## Evolution and the Foundations of Biology

# **Overview: Inquiring About Life**

## An organism’s inherited characteristics that allow it to be well adapted for its environment are the result of evolution

## **Evolution** is the process of change (over MANY GENERATIONS )that has transformed life on Earth

# **Concept 1.1: Studying the diverse forms of life reveals common themes**

# **Theme: New Properties Emerge at Successive Levels of Biological Organization**

## Life can be studied at different levels, from molecules to the entire living planet

# **Theme: New Properties Emerge at Successive Levels of Biological Organization**

## **Reductionism:**

### complex systems are reduced to simpler components to make them more manageable to study

## **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

## Biologists today combine reductionism with **systems biology**, the exploration of a biological system by analyzing the interactions among its parts

## The systems approach poses questions such as

### How does a drug for blood pressure affect other organs?

### How does increasing CO2 alter the biosphere?

# ***Structure and Function***

## At each level of the biological hierarchy we find a correlation between structure and function

## Analyzing a biological structure can give clues about what it does and how it works

# ***The Cell: An Organism’s Basic Unit of Structure and Function***

## All cells share certain characteristics, such as being enclosed by a membrane

## The two main forms of cells are prokaryotic and eukaryotic

### A **eukaryotic cell** contains membrane-enclosed organelles, including a DNA-containing nucleus

### **Prokaryotic cells** lack a nucleus or other membrane-bound organelles and are generally smaller than eukaryotic cells

# **Figure 1.5**

# **Theme: Life’s Processes Involve the Expression and Transmission of Genetic Information**

## Chromosomes contain most of a cell’s genetic material in the form of **DNA** (deoxyribonucleic acid)

# ***DNA Structure and Function***

## A DNA molecule holds hundreds or thousands of genes, each a stretch of DNA along the chromosome

## **Genes** are the units of inheritance that transmit information from parents to offspring

## As cells grow and divide, the genetic information encoded by DNA directs their development

# **Figure 1.8**

## DNA provides blueprints for making proteins, the major players in building and maintaining a cell

## Genes control protein production indirectly, using RNA as an intermediary

## **Gene expression** is the process of converting information from gene to cellular product

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

## Input of energy, mainly from the sun, and transformation of energy from one form to another make life possible

## Plants and other photosynthetic organisms convert the energy of sunlight into the chemical energy of sugars

## This chemical energy of these producers is then passed to consumers that feed on the producers

# **Figure 1.9**

# **Theme: Organisms Interact with Other Organisms and the Physical Environment**

## Every organism interacts with physical factors in its environment

## 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

# **Figure 1.10**

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

## Similar traits among organisms are explained by descent from common ancestors

## Differences among organisms are explained by the accumulation of heritable changes

## The remarkably diverse forms of life on this planet arose by evolutionary processes

# **Classifying the Diversity of Life: The Three Domains of Life**

## Humans group diverse items according to their similarities and relationships to each other

## Careful analysis of form and function has been used to classify life-forms

## Recently, new methods of assessing species relationships, especially comparisons of DNA sequences, have led to a reevaluation of larger groupings

## Biologists currently divide the kingdoms of life into three domains: Bacteria, Archaea, and Eukarya

## Domains **Bacteria** and **Archaea** are prokaryotes

## Domain Eukarya includes three multicellular kingdoms: Plantae, Fungi, and Animalia

### Plants produce their own food by photosynthesis

### Fungi absorb nutrients

### Animals ingest their food

# **Figure 1.11**

## **Charles Darwin & The Theory of Natural Selection**

## 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 captured the duality of unity and diversity

## Darwin observed that

### Individuals in a population vary in their traits, many of which are heritable

### More offspring are produced than survive, and competition is inevitable

### Species generally suit their environment

## Darwin inferred that

### Individuals that are best suited to their environment are more likely to survive and reproduce

### **Over time (Within each New Generation)**, more individuals in a population will have the advantageous traits

## In other words, the environment “selects” for the propagation of beneficial traits

## Darwin called this process **natural selection**

# **Figure 1.15**

# **The Tree of Life**

## The forelimb of a human, foreleg of a horse, flipper of a whale, and wing of a bat all share a common skeletal architecture

## The shared anatomy of mammalian limbs reflects inheritance of a limb structure from a common ancestor

## The diversity of mammalian limbs results from modification by natural selection over millions of years

## 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 (**Cladogram)** that show ancestors and their descendants grouped by traits/ characteristics

# **Figure 1.16**