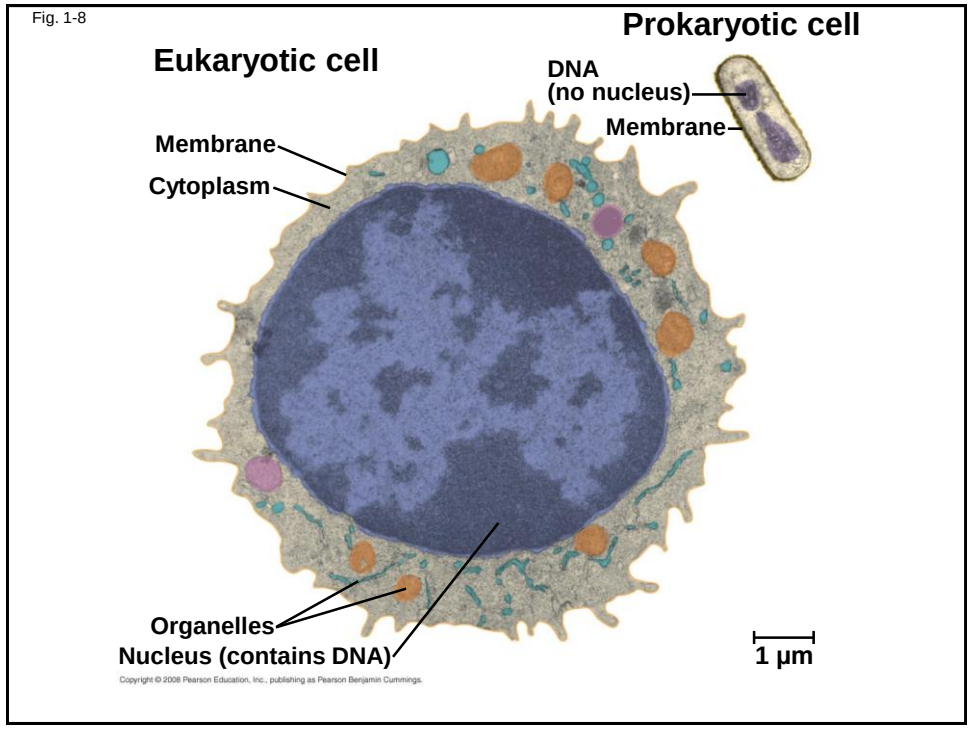
Form fits function in a gull's wing



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

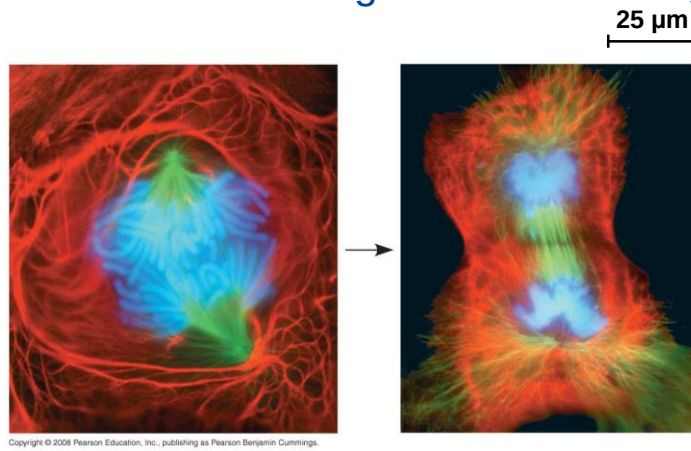


Theme: The Continuity of Life Is Based on Heritable Information in the Form of DNA

- 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.

Fig. 1-7

A lung cell from a newt divides into two smaller cells that will grow and divide again

