How to get the most of this book

Design of the Notes

This book is designed to help you improve your note-taking skills and help you to focus your studying. The notes are divided into each testing section or unit. Each section begins with outlines for each lecture topic which also provides a great way to review the material before your test. If you can explain the headings of the outline, you are probably in pretty good shape for the test.

Within each unit, the notes are separated into lecture topics. For the most part, we'll be covering one a day. I've left space for you to fill in definitions, figures or notes. Be sure you are following along so you know what you need to fill in.

Before class, review the notes we are going to cover (topic in syllabus) so you know what we will be covering that day. After the first day, you should have an idea of how many pages we cover a day, so you can just review the next couple of pages each lecture day. If you do this, you'll have an idea of what you need to fill in yourself, the key words you may have to write definitions for and the flow of the material.

Comparing with the book

These notes are sectioned by topic, not by textbook chapter. Textbooks are not novels, you don't have to read every page and you don't have read the book from start to finish. Compare the topic we are going to cover in class with the chapter I listed in the syllabus. Flip through the textbook before you come it, or at least read over the Chapter Review. After class, sit down with the notes and the book and review the material. A good way to start is to look at the figure in the textbook and see if you can explain what it means.

Study Questions

I've included questions at the end of each lecture topic so you can get a head start on the material. I recommend reviewing them directly after we talk about them in class. In your syllabus you can see that if you answer the questions for all the topics in a unit you can earn points along with increasing your understanding of the material. It is not an answer key! It is designed to help you focus your studying.

What is the Study Guide Assignment?

Before each exam, you will be given a list of questions to answer to earn points while you review. These questions will be similar to the questions at the end of each lecture topic. There may be a few questions that are different from these, but the ones at the end of the notes will help you prepare.

To earn full points on the assignment, you have to (1) give each section it's own page, (2) write out each question and then (3) answer each question completely. That means some answers maybe a word and some maybe a sentence. The more complete the answer, the better the chance are that you will choose the correct answer on the exam.

UNIT ONE – SCIENCE TO CELLS

Introduction to Science

I. Science as a way of learning
   a. What is Science?
II. What is Biology?
   a. Characteristics of Living Things
   b. Levels of Organization
III. Special Qualities of Biology
   a. Evolution as Unifying Principle
IV. Scientific Method
   a. How does it work?

Chemistry & Life

I. How we use Chemistry and Physics
II. The Atom
   a. Background
   b. 3 parts
   c. Forms of matter
III. Chemical Bonding
   a. Definition
   b. Stability
   c. 3 types of bonds
IV. Why Water is Important
   a. Cohesion & surface tension
   b. Specific heat
   c. Aqueous solutions
   d. Ice
   e. Hydrophilic/phobic
V. Acids/Bases (pH)
   a. Definitions
   b. How it works
   c. pH scale

Application of Chemistry: Molecules

I. Carbon
   a. Importance
   b. Shapes& Forms
II. Biological Molecules
   a. Polymers vs. Monomers
   b. Carbohydrates, Lipids, Proteins, Nucleic Acids

The Cell: Working Units of Life

I. Two Categories: Prokaryotic vs. Eukaryotic
II. Eukaryotic Cell
   a. Two types of Eukaryotic cells
III. Animal Cells
   a. Plasma Membrane
   b. Organelles
IV. Plant Cells
   a. Differences between Animal & Plant cells
V. Cellular Communication
   a. Plant Communication
   b. Animal Communication

How Cells Work: Introduction to Energy

I. Energy is Central to Life
   a. Pathway of Energy
II. What is Energy?
   a. Definition
   b. Forms
   c. Thermodynamics
III. How is Energy Used by Living Things?
   a. Efficiency
   b. Kinds
   c. Up and Downhill
IV. The Energy Currency Molecule: ATP
   a. What is it?
V. Efficient Energy Use in Living Things: Enzymes
   a. Lowering the Activation Barrier through Enzymes
VI. Membrane Functions
   a. Diffusion & Osmosis
   b. Transport Mechanisms
   c. Moving Big Stuff in & Out

Lab Hints:

Review the Summary questions and the words in bold in each lab
Try making a page for each lab with a summary of what you did
Be sure you can identify the parts of a microscope, the cells (both plant and animal)

I. What is Science?

- Two ways of looking at science: -→ Science is a way of learning and a body of knowledge

- Two features that distinguish sciences
  - Dependence on observation & measurements others can verify
  - Ideas are testable by experiments that others can repeat
- What's a theory?
  - A general set of principles, supported by evidence, that explains some aspects of nature

II. What is Biology?

- Basically the study of life
- We say things are living if: (fig)
  - Order: all living things are complex and organized
  - Regulation: can maintain *homeostasis* – constant internal environment
  - Growth and Development: Possess *DNA* (inherited information) to function
  - Energy utilization: can transform food into energy
  - Response to environment: can respond to stumli
  - Reproduction: can reproduce through information in DNA & make more cells
  - They evolved from other things
- Life is Also Organized in a Hierarchical Manner
  - Hierarchical
    - Lower levels of organization are integrated to make up higher levels
    - Office example in text – offices, departments, divisions
  - Levels of organization (fig)
    - Atoms – building blocks of matter
    - Molecules – atoms come together to form molecules
    - Organelles – tiny organs; mitochondria (energy transfer)
    - Cells – *living*: can do the things on the list
    - Tissues – collection of cells, different types
    - Organ – functional unit (heart: muscle and nerve tissue)
    - Organism – an assemblage of cells
    - Population – many organisms
    - Community – all the living things in an area
    - Ecosystem – all the communities & the physical environment

  - Three Domains
    - Bacteria - prokaryotic cells, small, old
    - Archaea – prokaryotic cells, small, live in extreme conditions
    - Eukarya – eukaryotic cells

III. Special Qualities of Biology

- The study of natural history led to life sciences like biology
  - Started out as descriptive studies, then they began to formulate theories
  - Differs from physics in many ways
- Evolution is the Unifying principle
  - Darwinian's thought process
    - Natural Selection as modes of speciation – what does that mean?
    - Family Tree
  - Means gradual modification of populations of living things over time
  - Can result in new species
  - Central theme because every living thing has been shaped by evolution
  - Helps to pull together why the planet is so diverse and unique
    - If they were shaped for a purpose, to ensure species proliferation, that makes more sense

IV. Scientific Method - Science as a process (fig)

- Definition: a means of coming to understand the natural world through testing of hypotheses
- Two features
  - Dependence on observation and measurement that others can verify
  - Ideas (hypotheses) are testable by experiments that can be repeated
- Steps:
  - Observations
  - Questions: what, why, or how
  - Hypotheses: a tentative, testable explanation for an observed phenomenon
    - Best if you have multiple possibilities or explanations
  - Experiment/Testing the hypotheses
    - Variable – adjustable condition in the experiment
      - Control stays constant
    - Other means of supportive evidence
      - Dinosaur- bird relation is untestable, can only use DNA to make inferences
  - Conclusion
    - Theory as to why you achieved those results
    - Reproducible
      - Will someone else find what you did, given the same material and methods?
    - Falsifiable
      - Open to negotiation through scientific inquiry
  - Nothing is ever proven in science, only suggested

Study Questions: Basic Science Knowledge

What is science? What is biology? Who can learn science?
What are the characteristics for what is living?
What are the levels of organization? What are examples of each?
What is the unifying principle of biology? Why does it unify?
What is the scientific method? What are the steps involved?
How do you set up an experiment?

