AP Biology: Chapter 19 Descent with Modification Notes

Endless Forms Most Beautiful

- Lepidopteran insects (moths and butterflies) have many features in common including a juvenile feeding stage called a caterpillar
- Lepidopteran species also have many features that are distinct from each other in both the caterpillar and adult forms
- Lepidopterans illustrate three key observations about life
    - The fit between organisms and their environment
    - The shared characteristics (unity) of life
    - The diversity of life

A new era of biology began in 1859 when Charles Darwin published *On the Origin of Species*

- *On the Origin of Species* focused biologists' attention on the great diversity of organisms
- Darwin noted that current species are descendants of ancestral species
- **Evolution** can be defined by Darwin's phrase *descent with modification*
- Evolution can be viewed as both a pattern and a process

Concept 19.1: The Darwinian revolution challenged traditional views of a young Earth inhabited by unchanging species

- Darwin's revolutionary ideas had deep historical roots
- *Scala Naturae* and Classification of Species
- The Greek philosopher Aristotle viewed species as fixed and arranged them on a *scala naturae*
- This view was consistent with the Old Testament, which holds that species were individually designed by God and therefore perfect
- Carolus Linnaeus was the founder of taxonomy, the branch of biology that organizes species into a nested classification system of increasingly general categories
- He also developed the binomial format for naming species (for example, *Homo sapiens*)
- Linnaeus ascribed the resemblance among species to the pattern of creation rather than evolution
- Ideas About Change over Time
- The study of **fossils** helped to lay the groundwork for Darwin's ideas
- Fossils are remains or traces of organisms from the past, usually found in sedimentary rock, which appears in layers or **strata**
- **Paleontology**, the study of fossils, was largely developed by French scientist Georges Cuvier
- Cuvier speculated that each boundary between strata represents a catastrophe that destroyed many species

- Geologists James Hutton and Charles Lyell perceived that changes in Earth's surface can result from slow, continuous actions still operating today
- Lyell further proposed that the mechanisms of change are constant over time
- This view strongly influenced Darwin's thinking
- Lamarck's Hypothesis of Evolution
- Lamarck hypothesized that species evolve through use and disuse of body parts and the inheritance of acquired characteristics
- The mechanisms he proposed are unsupported by evidence

Concept 19.2: Descent with modification by natural selection explains the adaptations of organisms and the unity and diversity of life

- Some doubt about the permanence of species preceded Darwin's ideas
- Darwin's Research
- As a boy and into adulthood, Charles Darwin had a consuming interest in nature
- Darwin first studied medicine (unsuccessfully) and then theology at Cambridge University
- After graduating, he took an unpaid position as naturalist and companion to Captain Robert FitzRoy for a five-year around-the-world voyage on the *Beagle*
- *The Voyage of the* Beagle
- During his travels on the *Beagle,* Darwin collected specimens of South American plants and animals
- He observed that fossils resembled living species from the same region, and living species resembled other species from nearby regions
- Darwin was influenced by Lyell's *Principles of Geology* and thought that Earth was more than 6,000 years old
- He observed the uplift of rocks on the coast of Chile following an earthquake and inferred that similar processes could explain the fossils of ocean organisms he found in the Andes
- His interest in geographic distribution of species was kindled by a stop at the Galápagos Islands west of South America
- He hypothesized that species from South America had colonized the Galápagos and speciated on the islands
- *Darwin's Focus on Adaptation*
- Darwin perceived **adaptation** to the environment and the origin of new species as closely related processes
- Biologists have since concluded that the diverse group of Galápagos finches arose from an ancestral form by the gradual accumulation of adaptations to different environments
- In 1844, Darwin wrote an essay on natural selection as the mechanism of descent with modification but did not introduce his theory publicly
- **Natural selection** is a process in which individuals with favorable inherited traits are more likely to survive and reproduce

- In June 1858, Darwin received a manuscript from Alfred Russell Wallace, who had developed a theory of natural selection similar to Darwin's
- In July 1958, Lyell presented Wallace and Darwin's work together to the Linnean Society of London
- Darwin quickly finished *On the Origin of Species* and published it the next year
- Ideas from *On the Origin of Species*
- Darwin explained three broad observations about life
    - The unity of life
    - The diversity of life
    - The match between organisms and their environment
- ***Descent with Modification***
- Darwin never used the word *evolution* in the first edition of *On the Origin of Species*
- The phrase *descent with modification* summarized Darwin's perception of the unity of life
- The phrase refers to the view that all organisms are related through descent from an ancestor that lived in the remote past
- In the Darwinian view, the history of life is like a tree with branches representing life's diversity
- Fossils of extinct species help to "fill in" the morphological gaps between present-day groups
- *Artificial Selection, Natural Selection, and Adaptation*
- Darwin noted that humans have modified other species by selecting and breeding individuals with desired traits, a process called **artificial selection**
- Darwin argued that a similar process occurs in nature

