I. Introduction

A) Modern Cell Theory
(1) All organisms are composed of at least one cell
(2) All cells are similar in their chemical composition
(3) All cells are similar in their metabolic activities
(4) All cells arise from pre-existing cells
(5) The cells of any multi-cellular organism is a result of the activities/sum or the activities of its interdependent cells

B) Cell Size
(1) Range

(2) Macroscopic
(a) ostrich egg 100,000-120,000 µm
(b) chicken egg 25,000 µm
(c) frog egg 500-1300 µm

(3) Microscopic
(a) RBC 7 µm
(b) WBC 10-12 µm
(c) Human egg 140 µm
(d) Human sperm 4 µm

(4) Surface to Volume
Relationship determines cell size

(a) _________________________
1) regulates what enters/exits (boundary)
2) Must transport enough nutrients IN and wastes OUT

(b) _________________________
1) Where majority of cells chemical reactions occur, monomers used, ATP synthesized, waste produced

(c) _________________________
1) surface increases by the square
2) volume increases by the cube
3) Volume/ cytoplasm increases at greater pace than surface/ membrane so cannot transport enough nutrients IN/wastes OUT.

(d) As the cell approaches maximum size
1) _________________________
   a) Smaller cells have greater surface-to-volume ratio so membrane can maintain homeostatic balance
   2) dies--ultimate outcome of homeostatic imbalance
II. The Plasma Membrane

A) Fluid Mosaic Model of Plasma Membranes

(1) General Functions of Plasma Membranes

(a) _________________________________ Separates cytoplasm from extracellular environment

(b) _________________________________ Controls what enters/exits cell

(c) Workbench for chemical reactions _________________________________

(2) Molecular Composition of (Animal) Plasma Membranes

(a) _______________________ structure/grout holds together

(b) _______________________ tiles/mosaic—carry out different functions

(c) _______________________ maintains membrane fluidity

(d) _______________________ recognition markers (ABO blood groups)

B) Phospholipids

(1) _________________________________

(a) Water-loving
(b) Chemically interacts with H₂O
(c) Phosphate head—charged ion

(2) _________________________________

(a) Water-fearing
(b) Moves away from water
(c) FA tails not charged

(3) Phospholipids form a ______________ when mixed with water

(a) 2 layers of phospholipids
(b) FA tails sandwiched between 2 water solutions
   1) Cytoplasm
   2) Extracellular fluid
C) **Proteins—carry out the functions of the membrane!**

(1) __________________________
   (a) Pores or porins
   (b) Channels
   (c) Pumps

(2) __________________________

(3) __________________________ interact with chemical messengers to turn on/off various chemical activities of the cell

III. **Membrane Transport Mechanisms**

A) Terms
   (1) Semipermeable
   (2) Differentially permeable
   (3) Selectively permeable

B) **Transport Mechanisms**
   (1) diffusion
   (2) osmosis
   (3) facilitated transport
   (4) active transport
   (5) endo- & exocytosis

C) __________________________
   (1) (defined) movement of a substance from an area of high concentration to an area of low concentration
   (2) kinetic energy-inherent, heat

   (3) __________________________ balanced, equal throughout

   (4) Molecules that cross the plasma membrane by diffusion:
       a) hydrophobic
       b) lipid-soluble molecules
       c) alcohol
       d) respiratory gases
D) ________________

(1) movement of water across a semi-permeable membrane from an area of high water concentration to low water concentration

(2) ________________ describes the concentration of a solution outside of the cell (extracellular) as compared to the cytoplasm (intracellular)

(3) **Hypertonic solution** that has a higher solute concentration as compared to the cytoplasm/intracellular solution

(4) **Hypotonic solution**: solution that has a lower solute concentration as compared to the cytoplasm/ intracellular solution

(5) **Isotonic solution**: the solutions on either side of the membrane have the same solute concentration
E) Facilitated Transport

1. ___________________________________
   (a) Transport protein shape dictates solute that can cross membrane