I. Aspects of Physics & Chemistry that Apply to Biology

A. Every thing you see is Matter or Energy
   a. Matter – anything that takes up space and has mass
      i. *Mass* measures the quantity of matter in an object and is defined by:
         1. *Volume* is how much space it takes up
         2. *Density* measure concentration of matter

II. The Atom

A. Background
   a. First thought that all matter was earth, air, water and fire by Plato
   b. Democritus - substances were made up of invisible, indivisible "atoms"
      i. Around the same time
      ii. Not really indivisible
         1. Stanford's Linear Accelerator – smashes atoms

B. Three parts of an atom, have electrical charges (fig.)
   a. Protons - positively charge
      i. Tightly packed in the nucleus (core) with neutrons
      ii. Number elements have different number of protons
         1. Gold-79
         2. Iron-26
   b. Neutrons – neutral charge
      i. Number can vary, not dependant on the number of protons
   c. Electrons – negatively charged
      i. Move around the core some distance away
      ii. If atom is of neutral charge: number of electrons = number of protons
      iii. Important for bonding atoms together → make molecules
   d. *Atomic Number* -the number of protons
      i. Also it's place on the periodic table
      ii. Hydrogen is first, with 1
   e. *Atomic Mass* - only the protons and neutrons, not electrons

C. Forms of Matter
   a. Elements
      i. A substance that cannot be reduced to any simpler set of component substances through chemical processes
      ii. Defined by the number of protons in its nucleus
         1. Can't break the protons/neutrons apart to make other atoms
      iii. Alloy – combination of different elements like gold, silver and copper
   b. Isotopes (fig)
      i. Makes atomic number not as simple as it may seem
         1. Protons and Neutrons in the nucleus
         2. Neutrons can vary independently of the number of protons
         3. Neutrons add weight to the atom
      ii. Isotopes have the same number of protons, different number of neutrons
      iii. *Atomic weight* is the average mass of all the isotopes

III. Chemical Bonding → Matter Transformation

A. Process of chemical combination and rearrangement through shifting electrons

B. Quest for stability – need to bond with other atoms

a. Atoms have energy levels with electrons → draw it

i. First has two electrons surrounds the nucleus (protons and neutrons)

ii. Each other has eight electrons

iii. Need outer shell (valence) to be full to be stable

1. Ex: Carbon (6 total) has 4 in outer shell so it needs 4 to be stable

C

b. Unreactive vs. Reactive

i. Unreactive: outer shell is already full so unlikely to bond with other atoms

ii. Reactive: unfilled outer shell, looking of other atoms to fill unstable

C. Three Main Types of Bonds

1. Covalent Bond

i. Two atoms shared electrons in outer shell

ii. Example: Water

1. Explain starting with oxygen, point on the number of electrons in outer shell

O

H H

2. 2 H + 1 O → 8 total electrons in oxygen shared w/ hydrogen

a. Makes mickey mouse looking molecule

i. Hydrogen on one end

iii. Makes a molecule

1. A defined number of atoms in a defined spatial relationship

2. Molecular formula → H_20

iv. Polar and Nonpolar Covalent bonds

1. In Water Molecule, oxygen has *electronegativity*

a. Pulls electrons to itself

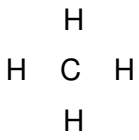
2. Polarity

a. means the molecule has a different electrical charge at one end as opposed to the other (nonsymmetrical)

b. Electrons are negatively charged & closer to the oxygen end, that end has a slight negative charge

How does this affect water molecule? – add charges to drawing

3. Nonpolar
    a. Symmetric electrons, around the nucleus
    b. Shared equally between the two + atoms
    c. Ex: Methane $4H + C \rightarrow CH_4$



v. Free Radicals
    1. Covalent bond that leaves 1 atom with an unpaired electron
    2. Antioxidants (vitamins ACE) theoretically destroy these
    3. Linked to some cancers

2. Ionic Bonding (fig.)
    a. One atoms gives up an electron to the other
    b. Differences in electronegativity in atoms causes one to pull an electron from the other one
        i. Ex: Sodium and Chloride (NaCl, or table salt)
            1. Na has the 1 in the outer ring
            2. Cl has 7
                a. Na loses an electron to chloride becoming Na+ (ion)
                b. Cl gains the electron becoming Cl- (ion)
        ii. They are attracted to each other due to opposite charges
        iii. Millions of atoms are attracted to each other forming salt
            1. Whole collection is called an *ionic compound*

Na Cl → Na Cl

3. Hydrogen Bonding
    a. A positive hydrogen atom of one molecule is weakly attracted to the negative, unshared electrons of the oxygen neighbor
        i. So continually breaks and rebonds with oxygen molecules
        ii. Leads to surface tension
            1. More activity at air-water interface

    b. Usually oxygen or nitrogen
        i. Both are polar covalent bonds
        ii. Remember carbon was non-polar

IV. Importance of Water

A. Earth and humans are mostly water (71-66% respectively)
B. Cohesion of water where air meets the water
    i. Cohesion leads to surface tension
        1. Water molecules only attracted to the sides & down, not up
        2. Why some bugs can walk on water & why water forms drops
        3. Have surface tension in your lungs that can effect stretch

C. Specific Heat –water holds a lot of energy
    i. It's a good insulator because it has high specific heat
        1. Comparatively, it takes a relatively large amount of energy to raise the temperature of water
    ii. Temperature measures heat (movement of molecules)
    iii. Water helps us keep homeostasis – constant temperature
        1. Sweat releases heat from the body via water
            a. Droplets can hold a lot of heat

D. Water as universal solvent – Aqueous solutions
    i. A solute dissolved in a solvent makes a solution!
        1. Solute: what's being dissolved (salt)
        2. Solvent: in what it's dissolving (water)
    ii. Solution: a homogenous mixture of two or more kinds of molecules, atoms or ions
        1. Nonpolar solutes dissolve in Nonpolar solvents
            a. Water & salt are polar so dissolve
            b. Soap & grease are Nonpolar so soap breaks up grease
        2. Something's are water-soluble and some are fat-soluble for structures
    iii. Aqueous solution – water as the solvent
        1. Breaks down the bonds of compounds that are placed in it
        2. Water molecules surrounds each atom to prevent rebonding
        3. Dissolves more things than any other liquid

E. Ice (fig)
    i. Less dense than water so it floats!
        1. More space between bonds (space further apart)
        2. Ice caps melting will increase water level
        3. Freeze ice, water rises (ice cube tray example)
        4. Insulates the water beneath from freezing temperatures
            a. Ice-fishing: fish live under the ice even though the ice is frozen
            b. Keeps the water under the ice warmer than air

F. Hydrophilic vs. Hydrophobic
    i. Hydrophilic
        1. Compounds that will interact with water Na^+ & Cl^-
    ii. Hydrophobic
        1. Compounds that don't interact with water
            a. Means they don't mix (water and oil)
        2. Skin is not water permeable, like gortex

V. Acids and Bases

a. Aqueous solutions have a certain amount of either acids or bases
   i. Acid
      1. Any substance that yields hydrogen ions when put in solution
   ii. Base
      1. Any substance that accepts hydrogen ions in solution

b. How it works (fig)
   i. $HCl + H_2O \rightarrow$ dissociates into H^+ and Cl^-
      1. HCl yields hydrogen ions (H^+) so its more acidic

   ii. $NaOH + H_2O \rightarrow$ dissociates into Na^+ and OH^-
      1. $NaOH \rightarrow OH^-$ - negatively charged hydroxide ion will readily bond with positively charged H ions
      2. They accept H ions in solution
      3. Takes up H and just makes more water
         a. Not enough OH/H to keep it all water so it's basic!

c. pH scale
   i. pH number:
      1. Concentration of H^+ ions in solution
         a. Net effect of hydrogen ion yielding & accepting
         b. How of pH is quantified and given a number
   ii. Logarithmic scale
      1. pH of 9 is 10x more basic as 8 & 100x more basic as 7
   iii. Terms of pH
      1. Higher pH = more basic
      2. Alkaline also means basic
      3. Acids are also called proton acceptors in biology
   iv. Importance of pH
      1. Lots of living things are sensitive to pH
         a. Enzymes will change shape in acidic solutions
         b. Asthmatics have acidic breath,
            i. Acidity increases airway restriction
   v. Buffer systems
      1. Most things live at ~ pH 6-8
      2. Body has systems to keep the pH more constant
         a. Work to neutralize the infusion of an acidic or basic solution
         b. Usually involves the accepting or donating of H+
         c. Digestive system
         d. Stomach is acidic, but still stays a constant (pH 2)

Study Question for Chemistry – Review Homework to help you understand material

Define Atomic number, mass, isotope
What is atomic number, atomic mass, how can you determine how many electrons there are?
What is the fundamental **difference** between covalent and ionic bonds?
A substance that cannot be reduced to any simpler component of substance is called a..
Why do water molecules stick together? Can you apply it?
What are the unique properties of water? How are they used by living things?
A solution is made up of a solute + a solvent. What does each mean?
What does hydrophobic and hydrophilic mean?
Why does pH matter? Can you apply your knowledge of pH?
Compounds that help to prevent drastic changes in the pH of a solution are called:

I. Organic means it's made of Carbon

a. Life is based on carbon compounds in water (like flour in baking)
b. Bonding capacity
    i. Since it has 4 valance electrons, it can bond 4 more electrons
    ii. Bonds are covalent – more stable because they share electrons
c. CH_4

d. Chain - C_3H_8

e. Isomers
    i. Two forms of the same chemical formula

f. Benzene Ring – C_6H_6
    i. Double bonds between C and C

II. Biological Molecules

a. Monomers are the small building blocks of Polymers
    i. Hydrolysis – too break with water
b. Carbohydrates (end with –ose) - Contains carbon, oxygen and hydrogen:
    i. Have 2x the H as O
    ii. Monosaccharides: Glucose: $C_6H_{12}O_6$
        1. Most important energy source
        2. Can be built into disaccharides: lactose, sucrose

    iii. Polysaccharides (fig) – many sugars together
        1. Starch
            a. How plants store carbohydrate
            b. Potatoes, rice (seeds), corn, wheat, carrots (roots)
        2. Glycogen
            a. How animals store carbohydrates
            b. Carbohydrate loading: glycogen loading
        3. Cellulose
            a. Cellulose is not digested by enzymes, only bacteria
            b. Insoluble fiber: move things through GI tract
        4. Chitin
            a. Forms the exoskeleton of arthropods

c. Lipids
    i. Still oxygen, carbon and hydrogen: just has more H than O than Carbs
    ii. Fats, oils, cholesterol, hormones
    iii. No monomer that they are all made up of
    iv. Relatively water insoluble: make good internal containers
    v. Three Classes of Lipids
        1. Glycerides - most common kind of lipid
            a. Two parts
                i. Head = glycerol
                ii. Tail = fatty acids chain of C & H
            b. Glycerol to Glyceride
                i. Alcohols have OH group on it
                ii. Together = Glyceride
                    1. 2 = diglyceride; 3 = triglycerides
            c. R chain determines Saturation level (fig)
                i. How many Hydrogens they contain
                ii. Saturated = no double bonds
                    1. Linked to heart disease via high cholesterol
                iii. Monounsaturated = one double bond
                iv. Polyunsaturated = more than one double bond
            d. Fats (margarine) from Oils (vegetable oil)
                i. Hydrogenation: decreases the number of double bonds
                ii. Saturated fats line up so they "stack" better & make things more solid
                iii. Polyunsaturated fats don't stack so they stay liquid at room temperature
            e. Energy Storage (fig)
                i. Can be used to store energy and insulate body

        2. Steroids (fig.)
            a. Smaller lipid with a slightly different structure → 4 Carbon rings
            b. Cholesterol (not all bad!)
                i. Breaks down fats
                ii. Builds outer membranes of cells
                iii. Precursor to steroid hormones:
                    1. Testosterone (male hormone)
                    2. Estrogen (female hormone)
                    3. Commercial steroids = male hormones

        3. Phospholipids (fig)
            a. Like triglycerides but has two fatty acid tails (not three)
                i. Hydrocarbon tail = hydrophobic
            b. Phosphate group (phosphorus atom with 4 oxygens around it) attached to the OH group of glycerol
                i. Phosphate group (has charge) so its hydrophilic
            c. Becomes phospholipids bilayer for cells to contain water

d. Proteins
    i. Types of Proteins
    ii. Parts of proteins
        1. Amino acid chains (monomer) – building block
            a. Amino group and a carboxyl group attached to a carbon
            b. R group defines amino acid (fig)
            c. 20 total amino acids that all proteins
                i. Acid chain are in different orders
                ii. Join together in the same way (fig)
                    1. Lose water
        2. Polypeptide (polymer) – chain of amino acids
        3. Folded in 3D way → protein

    iii. Shapes of proteins
        1. Function of the protein is based on it's configuration
            a. Needs to fit with the receptor correctly to do it's job
    iv. Four Levels of Proteins (fig.)
        1. Primary – chain of amino acids
            a. The order determines the rest of the shape

        2. Secondary – simple shapes
            a. Alpha helix of DNA
            b. Pleated sheet
            c. Random coil
        3. Tertiary – folded polypeptide chain

        4. Quaternary – two + polypeptide chains

    v. Denature
        1. Changes the shape of protein → changes function
            a. Alcohol changes the shape and function of bacteria
    vi. Lipoproteins and Glycoproteins
        1. Lipoproteins
            a. Made up of a protein capsule surrounded by fat
            b. Two types based on ratio of protein to lipid
                i. HDL – high density lipoprotein
                    1. Carry cholesterol: outlying cells → liver
                ii. LDL – low density lipoprotein
                    1. Carry cholesterol: liver → outlying cells
                    2. Brings to coronary arteries of the heart and builds "plaque"
        2. Glycoproteins
            a. Carbohydrates and proteins
                i. Receptor of proteins
                    1. Sit on cell surface
                    2. Ex: insulin

e. Nucleotides & Nucleic Acids
    i. Nucleotides, like adenosine phosphates, serve as energy carriers
        1. Ex: ATP
    ii. Where does the cell get information to make proteins, etc?
        1. DNA – deoxyribonucleic acid
            a. Information center of a cell: directions for everything
                i. 3 billion nucleotides in our main DNA molecules
                ii. Each cell has a copy
        2. Ribonucleic acid (RNA)
            a. Moves the DNA encoded information to the place in the cell where proteins are made
        3. Nucleotide
            a. Structural unit (monomer) for DNA (fig 3.25)
            b. Three parts
                i. Phosphate group
                ii. Sugar (deoxyribose)
                iii. Base
            c. One links to another and forms a chain
            d. Two chains come together to form double helix
                i. Chains “run” in opposite directions
            e. This is what Rosalind Franklin didn’t figure out

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Study Questions for Biological Molecules

What is a monomer? Polymer?
What makes something organic?
What are the four basic types of biological molecules? What are their monomers? Polymers?
How can you tell what type of molecule something is by it’s spelling?
What makes a lipid saturated or unsaturated?
What are the stages of protein folding?
What types of carbohydrates are digestible by us? Which aren’t?

I. General Information

a. Must be produced by other cells
    i. Can't be made in a lab
    ii. Linked to cells 3.5 billion years ago
    iii. Cells are specialized for different jobs

II. Two Categories: Prokaryotic vs. Eukaryotic

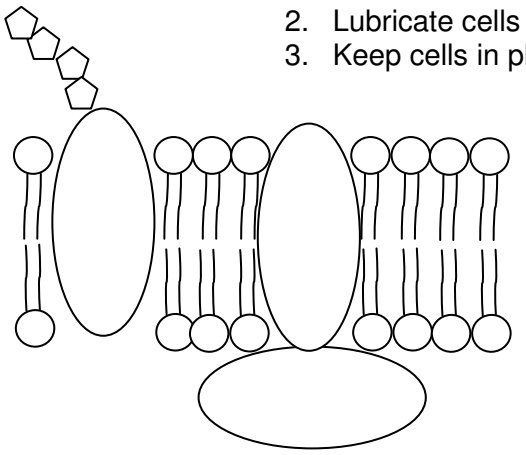
a. Prokaryotic
    i. Either way bacteria or microscope form of life (archea)
    ii. DNA localized in nucleoid region no nucleus
    iii. Mainly single-celled
    iv. Can live with or without oxygen some are poisoned by oxygen
    v. Older more abundant
b. Eukaryotic
    i. All others (plants, animals, fungi, and protests)
    ii. Eukaryotic means true nucleus bound within a thin membrane that contains almost all DNA in cell
    iii. Larger than prokaryotic
    iv. Often multicelled organism
    v. Most are aerobic → need oxygen to exist
c. Compartmentalization in Eukaryotic (internally specialized)
    i. Has organelles "tiny organs"
    ii. Internal compartments that are absent almost altogether in prokaryotes
    iii. Eukaryotes employ mitochondria to transform energy from food

III. Eukaryotic Cell

a. Two types of Eukaryotic cells:
    i. Animal cells
    ii. Plant cells
b. Both have:
    i. Nucleus – a membrane-lined compartment that serves as the cell's information center
    ii. Organelles – outside nucleus
    iii. Cytoplasm – region outside nucleus
    iv. Cytosol – protein-rich; jelly like outside nucleus
    v. Cytoskeleton – a kind of internal scaffolding that has different kinds of units
    vi. Plasma membrane – outer boundary of cell

