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**IDX G9 BIOLOGY H STUDY GUIDE ISSUE 5**

**By Joy and Edward**

**16.1 Darwin’s Voyage of Discovery**

* **Charles Darwin** (Feb 12, 1809)
  + Published convincing evidence that species evolve, with reasonable explanation.
* **Evolution**: The process of change over time.
* **Voyage of HMS Beagle (1831)**: As a naturalist, the 5-year voyage mapped the South America coast, challenging the belief that species are unchanging.
* **Patterns of biological diversity**
  + **Vary globally**: inhabited separated but ecologically similar habitats around globe
    - Similar not because they are closely related, only because of similar environments
    - e.g. emus, rheas, ostriches
  + **Vary locally**: species occupied different habitats within a local area
    - In Galapagos Islands: different types of birds and turtles
  + **Vary over time**: Fossils of extinct animals are similar to living species
    - Fossils: preserved remains or traces of ancient organisms

**16.2 Ideas that Shaped Darwin’s Thinking**

* **James Hutton**:
  + 1785: Theory of Geological Change.
    - Forces change the Earth's surface slowly, indicating Earth is much older than thousands of years because geological processes take a very long time (e.g., Grand Canyon formation).
* **Charles Lyell**:
  + "Principles of Geology": proposed that current geological processes are the same as those which shaped Earth millions of years ago, and Darwin found evidence to prove this.
* **Jean - Baptiste Lamarck**:
  + 1809: Hypothesis of the Inheritance of Acquired Characteristics.
  + Acquired characteristics: traits altered by an individual organism during its life
    - by use / disuse of a body part could cause change in features within the lifetime of that organism
    - changes would be passed on to offspring
    - eg. Giraffes having long necks
  + Evaluation (incorrect hypothesis):
    - evolution occurs in populations, not individuals
    - evolution does not mean species are becoming better, there is no direction for evolution
  + However, Lamarck was among the first to suggest species changed and explain evolution scientifically using natural processes.
* **Thomas Malthus**:
  + 1798: "Principle of Populations"
    - stated that if the human population grew unchecked, there wouldn't be enough food and living space for everyone
* **Artificial selection**: Nature provides variations, and humans select useful ones, which requires inherited variation.

**16.3 Darwin Presents his Case**

* **1858 - “On the Origin of Species”**: Outlined the ideas of evolution by natural selection, with three principles:

1. **Struggle for existence**: If more individuals are produced than can survive, population competes to obtain food, living space, and other limited necessities of life (e.g., only 50% of bears survive past 1 year).
2. **Variation and adaptation**: Individuals in a population vary in heritable characteristics
   * Adaptation: heritable characteristics that increases an organism's ability to survival and reproduce in its environment
     + camouflage
     + mimicry
     + behaviors
3. **Survival of the fittest**:
   * Fitness: how well an organism can survive and reproduce in its environment
   * Survival of the fittest: the difference in rates of survival and reproduction
     + passes hereditary adaptations to the next generation

* **Natural selection**: process by which organisms with variations most suited to the local environment survive and leave more offspring
  + Fitness is influenced by the environment
  + Well adapted individuals survive and reproduce
    - Populations change as environment change
  + Acts on inherited traits
  + Doesn't make organisms “better” or move in a fixed direction (e.g., peppered moth).
* Darwin proposed: over generations, adaptation could cause successful species to evolve into new species
* **Descent with modification**: Living species are descended (with modification) from common ancestors, supported by fossil records (e.g., antibiotic resistance in bacteria).

