**MOLECULAR CELL PHYSIOLOGY – Overview of Cell Structure & Function**

**I. The cell**
- **A. Cells are fundamental organizational units of all living things**
- **B. Types of cells**
  - **2. Prokaryotic (no true nucleus, no membrane-bound organelles)**
    - **a) Simple structure with accommodations for simplicity**
      - **1)) Nucleoid (condensed region of DNA)**
      - **2)) Mesosome (invagination of cell associated with DNA synthesis)**
      - **3)) For gram (-) cells, periplasmic space between inner & outer cell membranes**

***** Hereafter, information focuses on eukaryotes unless specified otherwise *****

  - **2. Eukaryotic (true nucleus and membrane bound organelles)**
    - **a) Plant**
    - **b) Animal**

**II. Constituents of a typical cell**
- **A. Water, inorganics, and others (sugars, vitamins, fatty acids, etc (75 to 80% by weight)**
- **B. Macromolecules including proteins, polysaccharides, and DNA (20 to 25% by weight)**
  - **1. Proteins are the most abundant and functionally versatile of the macromolecules**

**EXAMPLE OF A TYPICAL EUKARYOTIC CELL: A liver hepatocyte cell is generally in the shape of a cube, 15 micrometers per side and has a density of 1.03 g/mL. Converting to centimeters, this means the cell is 0.0015 cm per side and this number cubed (3.375 E-9) is the volume in cubic cm (also mL). With this information, it is possible to calculate cell mass since M = (D)(V). The calculation is (1.03 g/mL)(3.375 E-9 mL) = 3.476 E-9 g. If 20% of the cell weight is protein, this means each cell has (3.476 E-9)(0.20) = 6.95 E-10 g protein. Using an estimated protein mass of 52,700 g/mol (this is the average mass of yeast protein), we can figure out the total number of proteins in cells using Avogadro's number: [(6.95 E-10 g protein)/(52,700 g protein/mol)][6.023 E23 molecules / mol] = 7.95 E9 protein molecules per liver cell. If a typical cell contains 10,000 different proteins, that means a cell contains about (7.96 E9 total protein molecules)/(1 E4 different proteins) = 7.95 E5 molecules of each protein on average per liver cell. The actual range is about 20,000 (insulin-binding protein) to 5 E8 (structural protein, actin) molecules of each protein.**

**III. Cytosol vs cytoplasm**
- **A. Cytoplasm includes both the cytosol and the organelles**
- **B. Cytosol typically refers to only the liquid portion of the cytoplasm**
- **C. Cytosol also includes fibrous protein referred to as the cytoskeleton**
  - **1. Microtubules**
  - **2. Microfilaments**
  - **3. Intermediate filaments**

**IV. Organelles (eukaryotic cells)**
- **A. Cell wall (primary and secondary)**
  - **1. Plants**
  - **2. Support, structure, & protection**
- **B. Nucleus**
  - **1. Genetic information - DNA**
  - **2. Cell regulation - "the brains"**
- **C. Chloroplasts**
  - **1. Plants**
  - **2. Photosynthesis**
    - **a) Thylakoids - light capture**
    - **b) Stroma - conversion to sugar**
  - **2. Contain some DNA**

**MOLECULAR CELL PHYSIOLOGY – Overview of Cell Structure & Function (continued)**

**IV. Organelles (continued)**
- **D. Mitochondria**
  - **1. Energy from sugars**
  - **2. Contain some DNA**
- **E. Cytomembrane system**
  - **1. Packaging & transport**
    - **a) Golgi apparatus (dictyosomes)**
    - **b) Endoplasmic reticulum**
    - **c) Ribosomes**
- **F. Microbodies**
  - **1. peroxisomes - photorespiration**
  - **2. glyoxisomes - conversion of fats into sugars**
- **G. Microtubles - movement & wall synthesis**
- **H. Ergastic materials**
  - **1. Starch grains - storage**
- **I. Vacuoles**
  - **1. Storage**
  - **2. Waste**
  - **3. Water regulation**

**V. Some information about cell function**
- **A. Expression of proteins**
  - **1. DNA → [rRNA, mRNA, tRNA] → Protein**
- **B. Signaling**
  - **1. Signals interact or bind to cell surface receptors on the outer membrane**
  - **2. Signal transduction proteins (often intracellular proteins) send signal to the interior**
  - **3. Complex is activated at interior of the cell**

**VI. Cell division**
- **A. The cell cycle: interphase and mitosis (prophase, metaphase, anaphase, telophase)**
- **B. Interphase: "what a cell does for a living"**
  - **1. Regulation – what the cell will do such as muscles and exercise or red blood cells and oxygen transport**
  - **2. If more cells are needed, cell proceeds to mitosis**
    - **a) Prokaryotes: about 30 minutes**
    - **b) Eukaryotes: 10 to 20 hours**
- **C. Mitosis: prophase, metaphase, anaphase, telophase**
  - **1. Mitotic apparatus captures chromosomes**
  - **2. Pushes and pulls chromosomes to opposite ends**
  - **3. Prophase and metaphase similar in animals and plants**
  - **4. Anaphase and telophase differ in animals and plants**
- **D. Variations in the cell cycle**
  - **1. Cancer: cells multiply but are not needed**
  - **2. Tumor: unchecked cell growth**
  - **3. Apoptosis: programmed cell death**

**VII. Growth and differentiation**
- **A. Multicellularity**
  - **1. At first, group of cells resulting from division "hang out" together**
    - **a) Primitive: cells congregate together in and around an extracellular matrix**
    - **b) Plants: cells stick together with cell adhesion molecules (CAMs) and communicate through plasmodesmata**
    - **c) Animals: cells around a basal lamina (tough supporting layer underlying cell sheets) and extracellular matrix may be present**

**MOLECULAR CELL PHYSIOLOGY – Overview of Cell Structure & Function (continued)**

**VII. Growth and differentiation (continued)**

- **B. Differentiation results in varying function and morphology**
  - **1. In humans, for instance, embryo develops because**
    - **a) Genes specify pattern**
    - **b) Cell-cell interactions induce the genetic program**
  - **2. Axial symmetry (left and right sides mirror each other) is the most basic pattern**
    - **a) Result of conserved patterning of genes**
    - **b) Genes ➔ proteins ➔ influence other cell adhesion and signaling**
      - **1)) Permits integration and coordination of events in different parts of developing embryo**
- **C. In humans**
  - **1. 100 trillion (E12) cells**
  - **2. 3.16 billion (E9) base pairs of DNA in each cell**
  - **3. 100,000 genes in human DNA**