IV. **Boundary of the Cell**

a. Plasma Membrane (Fluid Mosaic) Functions
    i. Keeps important things in
    ii. Keeps bad stuff out
    iii. Controls passageway of necessary molecules
    iv. Interprets signals from other cells
b. Phospholipid Bilayer (fig)
    i. 2 long fatty-acid chains – hydrophobic
    ii. Phosphate bearing group – hydrophilic
        1. Point outward, toward water of extracellular fluid and cytosol
    iii. Only hydrophobic molecules (and small hydrophilic molecules) can pass
        1. Lets things like steroids in
        2. Keeps hydrophilic substances out: ions, polar molecules, etc.
c. Cholesterol
    i. Act as a patch substance on the bilayer, keeps out small molecules
    ii. Keep the membrane at an optimum level of fluidity
d. Proteins
    i. 2 major types
        1. Integral -from side to side or partway in membrane
        2. Peripheral - lie on either side of membrane
    ii. Functions
        1. Structural Support
            a. Peripheral proteins help connect membrane to cell by being attached to cytoskeleton
        2. Recognition/Transport
            a. Binding sites tell molecules if they can pass, or not
            b. Certain proteins respond to certain molecules, not all
                i. Very specific with what they interact with
            c. A cell with a *foreign* set of binding sites will be destroyed by the immune system
        3. Communication
            a. Receptor proteins – for cells to communicate with each other
                i. Hormones, electrical charges, etc.
            b. Changes cells activity
e. Glycocalyx – “sugar coat”
    i. Carbohydrate or Sugar-side chains
    ii. 3 Main Functions
        1. Serve as binding sites for proteins
        2. Lubricate cells
        3. Keep cells in place by sticking to something



V. What's inside the Cell

a. Good Way to Learn Parts → Protein Export (fig.)
    i. Nucleus (fig.) – Control Center
        1. DNA is largely confined here
        2. Defined by nuclear envelope: double membrane
        3. Each cell needs to have its own copy of DNA through duplication
        4. Nucleolus → part of the nucleus designed to make ribosomes from rRNA (ribosomal RNA)
    ii. mRNA – Messenger RNA
        1. DNA instruction is copied onto the mRNA,
        2. Leaves nucleus through the nuclear pores
    iii. Ribosomes – "work benches" of protein synthesis (fig.)
        1. mRNA moves to ribosome & starts to read information
        2. If the protein will be used in the cell makes protein in cytosol
        3. If the protein will be used in the cell membrane or will exported:
            a. Ribosome moves to Endoplasmic Reticulum (ER)
    iv. Rough Endoplasmic Reticulum -
        1. Means: *network within the cytoplasm*; rough has ribosomes attached
        2. Produces an amino acid inside ER membrane
            a. Cisternal Space → where the polypeptide chain folds up and sugar side chain is added
                i. Cisternae – membranous sacs
            b. Also gets rid of chains that are defective
            c. Protein in membrane can *bud off* and then fuse to another membrane-bound organelle
    v. Transport Vesicles → endomembrane system
        1. Moves proteins around
    vi. Transport Vesicles then bind to Golgi Apparatus for processing & sorting
        1. Sugars are trimmed, or phosphate groups are added
        2. Reads proteins and routes to the right place
        3. Protein moves to plasma membrane for export
            a. Exocytosis – leaves cells

b. Other parts
    i. Smooth ER
        1. No ribosomes, not for protein synthesis
        2. Lipid synthesis & detoxification
    ii. Lysosomes (fig.)
        1. Fuse to worn-out organelles, break them into smaller pieces
        2. Use enzymes to digestion old organelle
        3. Waste, non-renewable parts are expelled
    iii. Mitochondria (fig.)
        1. Place where ATP, water & carbon dioxide is made from food & oxygen

c. What gives an Animal cell structure? Cytoskeleton (fig.)
        1. Proteins strands that give cells there shape
        2. 3 component parts
            a. Microfilaments – slender shape
            b. Intermediate filaments
                i. Stabilizes position of organelles & nucleus, cell shape
            c. Microtubules
                i. Determine cell shape
                ii. Move vesicles between organelles
                iii. Underlying structure for cilia & flagella for cell movement

VI. Plant Cells (fig.)

a. Differences btwn Animal & Plant cells
    i. Thick Cell Wall
        1. Plasma membrane is thin and frail
        2. Cell wall is thick & rigid → plants are stationary
            a. Provide structure strength
            b. Limit water absorption
            c. Protect plant from outside influences
        3. Made of cellulose & lignin (very strong)
        4. Can be sites of metabolic activity too
    ii. Central Vacuole
        1. Can be 90% of cell volume
        2. Mainly water
        3. Also: stores nutrients, involved in metabolism & retains or digests waste products (like Lysosome)
        4. Can contain pigments too
    iii. Plastids (chloroplasts)
        1. Only in plants and algae
        2. Give color to plants → Chloroplasts
            a. Contains chlorophyll
            b. Sites of photosynthesis:
                i. Sunlight + CO_2 → Glucose + H_20 + O_2

VII. Cellular Communication (fig.)

a. Remember cells together make up tissues
    i. Have to talk amongst themselves
b. Plant Communication
    i. Talk through plasmodesmata - channels in the cell wall
        1. Cytoplasm is continuous between cells
c. Animal Communication
    i. Cell/Gap junctions – let cells communicate with each other
        1. Passage of small molecules and electrical signals
        2. Only open when necessary

Study Questions for the Cells and their functions

What are the different types of cells?
What are the differences between eukaryotic & prokaryotic cells?
What are the parts of the plasma membrane? Why is it called a fluid mosaic model?
What are the functions of each part of the membrane?
What are the organelles found in an animal cell? Plant cell?
What are the functions of each organelle? How do they relate to protein synthesis?
Can you apply your knowledge of organelles?

For lab practical: be able to Identify organelles on models in lab

I. What is Energy?

A. Energy → Capacity to do work
   a. Bring about movement against an opposing force & bring about change
   b. Food calories →1 calorie is the amount of energy that can raise the temperature of 1 gram of water 1 degree Celsius
      i. 1 Calorie (or 1kcal) = 1000 cal

B. Forms of Energy
   a. Potential energy – stored energy
   b. Kinetic energy – energy in motion
      i. Potential becomes kinetic with action

C. The Study of Energy: Thermodynamics (bioenergetics)
   a. The First Law → Transformation (Conservation) of Energy
      i. Energy is never created or destroyed, it is transformed
      ii. Losses energy through transformation via heat produced by reaction

   b. The Second Law → The Natural Tendency toward Disorder
      i. Energy transformations will run from greater order to lesser order
         1. Not all of the energy created is useful, some is dissipated
      ii. Energy transfer results in a greater amount of disorder in the universe
         1. Entropy – measure of the amount of disorder in a system

II. How is Energy Used by Living Things?

A. Efficiency – how well it converts energy without loss
B. Kinds of Work for Living Things
   a. Mechanical work – contracting muscles
   b. Transport work – moving sodium ions against the gradient
   c. Synthetic/Chemical work – buildup complex molecules (proteins) from simpler ones (amino acids)
C. Energy In versus Energy out
   a. Downhill /Exergonic – energy out
      i. Breakdown of molecules → Energy is released
   b. Uphill/Endergonic – energy in
      i. Runs uphill because you need energy to build stuff
      ii. What you make holds the energy in bonds
   c. Coupled Reactions
      i. When exergonic reactions "fund" endergonic reactions

III. The Energy Molecule: ATP

- ATP – Adenosine Triphosphate (fig)
  - Nitrogen containing molecule with 3 phosphate groups attached to it
  - Linkage represents a move *up* the energy hill
- How does ATP Function? (fig)
  - Downhill reaction – phosphates spilt
    - 1 phosphate stays with enzyme, ADP travels away
    - Energy needed to hold onto 3rd phosphate is now released
- The ADP/ATP Cycle
  - Once 3rd phosphate breaks off → ADP (Adenosine Diphosphate)
  - ADP will find another phosphate to remake ATP
- ATP as Money
  - Good from transferring, not as good for long term storage

IV. Efficient Energy Use in Living Things: Enzymes (-ase)

A. Hastening Reactions
   a. Enzymes – proteins that facilitate nearly every chemical process that takes place in living things
   b. Only accelerate reactions without changing the products
B. Specific Tasks and Metabolic Pathways
   a. Each enzyme is specific to what it breaks down
   b. Metabolic pathways – multiple enzymes needed for process
      i. Each enzyme does a particular job (assembly line)
   c. Substrate
      i. Substance being worked on – first half of enzyme name
   d. Metabolism
      i. Sum of all chemical reactions that a cell or larger organism carries out