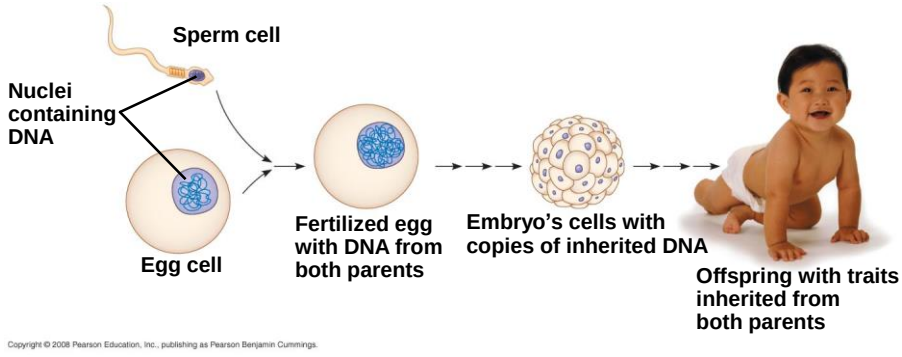


DNA Structure and Function

- 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

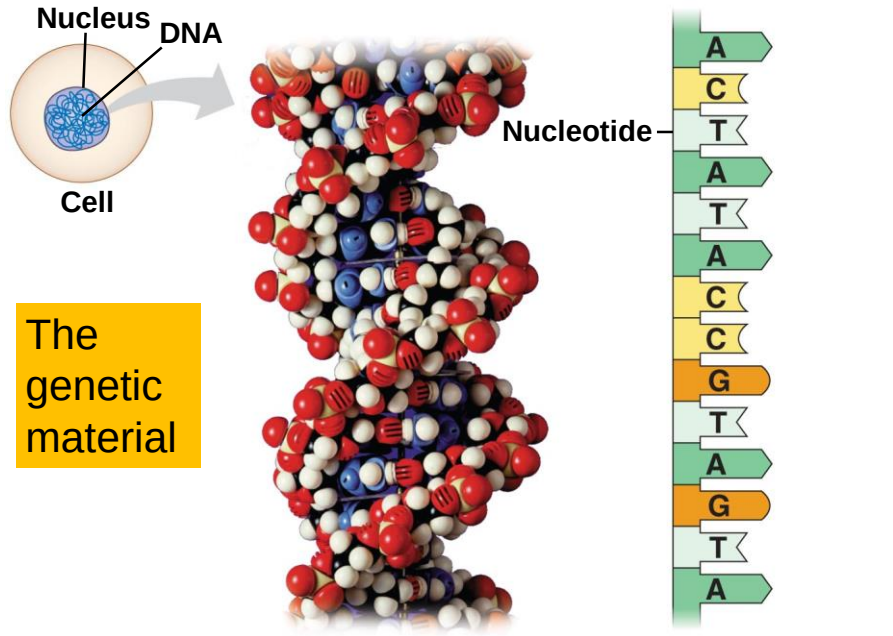
Fig. 1-9

Inherited DNA directs development of an organism



- 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**

Fig. 1-10



The genetic material

- **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

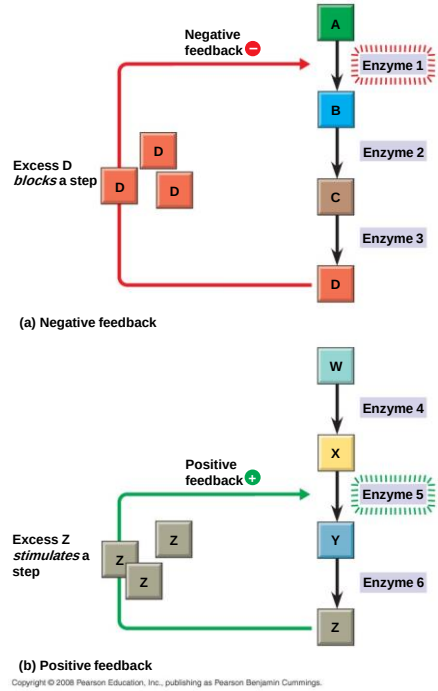
- An organism's **genome** is *its entire set of genetic instructions*
- The human genome and those of many other organisms have been sequenced using **DNA-sequencing machines**
- **Genomics** *is the study of sets of genes within and between species*
- **Bioinformatics**, *which is the use of computational tools to process a large volume of data*

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

Fig. 1-13

Regulation by feedback mechanisms



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**"
- **Evolution unifies biology** at different scales of size throughout the history of life on Earth

