BIOL 200 (Section 921)
Lecture # 1
June 19, 2006

Reading: Essential Cell Biology (ECB) 2nd edition. **Chap 1** and **Chap 2, Chap 5**, pages 169-177
Background Study Material: Study Panels 2-1, 2-2, 2-3, 2-4, 2-5, 2-6, 2-7 (pages 66-79).
Good questions: 1-6, 1-7, 1-9, 1-10, 1-12, 1-18.
Assignments: 1.Make a diagram relating the relative size of a typical nucleus, mitochondrion, a bacterium and a ribosome.
2. Practice to identify the cell organelles in electron micrographs of a variety of cell types using the Image Database website: http://www.biomedia.cellbiology.ubc.ca/

Learning Objectives

- Be able to critically define cells and organelles
- Know the major classes of eukaryotic cell organelles and their functions.
- Develop a general feel for the flow of information and the flow of material in cells.
- Know the different types of microscopy and their functions
- Know the mechanism and key reactions of synthesis of macromolecules
- Know the different forces that stabilize the DNA structure

I. CELL ORGANIZATION - Structure & Function

Cells and organelles

Cells are biological structures, bounded by membrane that are capable of carrying out essential life processes such that they can maintain a stable internal environment with concentrations of molecules and ions that differ from those outside, can transform and assimilate material, and reproduce.

- Single cells can be an individual=unicellular organism
- Cells can be organized into communities=either as colonies of individuals or multicellular organisms. In multicellular organisms, cells specialize or "differentiate". All cells of an organism contain same DNA but differential gene expression leads to very different cell structures.
- Cells are divided into two fundamental types: (Panel 1-2: bacterial cell vs. 2 types of eukaryotes (animal and plants).

1. Eukaryotes (true nucleus)-typical of multicellular organisms, contain nuclei and subcellular compartments surrounded by cytoplasm. Can be unicellular (e.g. protozoans)
2. Prokaryotes (before nucleus)-bacteria, nucleic acids in cytoplasm; Prokaryotic cell – no organelles, no membrane bound nucleus, no cytoskeleton

Organelles are

- Cellular structures visible in light or electron microscope that have a regular structure and defined function.
- They may or may not be membrane limited.
- They are units of both structure and function, and are found in all cells of the same type.

Examples of organelles: nuclei, mitochondria, chloroplasts. Golgi apparatus, centrioles, chromosomes, ribosomes.
Size and function of organelles?

Organisms

Cells may or may not be organisms. Protists are eukaryotic organisms whose body consists of a single cell (example, *Paramecium* or *Euglena*).

II. MICROSCOPY

Resolution is defined as the closest spacing of two points which can be distinguished as separate entities. $R=0.61\lambda / N.A.$ ($NA=n\sin\alpha$)
where λ is the wavelength of the illumination source, and NA is the numerical aperture (light gathering ability) of the objective lens. NA is determined by the refractive index (n) of the medium between the specimen and objective lens and α is the half angle of the cone of light entering the objective.

Light microscopy has been the basis for the development of cell biology. Light microscopy involves visible light and glass lenses to form an image of the specimen. The best resolution of a light microscope is about 200 nm (0.2 um)

- Advantages: Live cells can be viewed. Images show color if specimens are stained with dyes.
- Disadvantages. Limit of resolution is 0.2 um.

Specialized types of light microscopy:

Fluorescence microscopy - uses fluorescent dyes and antibodies to bind to and detect certain proteins or other molecules. These fluorescent molecules absorb ultraviolet light and emit light of a lower wavelength. Fluorescently labeled cells glow bright against a dark background.

Confocal scanning light microscopy (CCLM) - type of fluorescent microscope: uses a laser beam to excite the fluorochrome in a thin slice called a Z-section or optical section. The light emitted by the fluorochrome is focussed on a site, i.e. "confocal", with a pinhole aperture that removes out of focus fluorescence. Allows many slices of a structure to be gathered as digital image files and then 3-D reconstructions made on the computer.

Electron microscopy-uses beam of electrons instead of beam of light. Electrons would be scattered by air molecules so all electron microscopy done in a vacuum.

Transmission electron microscopy (TEM) is highly analogous to light microscope. Beam of electrons go through thin layer of sample and are either diffracted by interacting with sample or go straight through (transmitted).
Electrons have shorter wavelengths than light. For a typical electron microscope, the wavelength of the electrons are about 0.004 nm, while the numerical aperture of an electron microscope is about 0.012, so resolution of the electron microscope about 0.2 nm

Advantages: good resolution of size range important to cells (200 nm to 0.2 nm; size from organelles to macromolecules).
Disadvantages: samples must be able to withstand electron bombardment and vacuum, so elaborate sample preparation is necessary (fixation, resin embedding, sectioning into slices 50-100 nm, heavy metal stain). Hard to reconstruct 3-D structure from 2-D slices.

Scanning electron microscopy (SEM)-beam of electrons is scanned across a sample and as it hits the sample, secondary electrons are ejected. These are collected by a secondary electron detector which electronically builds an image based on the electron intensity (from white to black).

Advantages: great for surfaces, 3-D images
Disadvantages: electrons require vacuum so most samples have to be fixed and dried.

III. MACROMOLECULES

Major points

- Macromolecules are polymers consisting of (usually) bifunctional monomers joined by a condensation reaction.
- Macromolecules typically have an overall molecular polarity.
- The sequence of monomers can be determined by either informational or non-informational systems. Both are dependent on enzymes.
- Nucleic acids and Proteins are an example of an informational macromolecules
- Polysaccharides and Fats/Lipids are examples of non-informational macromolecules

Macromolecules - Monomers and Polymers

1. What are macromolecules?

- Differ from simple molecules in that they are usually larger
- Are polymers or multimers of a number of subunits that are joined together.

2. What are the requirements of monomers (sub-units)?

- Must be bifunctional - that is, have two reactive groups that can form bonds to other molecules
- Must combine so that the original two types of reactive groups are still present. The ends of the chain of subunits carries the same types of reactive groups that were present in the original molecule.
- Must be capable of being joined by a condensation reaction that joins the 'head' of one monomer to the 'tail' of the next.
- Condensation reactions are typically driven through high energy intermediates.
    - These high energy compounds may be monomers for the reaction or
    - The condensation reaction may be coupled to degradation of a high energy intermediate in a separate coupled reaction.

3. Types of polymers

- Homopolymers - (or homomultimers) all subunits are of the same sort.
- Heteropolymers (or heteromultimers) - subunits are of different sorts. All of them share the same chemical properties that allow them to form the required bonds for the condensation reaction.

Informational Macromolecules - NUCLEIC ACIDS AND PROTEINS

Nucleic acids are involved in information storage and transfer

Protein products represent the expressed information that has to do with the organization, structure and chemical properties of proteins.

Nucleotide Structure (see panel 2-6, p. 67)

1) Sugars : DNA contains deoxy ribose, whereas RNA contains ribose
2) Phosphate group
3) Bases - DNA contains purines (adenine (A) and guanine (G)) and pyrimidines (cytosine (C) and thymine (T)). In RNA, thymine (T) is substituted with uracil (U).