VI. Lowering the Activation Barrier through enzymes

A. Enzymes lower the amount of energy needed to get the chemical reaction going (fig)
   a. Activation energy – the energy required to initiate a chemical reaction
   b. Energy needed to push the rock up the hill is great without the help of the enzyme
B. How Do Enzymes Work?
   a. Catalysts – substances that retain their original chemical composition while bringing about a change in a substrate
   b. Most are ball-like proteins that "fit" into substrate (lock & key)
      i. Active site – where the enzyme action occurs
   c. Coenzymes – include some accessory molecules
      i. Vitamins tend to be coenzymes

VII. Regulating Enzymatic Activity

A. Factors that influence the amount of "product" an enzyme turns out
   a. Amount of substrate
   b. Enzyme can be occupied by another molecule and therefore can't function
B. Regulation of Enzymes (fig)
   a. Negative feedback – home heating system
      i. Kicks on heat when house is cold
   b. Inhibitors or Allosteric (allo - other; steric – shape)Enzymes
      i. Changes shape of enzyme so it can't bind with substrate when not needed

Viii. Membrane Functions

A. Diffusion
   1. Movement of molecules or ions from a region of higher concentration of lower concentrations
      a. Moves down a concentration gradient

      b. Movement through membranes
         i. If permeable, both water & solutes can move across membrane
         ii. If semipermeable, water moves freely, solutes don't
      c. Plasma Membrane is semipermeable
         i. its permeable to water and lipids, not charged substances

B. Osmosis
   1. Passive Transport of water across a selectively (semipermeable) membrane
      a. Osmosis moves water across the membrane, not solutes
   2. Plants take as much water in the cell as will fit (turgid vs. flaccid/wilted)
      a. Plasmolysis – not enough water, so cell dies off
   3. Animal cells would burst if too much water enters
      a. Osmoregulation – control of water balance in animals
   4. Terms:
      i. Hypertonic – a fluid has a higher concentration of solutes than another, water flows out of cell
      ii. Isotonic – same concentration of solutes inside and out
      iii. Hypotonic – a fluid that has a lower concentration of solutes than another, water flow into cell

III. How Do Materials Move In and Out

a. Some materials need forces and special protein channels or they need protein channels and energy to cross the membrane
b. Passive Transport
   i. Two Kinds – both required No Energy
      1. Simple Diffusion
         a. Doesn't require special protein channels
         b. Water, oxygen, carbon out of cell
      2. Facilitated Diffusion
         a. The passage of materials through the plasma membrane, using both a concentration gradient and a channel made by a transport/integral protein

c. Active Transport (fig)
   i. Sometimes molecules need to be higher concentration inside the cell
   ii. Molecules need to move against the concentration gradient
   iii. ATP required to *"pump"* molecules across membrane

IV. Moving Big Things In and Out

a. Movement Out: Exocytosis
   i. The movement of materials out of the cell through a fusion of vesicles with the plasma membrane
   ii. Cells use exocytosis to export protein

b. Movement In: Endocytosis
   i. The movement of relatively large materials into the cell by infolding of the plasma membrane
   ii. Three Forms
      1. Pinocytosis
         a. Plasma membrane creates an enclosure that pinches off to become a vesicle that moves into the cell

      2. Receptor-Mediated Endocytosis
         a. Cell-surface receptors bind with materials to bring them into the cell & then material moves in cell membrane to place where vesicle budding brings them in

      3. Phagocytosis
         a. Certain cell engulfs whole cells, fragments of them or other organic materials

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Study Questions for Introduction to Energy

What is the definition of energy? What is the difference between potential and kinetic energy?
What are the laws of thermodynamics and what are their consequences?
What is meant by endergonic and exergonic? Can you give examples?
What is an enzyme? What is its job? What can affect its function? What does it work on?
What is ATP? What is it used for? Where do we get it?
How do things pass through the membrane? Little things and big thing
What mechanisms take energy? Which don't?

Deriving Energy from Food: Cellular Respiration

I. Cycling Energy through the System
II. Making Energy from Food
III. 3 Stages of Cellular Respiration: Glycolysis, Citric Acid & Electron Transport Chain
- First Stage; Glycolysis
  - A) fermentation
- Second Stage; the Citric Acid Cycle
- Third Stage; ETC

How to Make Oxygen: Photosynthesis

I. Photosynthesis & Energy
II. The Components of Photosynthesis
  a. Stage 1: The Steps of the Light-Dependent Reactions
III. What Makes the Light-Dependent Reactions So Important?
  a. Stage 2: The Steps of the Light-Independent Reactions
IV. Different Kind of Photosynthesis: The C4 Pathway
V. Another Photosynthetic Variation CAM Plants

Cellular Reproduction: Mitosis & Meiosis

I. Introduction to Cell Division
II. DNA & Chromosomes
III. Mitosis and Cytokinesis
  a. Phases of Mitosis
  b. Cytokinesis
  c. Variations in Cell Division
  d. Cancer: Mitosis out of Control
IV. Meiosis and Sexual Reproduction
  a. What is it?
  b. Steps in Process
  c. Genetic Diversity
  d. Gamete Formation
V. Comparison of the two

DNA Structure and Function

I. Components of DNA
  a. Replication
II. Genotype to Phenotype: Protein Synthesis
  a. Genetic Code
  b. Transcription & Translation

Mendel and His Discoveries

I. Mendel's Experiments
  a. Yellow and Green Peas
II. Crosses Involving Two Characters
III. Incomplete Dominance
IV. Codominance
  a. Blood Typing

V. Pleiotropy
VI. Multiple Alleles and Polygenic Inheritance
VII. Genes and Environment

Chromosomes and Inheritance

I. X-linked inheritance
II. Structural Aberrations in Chromosome
    a. Examples
III. Aberrations in Chromosomal sets: Polyploidy
    a. Examples
IV. Incorrect Chromosome Number: Aneuploidy
    a. Examples
V. Autosomal Genetic Disorders

Genes and DNA Technology

I. How and Genes are Regulated
II. Cloning of Plants and Animals
III. Genomics & Recombinant Technology
IV. DNA Fingerprinting and Forensics
V. Viruses

Evolutionary Thought

I. Evolution and Its Core Principles
II. Pre-Darwinian Thought
III. Darwin and the Theory of Evolution
IV. Alfred Russel Wallace
V. Acceptance and Controversy
VI. Evidence

Why is oxygen essential for breathing?

c. Oxygen allows us to extract energy that is then used to put ATP together
d. Use ATP to live

I. Cycling in the Biosphere ADP (fig)

A. Producers & Consumers
    a. Autotrophs – "self-feeders" like mainly plants & other producers
    b. Heterotrophs – "other feeders" eat plants so are consumers
B. Relationship between Photosynthesis and Respiration
    a. Processes relate because one produces the reactants of the other

II. Making Energy from Food

A. We use electrons in glucose to fund the process
    a. Glucose donates electrons (separates) → energy provided to make ATP
    b. Final molecule that receives electron is oxygen

B. Redox Reactions
    a. Oxidized – a substance that loses one or more electrons to another
        i. Metal rusting
    b. Reduction – a substance that gains electrons (reduction in charge)
        i. Happens together; one is oxidized, one is reduced

C. Many Molecules Can Oxide Other Molecules
    a. Oxidation – not just with oxygen
        i. Oxidizing agent – any compound that serves to accept electrons from another (causes the other to be oxidized)
    b. Electron carriers – molecules that shuttle electrons down energy hill
        i. Usually a transfer of Hydrogen (1 proton; 1 electron)
    c. Redox through intermediates
        i. NAD – nicotinamide adenine dinucleotide (fig)
            1. Cab for electrons
                a. Empty – NAD+, missing an electron
                b. Full – NADH; picked up a H & an e from another H
D. How does NAD do it's Job?
    a. The oxidized molecules is glucose derivatives
    b. Glucose and NAD come together by enzymes (review enzyme equation)

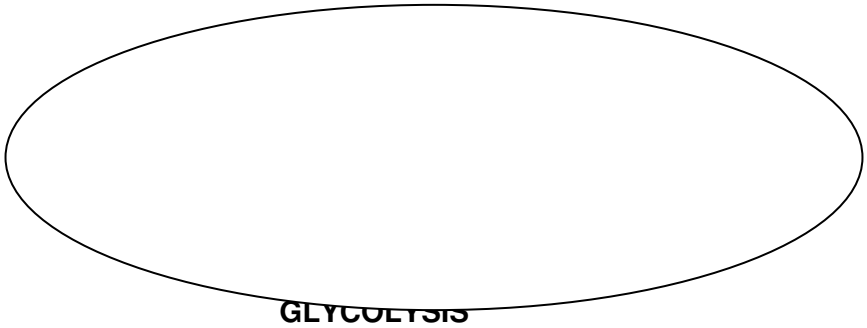
III. 3 Stages of Cellular Respiration: Glycolysis, Citric Acid Cycle & ETC

