Cell Structure
Chapter 4

Outline

• Cell Evolution
• Cell Theory
• Cell Size
• Prokaryotic Cells
• Eukaryotic Cells
  - Organelles
    • Containing DNA
    • Endosymbiosis
  - Plant Cells
  - Animal Cells
Fundamental Properties of Life

- cellular organization
- sensitivity
- growth
- development
- reproduction
- regulation
- homeostasis
- heredity

Origin of Life Hypotheses

- Special creation
  - supernatural or divine origin
- Extraterrestrial origin
  - panspermia
- Spontaneous origin
  - life originated from inanimate materials
Reducing Atmosphere

- Life most likely emerged under high-temperature conditions.
  - Early atmosphere is often referred to as a reducing atmosphere.
    - exact conditions unknown
      - ample availability of hydrogen atoms
      - very little oxygen

Origin of Life - Location

- Ocean’s edge
  - bubble hypotheses
- Under frozen seas
  - problematic due to necessary conditions
- Deep in Earth’s crust
  - byproduct of volcanic activity
- Within clay
  - positively-charged clay
- Deep-sea vents
  - conditions suitable for Archaea
Miller-Urey Experiment

- attempted to reproduce early reducing atmosphere and produce organic compounds from inorganic materials
  - hydrogen-rich
  - electrical discharge
    - succeeded in producing amino acids
Chemical Evolution

- Ongoing debate concerning actual path
  - RNA World - Molecules could not have consistently formed without a mechanism of heredity.
  - Protein World - Replication would be impossible without enzymes.
  - Peptide-Nucleic Acid World - RNA is too unstable, thus a precursor must have existed.

Cell Origin Theories

- Bubble theories
  - Certain molecules spontaneously form bubbles.
    - would serve to shield hydrophobic regions from contact with water
      - supports ocean’s edge scenario
Cell Origin Theories

- Oparin's Bubble Hypothesis
  - Primary abiogenesis - protobionts allowed chemical complexity to develop
    - Many different bubble scenarios have been proposed.
      - no agreement about composition or how the process occurred

Bubble Hypothesis

1. Volcanoes erupted under the sea, releasing gases enclosed in bubbles.
2. The gases, concentrated inside the bubbles, reacted to produce simple organic molecules.
3. When the bubbles persisted long enough to rise to the surface, they popped, releasing their contents to the air.
4. Bombarded by the sun’s ultraviolet radiation, lightning, and other energy sources, the simple organic molecules released from the bubbles reacted to form more complex organic molecules.
5. The more complex organic molecules fell back into the sea in raindrops. There, they could again be enclosed in bubbles and begin the process again.
Earliest Cells

- Microfossils have been found in rocks as old as 3.6 billion years old.
  - resemble prokaryotes
    - lack nucleus of more complex eukaryotes

Archaebacteria

- extreme-condition prokaryotes
  - lack peptidoglycan in cell walls
    - methanogens
    - extreme halophiles
    - extreme thermophiles
  - thought to have split from Bacteria 2 bya.
Bacteria

- second major group of prokaryotes
  - strong cell walls
  - simpler gene structure
  - contains most modern prokaryotes
    - includes photosynthetic bacteria
      - cyanobacteria

First Eukaryotic Cells

- Eukaryotes probably arose about 1.6 bya.
  - Internal membrane-bound structures such as mitochondria and chloroplasts are thought to have evolved via endosymbiosis.
    - Energy-producing bacteria were engulfed by larger bacteria.
      - beneficial symbiotic relationship
First Eukaryotic Cells

- Sexual reproduction
  - Eukaryotic cells can reproduce sexually, thus allowing for genetic recombination.
    - Genetic variation is the raw material necessary for evolution.
- Multicellularity
  - arisen many times among eukaryotes
    - fosters specialization
Extraterrestrial Life