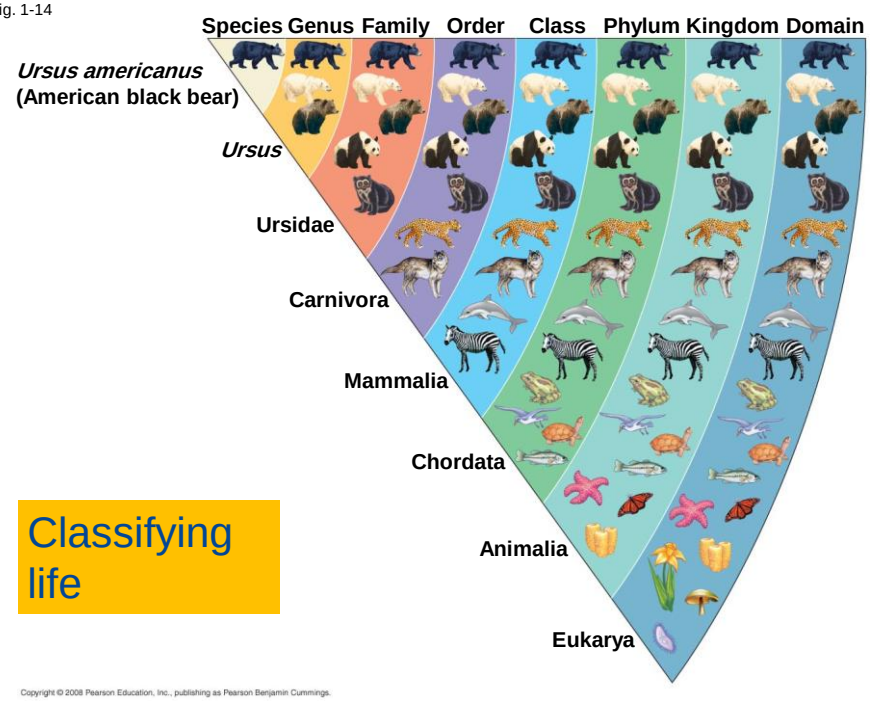
Classifying the Diversity of Life

- **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

Fig. 1-14



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

Fig. 1-15

The three domains of life

- 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

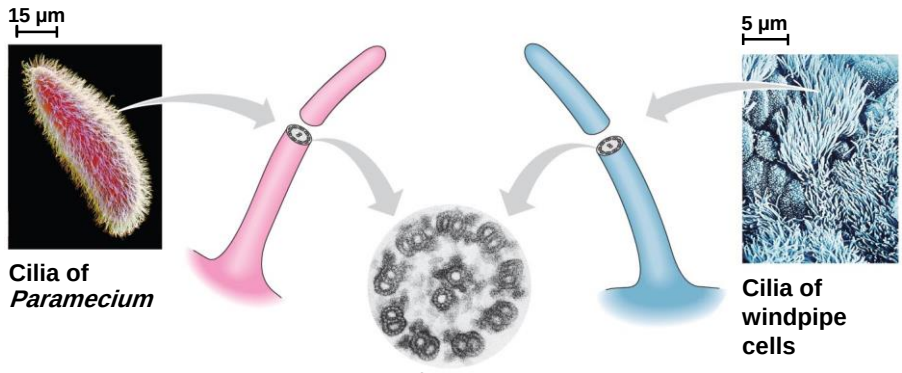
- Other eukaryotic organisms were formerly grouped into the **Protist kingdom**, though these are now often grouped into many separate groups

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*

Fig. 1-16

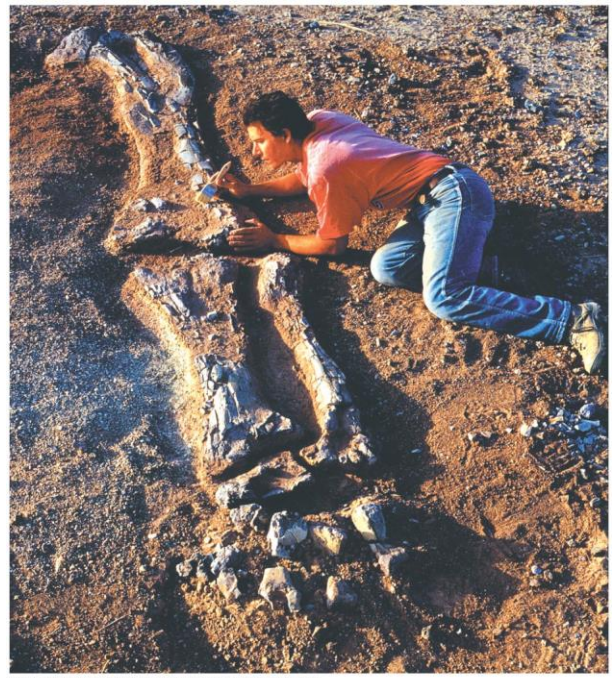
An example of unity underlying the diversity of life: the architecture of cilia in eukaryotes