A. $C_6H_{12}O_6 + 6O_2 + ADP \rightarrow 6CO_2 + 6H_2O + 36ATP$
   a. $6O_2$ are final electron acceptor

B. Glycolysis – First Stage
   a. Net production of 2 ATP per glucose molecule
   b. Doesn't use oxygen directly
      i. Used by bacteria & one-celled Eukaryotes as only energy source

C. Citric Acid Cycle & Electron Transport Chain
   a. More Oxygen dependant parts of cycle (aerobic)
   b. Glycolysis occurs in cytoplasm
   c. Citric Acid and ETC in Mitochondria

D. Overview of Stages of Cellular Respiration (fig)
   a. Main function – transfer of electrons to the electron carriers (NAD & FAD)
   b. Then carriers bring electrons to ETC, where they are oxidized (loss e)



GLYCOLYSIS

A. First stage of aerobic energy – means sugar splitting
B. STEPS
   a. Glucose enters bloodstream with phosphate attached by ATP
      i. Needs to become less stable
   b. Glucose is rearranged, and another P is added
   c. Glucose with phosphate is cut in half (3 carbon sugars)
   d. Sugar is oxidized by NAD+
   e. Each sugar now adds P to ADP to make 2 ATPs
   f. This happens twice

A. FERMENTATION – ONLY GLYCOLYSIS

A. When Glycolysis is only step – no oxygen added (anaerobic)
    a. Fermentation in Animals – lactic acid build up in muscles

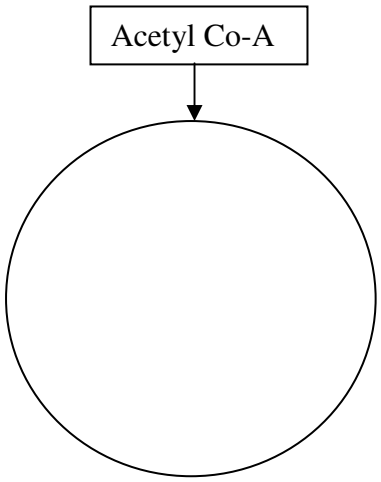
Glucose ⟶ 2 pyruvic acids ⟶

    b. Fermentation in Yeast – pyruvic acid turns into ethanol (alcohol)

Glucose ⟶ 2 pyruvic acids ⟶

CITRIC ACID CYCLE

A. Site of Action Moves from Cytoplasm to the Mitochondria (fig)
    a. CAC takes place in the interior of the organelle
    b. ETC within the inner membrane
B. Between Glycolysis & CAC, and Intermediate Step
    a. Pyruvic acid combines with an enzyme (co–enzyme A) forming acetyl coenzyme A (acetyl CoA)
    b. By-product is CO_2 → goes into bloodstream and is breathed out
C. Why is it called the Citric Acid Cycle?
    a. Acetyl CoA enters the cycle
        i. Remember there were 2 pyruvic acids made so goes through 2x
    b. Yields → 6 NADH, 2 FADH and 2 ATP
D. STEPS → also called citric acid cycle
    a. Acetyl CoA combines with 4C oxaloacetic acid, CoA separates
    b. Citric acid is oxidized in NAD+ → NADH reaction goes to ETC
        i. CO_2 is also made
    c. Alpha-ketoglutaric acid loses CO_2 & gets oxidized by NAD+
    d. Succinic acid oxidized by FAD+, losing 2 Hs → $FADH_2$
    e. Malic acid is oxidized by NAD+ → goes to ETC
    f. Oxaloacetic acid ready for next turn

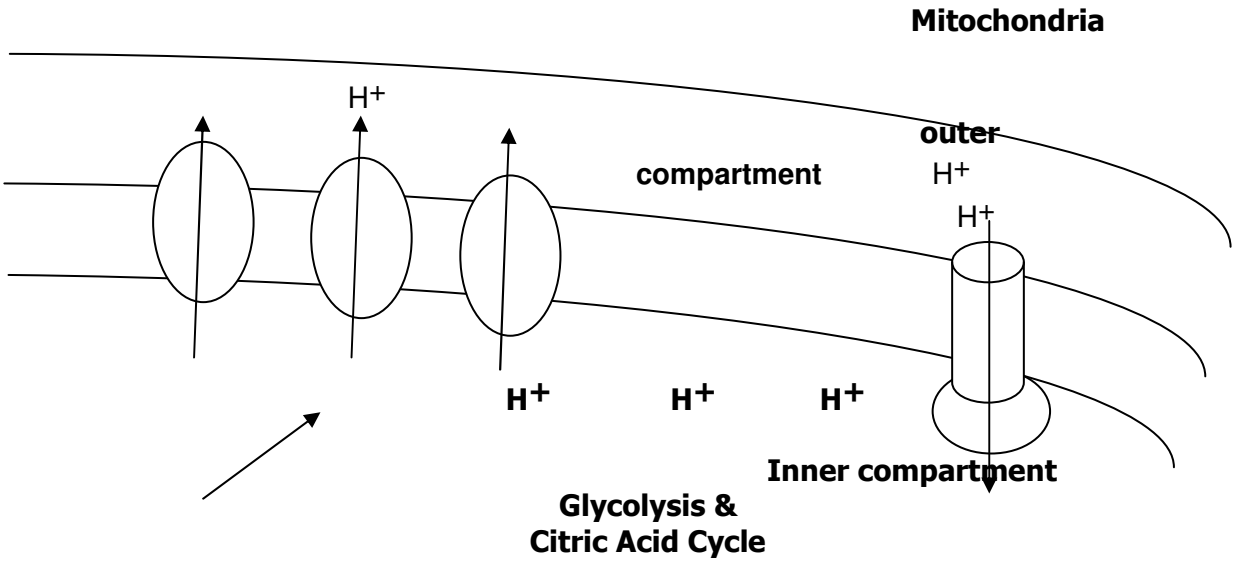


Net Production

What Moves to ETC?

ELECTRON TRANSPORT CHAIN

A. What happens here?
   a. Here is where the Hs get dropped off
   b. NADH → meets up with appropriate enzyme and is oxidized (losses H)
   c. Makes 32 ATP out of 36 total
B. Visualizing the ETC (fig)
   a. 3 large enzymes with 2 smaller molecules that link them together
   b. NADH lets H off at first enzyme, then e- goes to small molecule and down link
   c. H+ travels across into outer compartment of mitochondria
C. Where's the ATP?
   a. Release of H from NADH gives off enough energy that it pushes H across membrane
      i. Fall of electrons causes enzyme to change it's shape and facilitates the movement of hydrogen ions
      ii. H+ is being pushed against the electrical & concentration gradient
      iii. Ions are being pumped up hill with energy supplied by the downhill fall of electrons through ETC
   b. H+ in outer membrane space move back across membrane into inner compartment, through a special enzyme (ATP synthase)
      i. Now moving down concentration & electrical gradient
   c. Movement of H+ makes enzyme spin (100 revolutions/second)
   d. Spinning causes synthesis of ATP from ADP & Phosphate
D. Finally, Oxygen is Reduced, Producing Water
   a. Oxygen is final acceptor of working electrons
   b. Oxygen accepts 2 electrons & 2 hydrogen ions
   c. $C_6H_{12}O_6 + 6O_2 + ADP \rightarrow 6CO_2 + 6H_2O + 36ATP$



Study Questions for Cellular Respiration

Hint: Map it out!
What are producers and consumers? How do they fit into the system?
What do we mean by Redox Reaction? Can you give an example and explain it?
What is Cellular Respiration? What are the stages?
What happens if there is no oxygen? How does the process change?
Where does each stages occur & what are the products?
Why do we breathe in oxygen? Eat carbohydrates? What does each become?