**16.4 Evidence of Evolution**

* **Biogeography**
  + **Biogeography** is the study of where organisms live now and where they and their ancestors lived in the past.
  + **Pattern 1**: Adaptive Radiation
    - One species evolved into several different forms that adapted to different environments, these new forms share a common ancestor
    - e.g., the Galapagos islands had 13 finch species adapted to different diets, which evolved from the single type seen on the mainland
  + **Pattern 2**: Convergent Evolution
    - Unrelated organisms live in and adapt to similar environments, and resemble one another
    - No recent common ancestor
    - e.g., dolphins, penguins, and fish each independently evolved the ability to swim
* **The Age of Earth and Fossils**
  + The Earth is 4.5 billion years old
  + **Fossils** are preserved remains or imprints of an organism that lived long ago.
  + Intermediate fossil forms show evolution of modern species from extinct ancestors
    - e.g., whales evolved from land-dwelling mammals
* **Comparing Anatomy and Embryology**
  + **Homologous structures**
    - Different species have structures that are adapted for different functions but share many similarities, evidence of a common ancestor
    - e.g., the forelimbs (five digits) in tetrapods (amphibians, reptiles, birds, and mammals)
  + **Vestigial structures**
    - Structures inherited from ancestors that have lost much of their original function due to different selection pressures, evidence of a common ancestor
    - e.g., hind limbs of whales and dolphins
  + **Analogous structures**
    - Body parts that share a common function, but not a common structure, NOT evidence of a common ancestor
    - e.g., bee wings and bird wings
  + **Comparative embryology**
    - Similar patterns of embryo development, evidence of a common ancestor
    - e.g., all vertebrate embryos exhibit common structures
* **Genetics and Molecular Biology**
  + All living organisms use the same universal genetic code
  + Similarities in DNA/RNA/protein sequences are evidence of a common ancestor
  + Homologous genes
    - e.g., Hox genes determine the head to tail axis, and are found in almost all multicellular animals
  + Homologous proteins
    - e.g., Cytochrome c functions in cellular respiration, and versions are found in almost all living cells
* **Testing Natural Selection**
  + The Grants documented that natural selection happens in wild finch populations frequently
  + Variation in a species increases the chance of it surviving environmental change

**17.1 Genes and Variation**

* **Genetics**: The scientific study of heredity
  + **Trait**: A specific feature inherited from an organism's parents
  + **Genes**:Basic unit of heredity that determine traits
    - Specific fragment of DNA on chromosome
  + **Alleles**: Different forms of a gene
    - Determine different forms of a trait, differ by a few bases only
  + **Gene pool**
    - All the genes (including all the different alleles for each gene) that are present in a population
  + **Allele frequency**
    - How often a particular allele occurs in a gene pool, compared to other alleles for the same gene
  + **Homologous chromosomes**
    - Pair of chromosomes, same length and shape
    - Same genes in the same order at the same positions
  + **Genotype**: Particular combination of alleles an organism carries
    - Determine a trait (together with environmental conditions)
    - **Homozygous**: same alleles (e.g., PP, pp)
    - **Heterozygous**: different alleles (e.g., Pp)
  + **Phenotype**: All physical, physiological, and behavioral characteristics of an organism
* **Genetics Joins Evolutionary Theory**
  + 1. Heritable traits are controlled by genes that are carried on chromosomes
  + 2. Mutations in genes generate various alleles, generating variation
  + 3. Individuals with phenotypes better suited to their environment produce more offspring and pass on more copies of their genes
  + 4. Evolution is any change in the relative frequency of alleles in a population over time
* **Sources of Genetic Variation**
  + **1. Mutation**
    - Any change in the genetic material of a cell (gene/chromosome mutation)
    - Can be beneficial, neutral or harmful, mostly neutral
    - Only mutations in germ line cells that produce gametes (sex cells) can be passed on to offspring
  + **2. Sexual reproduction**
    - 1. Meiosis (crossing over produces new combinations of alleles, and independent assortment of homologous chromosomes)
    - 2. Fertilization of sperm and egg
  + **3. Lateral gene transfer**
    - An individual organism passes genes to another that is not its offspring
    - Can be intraspecific or interspecific, increases genetic variation
    - e.g., bacteria conjugation
* **Single-Gene and Polygenic Traits**
  + The number of phenotypes for a trait depends on how many genes control it
  + **Single-Gene Traits**
    - A trait controlled by only one gene
    - e.g., pea plant flower color, with two alleles and two phenotypes
    - e.g., human blood type, with three alleles and four phenotypes
  + **Polygenic Traits**
    - Traits controlled by two or more genes
    - Wide (and usually continuous) range of phenotypes, tends to show normal distribution
    - Also influenced by environmental factors
    - e.g., human skin color is controlled by more than four genes