2. Solute follows its concentration gradient

3. No energy input required

F) Active Transport

1. Membrane Proteins: Transport protein shape dictates solute that is actively transported across membrane

2. Solute is transported against its concentration gradient

3. Energy input required—ATP

G) Endocytosis & Exocytosis

1. **Exocytosis**—move large amounts of substances OUT of cell, vesicle moved to membrane

2. **Endocytosis** (phagocytosis)-opposite of exocytosis

IV. Organelles

A) Cytoplasm:
   1. cyto = cell, plasm = jelly-like
   2. includes everything within cell except nucleus
   3. Structure/composition:
      (a) water
      (b) monomers
      (c) energy
      (d) macromolecules
      (e) other organelles

B) Nucleus

1. General Functions:
   (a) stores/houses/protects genetic information
   (b) Site of DNA replication
   (c) Site of DNA transcription

2. **Nuclear membrane/envelope**
   (a) structure: double membrane
   (b) Function: regulate what enters/exits nucleus

3. **Nuclear Pores**
   (a) structure: membrane proteins
   (b) function: transport proteins
(4) **Chromatin**
   (a) structure: DNA and proteins
   (b) function: unpackaged DNA, genetic code is accessible

(5) **Nucleolus**
   (a) structure: DNA, RNA *and proteins*
   (b) Function: ribosome synthesis

C) **Ribosomes**

   (1) Structure: RNA and Proteins
   (2) Function: protein synthesis
   (3) Location:
      (a) Associated with endoplasmic reticulum
      (b) Free-floating within cytoplasm

D) **Endoplasmic Reticulum**

   (1) **Smooth Endoplasmic Reticulum**
      (a) *structure*: membrane
      (b) *function*:
         1) lipid synthesis
         2) Alcohol detoxification

   (2) **Rough Endoplasmic Reticulum**
      (a) structure: membrane and ribosomes
      (b) function: protein synthesis

E) **Golgi**

   (1) structure: stack of flattened membranes
   (2) Function: macromolecule modification, processing and packaging

F) **Vesicles**

   (1) Structure: membrane bound sacs filled with molecules
   (2) Transport and storage of molecules within cell

H) **Endomembrane System**
G) Mitochondria
   (1) structure: Double-membrane organelle
   (2) Function: Aerobic cellular respiration

H) Lysosomes
   (1) structure: membrane bound sac containing degradative enzymes
   (2) Function: degradation/digestion

I) Cytoskeleton
   (1) structure: fibrous proteins
   (2) Function:
      (a) Movement
      (b) Anchorage site for organelles
      (c) Maintain Cell shape

   (3) Cilia: hairlike appendages that sweep substances across a surface
   (4) Flagella: locomotion
   (5) Centrioles move DNA (chromosomes) during cell division

V. Cell Cycle & Mitosis

A) Cell Cycle: all the stages a cell passes through from it’s formation until it divides

B) Interphase
   (1) 90% of cell’s life cycle
   (2) Metabolic activities

C) __________________________ type of nuclear division resulting in genetically identical daughter cells or clones

   (1) Prophase
      (a) Nuclear envelope is disassembled
      (b) Chromatin condenses or packaged into chromosomes
      (c) Centrioles assembled

   (2) Metaphase
      (a) Centrioles have migrated to opposite poles
      (b) Chromosomes are aligned at cell’s equator
(c) spindle (microtubule) apparatus is assembled

(3) Anaphase: chromosomes are distributed to opposite poles

(4) Telophase
   (a) nuclear envelope/membrane is reassembled
   (b) chromosomes uncondense into chromatin
   (c) nucleoli become visible
   (d) centrioles and spindle apparatus is disassembled

D) Cytokinesis: a new membrane is built/formed separating the cytoplasm in the formation of daughter cells

VI. DNA Replication & Protein Synthesis

A) DNA Structure: Watson & Crick

(1) Double stranded
(2) 2 polymers of nucleotides
(3) Sugar-phosphate backbone
(4) Double helix

(5) Base-pairing rules AGCT

   (a) __________________________
   (b) (double ring)-(single ring)

(6) complementary
(7) Hydrogen bonds
(8) Equidistant

B) Chromatin vs. Chromosomes

(1) __________________________ structure of DNA in a nondividing cell

(2) __________________________Condensed DNA in a dividing cell
C) DNA Replication

(1) Text:
(a) DNA Replication is semiconservative

(b) DNA replication is a process whereby the parent DNA molecule is used as a template to synthesize two daughter DNA molecules. At the end of DNA replication, each DNA molecule is composed of one parental strand of DNA and one newly synthesized (daughter) strand of DNA.