I. Photosynthesis & Energy

A. Ability to transform carbon dioxide into carbohydrates with the help of water
   a. Carbohydrates could then be stored as starch
   b. Make your own food

II. The Components of Photosynthesis

A. Photosynthesis
   a. The process by which certain groups of organisms capture energy from sunlight & convert it into chemical energy
      i. This energy initially being stored in a carbohydrate
   b. Absorption – light is taken in by the leaves
      i. Leaves capture a portion of light that falls on them
   c. Wavelengths (fig) – electromagnetic spectrum
      i. Very short wavelengths – gamma rays
      ii. Very long wavelengths – radio waves
      iii. "Color" are the waves in-between – we don't see that many

B. What Kind of Light Drives Photosynthesis?
   a. Uses waves in the visible light spectrum (between blue & red)
   b. Green is light wave that is reflected off the plant, the others are absorbed
      i. That's why it looks green

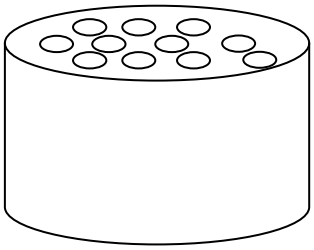
C. Where in the Plant Does Photosynthesis Occur?
   a. Leaves (fig)
      i. 2-part structure
         1. Blade – leaf part
         2. Petiole - stem
      ii. Blade - layers of mesophyll cells with epidermal cells on sides
      iii. Stomata – openings that let carbon dioxide in and water vapor out
         1. Thousands to a hundred thousand in a square cm

D. Photosynthesis Central: The Chloroplasts
   a. Pigment Cells inside chloroplasts that absorb sunlight
      i. Chlorophyll a – primary pigment
         1. Accessory pigments – also absorb light rays
   b. Chloroplast Structure
      i. Thylakoid Membranes – network of membranes
      ii. Grana – stacks of thylakoid membranes
      iii. Stroma – fluid material of the chloroplasts
      iv. Thylakoid Compartment – interior fluid space of each thylakoid
      v. Photosynthesis – takes place in the thylakoid membrane or stroma of the chloroplast

E. Two Essential Stages in Photosynthesis
   a. First Stage → Light Dependent
      i. Sunlight power stage (photo of photosynthesis)
      ii. Sunlight strips water of electrons & boosts them to a higher energy level
      iii. Electrons attach to electron carrier (NADP+) & brings e- to next stage

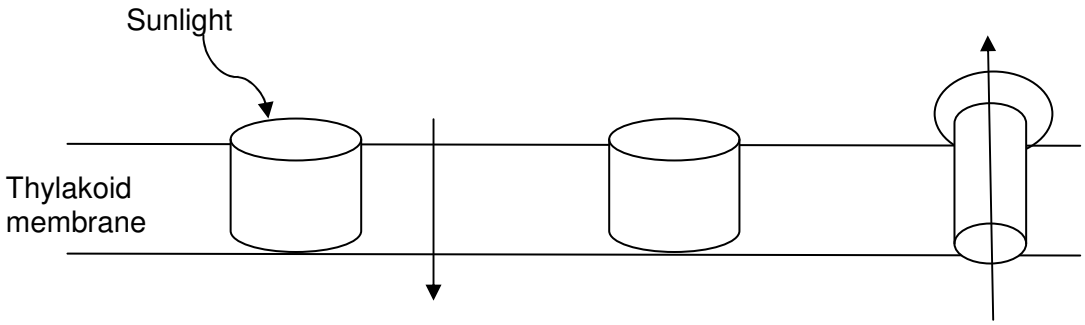
b. Second Stage → Light Independent (synthesis part)
    i. Electrons and CO_2 are brought together with a sugar
    ii. Combining the three yields a high-energy sugar

F. The Working Unit of Photosynthesis Is Called a Photosystem (fig)
    a. Photosystem or Reaction Center
        i. Chlorophyll a molecules transform solar energy into chemical energy
        ii. Photon – fixed quantity of light energy
    b. Process
        i. Sunlight absorbed by chlorophyll a in a reaction center
        ii. Electrons moved to another electron carrier (to primary electron acceptor) with the reaction center
        iii. Forms a photosystem
        iv. Moves from Photosystem II to Photosystem I



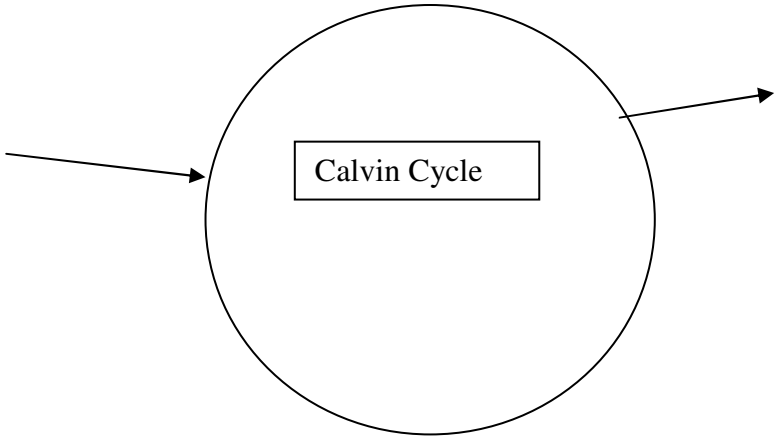
Stage 1: The Steps of the Light-Dependent Reactions

A. A Chain of Redox Reactions
   a. Split water in first step
      i. Photons from light excite electrons
      ii. Electron moves to Primary Electron Acceptor
   b. Electron moves down ETC to next photosystem
   c. Free electrons for carrier in second for NADPH
      i. NADP → NADPH
      ii. Moves electrons to light independent reactions
B. Why it's important to free Oxygen from Water
   a. provides O_2 to breathe (20% of atmosphere is O_2)



Stage 2 of Photosynthesis: The Light Independent Reactions

A. Where are we now? In the Stroma
B. The Calvin Cycle C_3: Synthesis in photosynthesis→ fixation of a gas
   a. Fixation – a gas being incorporated into an organic molecule (CO_2 into RuBP)
C. Steps in the Calvin Cycle (fig)
   a. Bringing together of 3 CO_2 and sugar (RuBP)
      i. 6C molecules become 6 3 carbon molecules
      ii. Rubisco – enzyme used to "pull" CO_2 and RuBP together
   b. Our food has arrived
      i. Many glucose make up starch
      ii. Final product is the whole plant



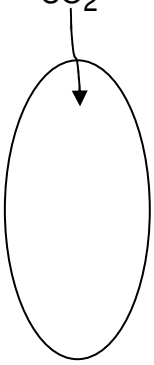
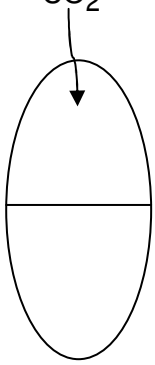
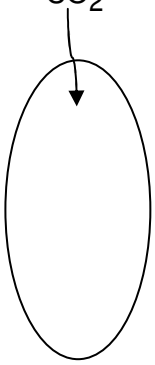
III. C4 Pathway

A. Photorespiration is likely in warm places (fig)
   a. Heat prompts stroma on leaves to close to preserve water
   b. CO_2 is kept out → Rubisco binds O_2 instead
      i. CO_2 is released into special cells around leaf veins (Bundle-sheath)

B. The C4 Pathway is Not Always Advantageous
   a. Costs ATP to shuttle CO_2 around to different cells & not for cold weather

IV. CAM Plants - Crassulacean Acid Metabolism

A. Environments that are not just warm, but also dry (cactus, pineapple, orchids, mint)
   a. CO_2 passes in; water vapor goes out
   b. Succulents (*Crassulaceae*) – close stomata in day time & open them at night
      i. Can suck in CO_2 at night and not lose as much water

	C3	C4	CAM
Used by: Benefits: Problems:			
How:			

Study Questions for Photosynthesis & Respiration

What is Photosynthesis? What are the stages? Where does each occur?
What are the molecules that move between the stages for both Respiration & Photosynthesis?
Why do plants give off oxygen? What do they take it? What does it become?
What are the other types of processes different plants may use? What are examples?