Darwin drew two inferences from two observations

- **Observation #1:** Members of a population often vary in their inherited traits
- **Observation #2:** All species can produce more offspring than the environment can support, and many of these offspring fail to survive and reproduce
- **Inference #1:** Individuals whose inherited traits
  give them a higher probability of surviving and reproducing in a given environment tend to leave more offspring than other individuals
- **Inference #2:** This unequal ability of individuals to survive and reproduce will lead to the accumulation of favorable traits in the population over generations
- Darwin was influenced by Thomas Malthus, who noted the potential for human population to increase faster than food supplies and other resources
- If some heritable traits are advantageous, these will accumulate in a population over time, and this will increase the frequency of individuals with these traits
- This process explains the match between organisms and their environment

- *Key Features of Natural Selection*
- Individuals with certain heritable traits survive and reproduce at a higher rate than other individuals
- Over time, natural selection increases the frequency of adaptations that are favorable in a given environment
- If an environment changes over time, natural selection may result in adaptation to these new conditions and may give rise to new species
- Note that individuals do not evolve; populations evolve over time
- Natural selection can only increase or decrease heritable traits that vary in a population
- The traits that are adaptive will vary with different environments

Concept 19.3: Evolution is supported by an overwhelming amount of scientific evidence

- New discoveries continue to fill the gaps identified by Darwin in *On the Origin of Species*
- There are four types of data that document the pattern of evolution
    - Direct observations
    - Homology
    - The fossil record
    - Biogeography
- Direct Observations of Evolutionary Change
- Two examples provide evidence for natural selection: natural selection in response to introduced species and the evolution of drug-resistant bacteria
- *Natural Selection in Response to Introduced Species*
- Soapberry bugs use their "beak" to feed on seeds within fruits
- Soapberry bugs feed most effectively when their beak length is similar to the depth of the seeds within the fruit
- In southern Florida, soapberry bugs feed on the larger fruit of balloon vines; they have longer beaks
- In central Florida, they feed on the smaller fruit of introduced goldenrain trees; they have shorter beaks
- Correlation between fruit size and beak size has also been observed in other locations
- In all cases, beak size has evolved in populations that feed on introduced plants with fruits that are smaller or larger than the native fruits
- These cases are examples of evolution by natural selection
- In Florida, this evolution in beak size occurred in less than 35 years
- *The Evolution of Drug-Resistant Bacteria*
- The bacterium *Staphylococcus aureus* is commonly found on people's skin or in their nasal passages
- Methicillin-resistant *S. aureus* (MRSA) strains are dangerous pathogens

- *S. aureus* became resistant to penicillin in 1945, two years after it was first widely used
- *S. aureus* became resistant to methicillin in 1961, two years after it was first widely used
- Methicillin works by inhibiting a protein used by bacteria in their cell walls
- MRSA bacteria use a different protein in their cell walls
- When exposed to methicillin, MRSA strains are more likely to survive and reproduce than nonresistant *S. aureus* strains
- MRSA strains are now resistant to many antibiotics
- Natural selection does not create new traits, but edits or selects for traits already present in the population
- The local environment determines which traits will be selected for or selected against in any specific population
- Homology
- Evolution is a process of descent with modification
- Related species can have characteristics with underlying similarity that function differently
- **Homology** is similarity resulting from common ancestry
- *Anatomical and Molecular Homologies*
- **Homologous structures** are anatomical resemblances that represent variations on a structural theme present in a common ancestor
- Comparative embryology reveals anatomical homologies not visible in adult organisms
- **Vestigial structures** are remnants of features that served important functions in the organism's ancestors
- Examples of homologies at the molecular level are genes shared among organisms inherited from a common ancestor
- Homologous genes can be found in organisms as dissimilar as humans and bacteria
- Many organisms have retained genes that, like vestigial structures, have lost their function
- *A Different Cause of Resemblance: Convergent Evolution*
- **Convergent evolution** is the evolution of similar, or **analogous**, features in distantly related groups
- Analogous traits arise when groups independently adapt to similar environments in similar ways
- Convergent evolution does not provide information about ancestry
- The Fossil Record
- The fossil record provides evidence of
    - The extinction of species
    - The origin of new groups
    - Changes within groups over time

- Fossils can document important transitions
    - For example, the transition from land to sea in the ancestors of cetaceans

Fossil evidence shows that living cetaceans and their close relatives, the even-toed ungulates, are more different from each other today than were early cetaceans and even-toed ungulates

- **Biogeography**, the scientific study of the geographic distribution of species, provides evidence of evolution
- Earth's continents were formerly united in a single large continent called **Pangaea**, but have since separated by continental drift
- An understanding of continent movement and modern distribution of species allows us to predict when and where different groups evolved
- **Endemic** species are species that are not found anywhere else in the world
- Islands have many endemic species that are often closely related to species on the nearest mainland or island
- Darwin explained that species on islands gave rise to new species as they adapted to new environments
- What Is Theoretical About Darwin's View of Life?
- In science, a theory accounts for many observations and explains and integrates a great variety of phenomena
- The predictions of a scientific theory must stand up to continual testing by experimentation and observation
- Darwin's theory of evolution by natural selection integrates diverse areas of biological study and stimulates many new research questions
- Ongoing research adds to our understanding of evolution