(2) Figure:

(a) DNA Topoisomerase
(1) enzyme
(2) changes shape of DNA molecule
(3) Breaks H-Bonds holding 2 strands together

(b) DNA nucleotides diffuse between parental DNA strands and H-bond to parental strands

(c) DNA Polymerase
(1) Enzyme—makes polymer of nucleotides
(2) catalyzes the sugar phosphate bond on new strand
(3) proofreads—base pairing rules
D) Protein Synthesis

(1) Central Dogma of Protein synthesis

(a) _______________ segment of DNA that codes for a polypeptide

(b) **Polypeptide**: chain of amino acids

(2) **3 types of RNA**

(a) mRNA (message RNA) RNA which carries the genetic code from the nucleus to the cytoplasm

(b) tRNA (transfer RNA) RNA which brings a specific amino acid to the ribosome to be added to the growing polypeptide

(c) rRNA (ribosomal RNA) Ribosome/organelle which builds the polypeptide

(3) **Transcription**

(a) location: nucleus

(b) **Gene**

1) segment of DNA that codes for a polypeptide.
   a) one strand
   b) code is sequence of N bases

2) **Gene Structure**

```plaintext
C A T T A C G T T A C G T T G A C T G G G
```

a) ______________ sequence of nucleotides RNA polymerase recognizes to initiate transcription

b) ______________ sequence of Nitrogen bases that identifies the amino acid sequence of a protein

c) **Terminator (sequence)**: sequence of nucleotides that RNA polymerase recognizes as the end of transcription
3) Events of Transcription

C A T T A C G T T A C G T T G A C T G G G

a) RNA polymerase
1. Enzyme
2. Recognizes promotor
3. Binds promotor
4. Creates sugar phosphate back on new RNA molecule that uses the DNA/gene as a template
5. Base pairing rules

b) At end of transcription
1. RNA polymerase finds another promotor to begin transcription
2. mRNA molecule transported to cytoplasm

4) Translation

a) location: cytoplasm

b) codon table used to determine amino acid sequence in polypeptide.
1. codon: triplet of nucleotides, code for a single amino acid

A U G C A A U G C A A C U G A

2. Each N base assigned position—1\textsuperscript{st}, 2\textsuperscript{nd}, 3\textsuperscript{rd}
3. Find A, first position, column #1 on table
4. In the columns for the second position, find U
5. In the last column, find G in the row that overlaps and that is the amino acid encoded by AUG.

Note: You will be asked to provide the polypeptide for a gene on an exam. You will need to USE the codon table, do NOT memorize the codon table (it WILL be provided to you).
(c) **tRNA brings the amino acid to ribosome-mRNA complex.**

1) if anticodon and codon complement, amino acid added to growing polypeptide chain

2) Codon and anticodon must base pair for tRNA to release

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<th>Third Position</th>
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<tr>
<td>valine</td>
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</tr>
</tbody>
</table>

![Diagram of tRNA binding to mRNA](image)

(c) tRNA brings the amino acid to ribosome-mRNA complex.

1) if anticodon and codon complement, amino acid added to growing polypeptide chain

2) Codon and anticodon must base pair for tRNA to release
(d) **Ribosome**: positions the mRNA and tRNA to check complementarity between codon and anticodon, if base-pairing correct, ribosome helps to make peptide bond between amino acids of the growing polypeptide

(e) codon table is described as being ‘degenerate’ or ‘redundant’

(f) **Mutation** change in the nitrogen base sequence of a gene

**Note**: ultimate source of diversity