- Universe has $10^{20}$ stars similar to our sun.
  - Conditions may be such that life has evolved on other worlds in addition to our own.
    - ancient bacteria on Mars.
      - largest moon of Jupiter, Europa, covered with ice.
    - liquid water may be underneath

Cell Characteristics

- Genetic material
  - single circular molecule in prokaryotes
  - double helix located in nucleus in eukaryotes
- Cytoplasm fills cell interior
- Plasma membrane encloses the cell
Cell Theory

- All organisms are composed of one or more cells.
- Cells are the smallest living units of all living organisms.
- Cells arise only by division of a previously existing cell.
Cell Size

- Most cells are relatively small because as size increases, volume increases much more rapidly.
  - longer diffusion time

Visualizing Cells

- Resolution - minimum distance two points can be apart and still be distinguished as two separate points
  - Compound microscopes - magnify in stages using multiple lenses
  - Transmission electron microscope - electrons transmitted through specimen
  - Scanning electron microscope - electrons beamed onto surface of the specimen
Prokaryotic Cells

- Simplest organisms
  - Cytoplasm is surrounded by plasma membrane and encased in a rigid cell wall composed of peptidoglycan.
    - no distinct interior compartments
      - gram-positive
      - gram-negative
        - Susceptibility of bacteria to antibiotics depends on cell wall structure.
Prokaryotic Cells

- Some use flagellum for locomotion
  - threadlike structures protruding from cell surface

Eukaryotic Cells

- Characterized by compartmentalization by an endomembrane system, and the presence of membrane-bound organelles.
  - central vacuole
  - vesicles
  - chromosomes
  - cytoskeleton
  - cell walls
Nucleus

- Repository for genetic material
  - Nucleolus - region of intensive ribosomal RNA synthesis
- Surface of nucleus bound by two phospholipid bilayer membranes
  - nuclear membrane
Chromosomes

- DNA of eukaryotes is divided into linear chromosomes.
  - exist as strands of chromatin, except during cell division
  - associated with packaging histones, packaging proteins
    - nucleosomes

Endomembrane System

- Compartmentalizes cell, channeling passage of molecules through cell’s interior.
  - Endoplasmic reticulum
    - Rough ER - studded with ribosomes
      - protein synthesis
    - Smooth ER - few ribosomes
      - lipid synthesis
Endomembrane System

- Golgi apparatus
  - collection of Golgi bodies
    - collect, package, and distribute molecules (e.g. proteins) synthesized at one location in the cell and utilized at another location

Endomembrane System

- Vesicles
  - Lysosomes - membrane-bound digestive vesicles
  - Microbodies - enzyme-bearing, membrane-enclosed vesicles.
    - Peroxisomes - contain enzymes that catalyze the removal of electrons and associated hydrogen atoms
Ribosomes

- Ribosomes are RNA-protein complexes composed of two subunits that join and attach to messenger RNA.
  - site of protein synthesis
  - assembled in nucleoli

![Ribosome diagram]

Organelles With DNA

- Mitochondria
  - self replicating with mtDNA
    - important to trace evolutionary lineages
    - mtDNA highly conservative (mutations not as frequent as genomic DNA (gDNA))
  - actually an independent unit
    - bounded by smooth exterior and folded interior membranes
    - interior membrane partitioned by cristae
      - folded for increase S/V for ATP synthesis
Endosymbiosis

- Endosymbiotic theory suggests engulfed prokaryotes provided hosts with advantages associated with specialized metabolic activities.

Cytoskeleton

- Network of protein fibers supporting cell shape and anchoring organelles
  - Actin filaments
    - cell movement
  - Microtubules
    - centrioles
  - Intermediate filaments
Plant Cells

- Central vacuole
  - often found in the center of a plant, and serves as a storage facility for water and other materials
- Cell wall
  - primary walls
  - middle lamella
  - secondary walls
Plant Cell

Animal Cells

- Animal cells lack cell walls
  - form extracellular matrix
    - provides support, strength & resilience
Summary

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