

General Biology 2: Lecture 1

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- Biology: the scientific study of living organisms and how they have evolved
- Evolutionary Theory → unity, diversity

“Nothing in Biology makes sense except in the light of evolution”

“Descent with Modification”

- Characteristics of (all) Living Organisms (Unity)
 - Cells and Organization
 - * Organisms maintain internal order
 - * Chemical uniformness
 - * Hierarchy of Organization
 1. Cells
 2. Tissues
 3. Organs
 4. Individuals
 5. Species
 - * Emergent properties
 - Sum of the parts creates unique properties
 - Energy Use and Metabolism
 - * Energy required to maintain order
 - * Energy used via metabolism
 - * Photosynthesis; Cellular respiration; ATP (glycolosis)
 - Response to Environmental Change
 - * Organisms react to stimuli
 - * Adaptations/behaviors promote survival
 - Regulation and Homeostasis
 - * Organisms regulate cells and bodies
 - * Maintain relatively stable internal conditions
(Disease: inability to maintain homeostatis)
 - Growth, Development, and Reproduction
 - * Growth produces more and/or larger cells
 - * Development produces organisms with defined sets of characteristics (DNA)

- * Reproduction sustains species over generations
 - * Genetic material causes offspring to have traits like their parents
- **Biological Evolutions**
 - * Populations of organisms change over generations
 - * Evolution results in traits that promote survival and reproductive success
- Core Concepts for Biological Literacy
 - Evolution
 - Structure and Function
 - Information Flow, Exchange, and Storage
 - Pathways and Transformations of Energy and Matter
 - Systems
- Structure Determines Function
 - Biological structures come about as a species adapts to its environment
 - Example: Human Hand
 - * Graps things (fine control)
 - * Grab Objects (power)
 - * Structure to function relationship:
 - Opposable thumb *rightarrow* touching fingers to base of hand (power grip)
 - Example: Bat Flight
 - * Bat fingers have a thin flap of skin that allows lift
- All species (past and present) are related by an evolutionary history
 - Vertical descent with mutation
 - Horizontal Gene Transfer (non-offspring)
 - * Different species transferring DNA between each other (e.g. bacteria)
 - * Process that likely led to the origins of prokaryotes (cell nucleus)
- Biological Evolution
 - Adaptation: any modification that makes an organism better suited to its way of life
 - “Descent with Modification”
 - * Populations of organisms change over generations
 - * Evolution results in adaptations
 - * Better adapted organisms tend to survive and produce more offspring
- How did Life Begin?
 1. 13 – 17 bya: Big Bang
 2. 4.6 bya: Solar System forms
 3. 4.55 bya: Earth forms
 4. 4 bya: Earth cools enough for outer layers and oceans to form

5. 3.5 – 4 bya: Life emerges

- Life requires interplay between RNA, DNA, and proteins
- Living cells come from preexisting cells
- Key steps:
 - * Nucleotides and amino acids produced prior to life
 - * Nucleotides and amino acids become polymerized to form DNA, RNA, proteins
 - * Polymers become enclosed in membranes
 - * Polymers enclosed in membranes exhibit cellular properties
- Primitize Earth
 - * Reducing Atmosphere Hypothesis
 - Atmosphere primarily consisted of H_2O vapor, N_2 , CO_2 , small amounts of H_2 and CO
 - Little free oxygen
 - Primordial soup (nutrient rich)
 - Spontaneous formation of organic molecules
 - Monomers evolved and joined to form polymers
 - Abiotic Synthesis (pre-biotic)
 - Theory given in 1920s by Oparin and Haldane
 - First Biomolecules
 - Miller and Urey (1953): Apparatus Experiment
 - Showed that biochemicals could be produced from simple non-biological sources
 - Primitize atmospheric gases
 - Strong energy sources
 - Yielded HCN , CH_2O , glycine, sugars, amino acids, N-bases
 - More recent:
 - Natural environment: CO , CO_2 , N_2 , H_2O
 - Organics can be made under a variety of conditions
 - Reducing (high pH) or neutral environments, both produce molecules
 - * Alternative Mechanisms?: Extraterrestrial Hypothesis
 - Organic carbon from asteroids and comets impacting prebiotic soup
 - Controversy: destroyed by intense heat of impact
 - * Deep Sea Vent Hypothesis
 - Key organics arose at deep-sea vents
 - Superheated water (300 degF) rich with H_2S and metal ions
- Origin of the 1st Cell
 - * Clay Hypothesis
 - Simple organics polymerize on solid surfaces (clay, mud, inorganic crystals) into complex organics
 - * Cell-Like Structures - Protobionts
 - Boundary (i.e. membrane)
 - Polymers inside contain information
 - Self-replication

- * Chemical Solution - RNA World
 - RNA in Protobionts:
 - Can store information, self-replicate, enzymatic functions (ribozymes)
- Advantages of DNA/RNA/Protein World
 - * Information Storage
 - DNA would have relieved RNA of information storage role and allowed RNA to perform other functions
 - * Metabolism and Other Functions
 - Proteins have a greater catalytic potential and efficiency (than RNA)
 - Proteins can perform other functions (e.g. structural)
- Fossil Record
 - * Fossil: remains and traces of past life or any other direct evidence of past life
 - * Paleontology: study of fossils and the fossil record
 - * Most fossils are traces of organisms embedded in sediment
 - * Older fossils in lower layers → series of fossil strata (layers)