Charles Darwin and the Theory of Natural Selection

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

Fig. 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**

Fig. 1-18

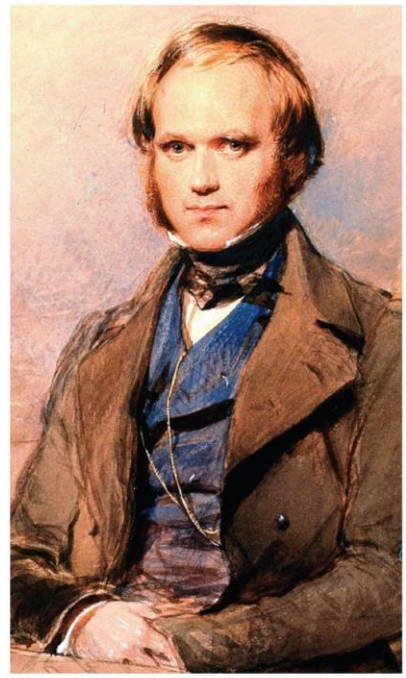
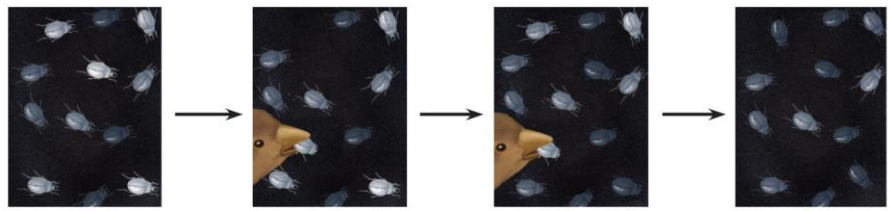


Fig. 1-19

Unity and diversity in the orchid family

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

Fig. 1-20



Natural selection

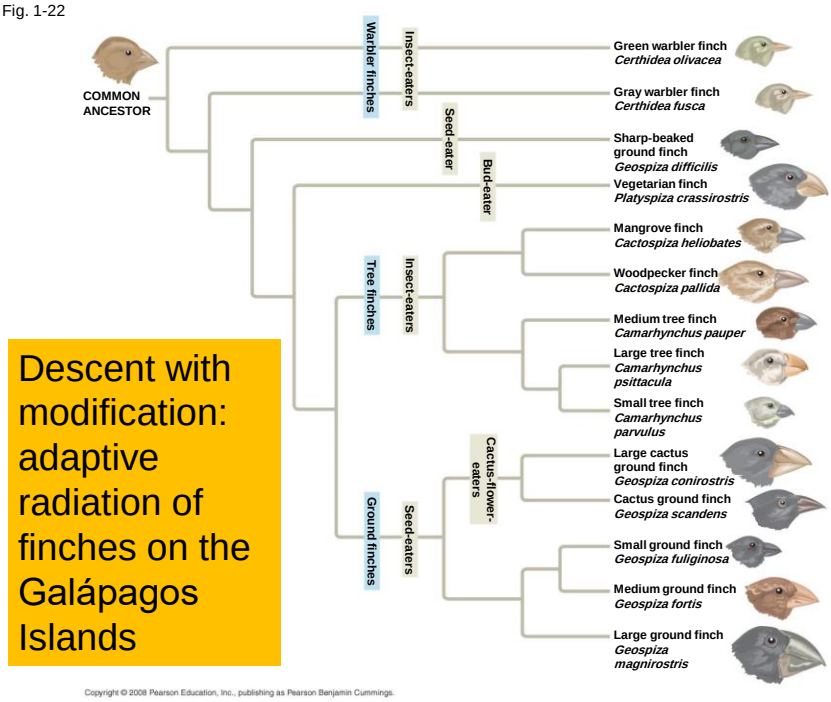
- **Natural selection** results in **the adaptation** of organisms to their environment
  - For example, bat wings are an example of adaptation

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 descendents

Fig. 1-22



Descent with modification: adaptive radiation of finches on the Galápagos Islands