II. Review of DNA

A. DNA & Protein Production – Body activities all depend on DNA
   a. DNA

   b. Genome

B. Proteins carry out the work needed to function
   a. Made up of amino acids

C. DNA code (fig)
   a. Four bases:

D. Genetics as Information
   a. Genetics

II. Introduction to Cell Division

A. Cell Division (fig)

B. Replication of DNA (fig)
   i. Original DNA molecule unwinds & new DNA strands are synthesized

III. DNA and Chromosomes ( )

A. Structural Components
   a. Chromatin

   b. Chromosomes

   c. After duplication makes sister chromatids → exactly alike
      i. Chromatid → one of the 2 identical strands of chromatin

B. Chromosomes
   a. Our 46 chromosomes are not exact duplicates, we get 23 from each parent
      i. Homologous chromosomes

   b. Humans have 22 autosomes & one pair of sex determining chromosomes
      i. Autosomes –
      ii. X and Y Chromosomes -
         1. Biological Females –
         2. Biological Males –
      iii. Karyotype

C. Chromosome Duplication Cell Division
   a. Terms:
      i. Mitosis – division of the cell's chromosome

ii. Cytokinesis- division of cytoplasm

b. The Cell Cycle (fig)

i. Two Main Phases

1. Interphase

a. G1 – cell growth gap phase 1 (12 hrs)

b. S – synthesis (6 hrs)

c. G2 - gap phase 2, prep for division (6 hrs)

2. Mitotic Phase (30 minutes)

a. Duplicated chromosomes separate, then cell splits into 2

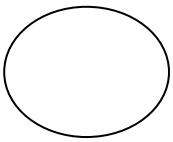
IV. Mitosis and Cytokinesis

A. Phases of Mitosis (fig)

a. Prophase

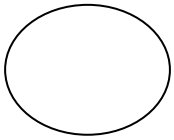
i. 46 Chromosomes for people – 92 chromatids

ii. Centromere



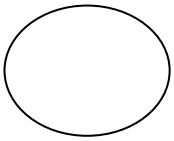
b. Metaphase

i. Chromosomes meet in the middle



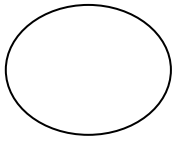
c. Anaphase

i. Sister Chromatids pull apart



d. Telophase

i. Cleavage furrow starts



B. Cytokinesis

a. Parent Cell becomes two cells

C. Variations in Cell Division

A. Plant Cells (fig)
   a. Pinching thing won't work, grow a new cell wall to divide them

B. Prokaryotes
   a. Binary fission in Bacteria (fig)
      i. Have a single circular chromosome attached to plasma membrane
         1. No nucleus! So not inside anything but the cell
      ii. Takes only 20 minutes

C. Other variations
   a. Brain cells – Only make a few when your young
   b. Leaf cells in plants – Only grow when the plant is growing and young
   c. Stem cells – In bone marrow

D. Cancer

a. Cell Cycle Control System

b. Cancer:

   i. Benign

   ii. Malignant

   iii. Metastasis

c. Naming of Cancers
   i. Carcinomas

   ii. Sarcomas

   iii. Leukemia/Lymphoma

d. Chemotherapy

I. Meiosis & Sexual Reproduction

B. What is it?

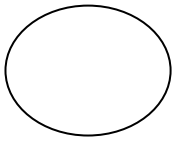
a. Diploid (2n) cell divides to produce haploid (1n) reproductive cells
b. One duplication followed by two divisions
c. 46 chromosome (2 sets) → 23 chromosomes (1 set) cell

C. Steps in the Process

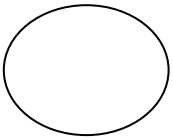
a. Compared to Mitosis (fig)

i. Start with duplication after Interphase: DNA has replicated already
ii. Mitosis lines up chromatids; meiosis lines up homologous chromosomes

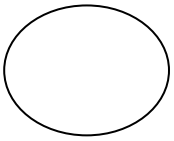
b. Meiosis I



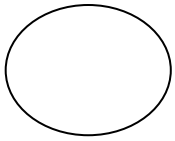
i. Prophase I



ii. Metaphase I



iii. Anaphase I



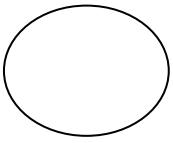
iv. Telophase I

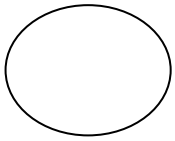
c. Interphase Pause

i. Regroup and tend to other things for a bit

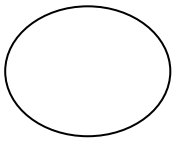
d. Meiosis II

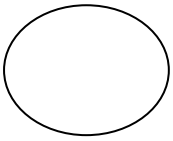
i. Prophase II & Metaphase II





ii. Anaphase II & Telophase II





C. Genetic Diversity Guaranteed

a. Independent assortment (random alignment)

b. Recombination (crossing over)

i. Chiasma

c. Random Fertilization

D. Gamete Formation (fig)

A. Sperm Formation – Spermatogenesis

a. Sperm - Only has DNA & mitochondria, no other organelles

i. 250 million daily

b. Continue to produce all of the life cycle, stem cells

B. Egg Formation – Oogenesis

a. Primary Oocyte → Secondary Oocyte & Polar Body → Eggs

b. Only produce a certain number of Oogonia mainly before birth

c. One oocyte a month will go through meiosis I to become Secondary oocytes, starts meiosis II, but is arrested until it is fertilized by the sperm, then it will finish meiosis II

d. Polar Bodies

i. After primary oocyte goes through meiosis I, one of the daughter cells will get more cytoplasm than the other, so it only produces 1 ovum, or egg and 3 polar bodies totals

Comparison of the 2 Types of Division

	MITOSIS	**MEIOSIS**

STARTING CELL		
DIFFERENCE IN # OFSTAGES		
DIFFERENCE IN WHAT HAPPENS DURING STAGES		
WHAT TYPE OF CELL DOES IT PRODUCE		
# of CHROMOSOMES IN RESULTING CELLS		

Study Questions for Cellular Division

- What is a chromosome, chromatid, chromatin?
    - How do they change after S phase?
- What are the stages of interphase? What happens in each stage?
- What are the stages of mitosis? What happens at each stage?
- What is the ploidy level for chromosomes at different stages? What is the difference in result between mitosis and meiosis? What are the resulting cells called?
- What is independent assortment? Crossing over? When does it happen?
- Chromosomes that are the same size and function are called what?
- The process of forming sperm in humans is termed what? Egg production?

I. What are Genes Now?

II. Discovery of the Helix

A. Watson & Crick

B. Rosalind Franklin

III. Components of DNA

A. What makes up DNA (fig)
   a. There is a full complement of DNA in nearly all cells in the body
   b. Nucleotide
   c. Phosphate Group
   d. Sugar – deoxyribose
   e. Bases – Steps of the staircase
      i. Adenine -
      ii. Guanine -
         1. Linked via hydrogen bonds

B. Replication (fig)

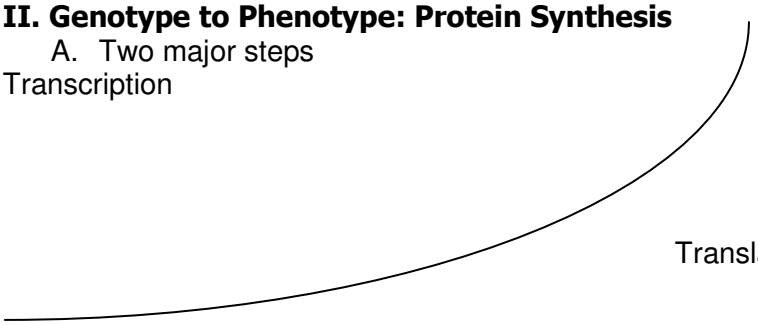
C. Proteins Production - Polypeptide Chain
   a. Hundreds of amino acids put together
   b. Synthesizing many proteins from 20 amino acids
      i. 10s of thousands of different proteins from 20 amino acids
      ii. Order determines the proteins

D. Important enzymes
   a. DNA polymerase –

II. Genotype to Phenotype: Protein Synthesis

A. Two major steps

Transcription



Translation

B. Transcription
   a. RNA is key

   b. DNA is Transcribed onto mRNA (messenger ribonucleic acid)
      i. mRNA:

      ii. RNA polymerase

      iii. Introns and Exons
         1. Exons do code for amino acids (Express amino acids)

   c. Triplet Code
      i. Codon →

      ii. Dictionary for the code
         1. Most amino acids are coded for by more than one codon

C. Translation
   a. Heads to Ribosome to make a protein

b. tRNA brings the aa to the ribosome to make the protein
    i. Definition:

    ii. Both floating freely: tRNA links to the aa on one end
    iii. tRNA links to the mRNA codon at ribosome via anticodon
        1. Anticodon

c. Can be translated by many ribosomes at once

III. Mutations

A. Mutations
    a. Definition:
    b. Many types (fig)
        i. C where there should be a T, Incorrect base pairs
    c. Types of Mutations

    d. Mutagens

B. Heritage Mutations
    a. Most in somatic cells, so not inherited
    b. Germ-line cells – pass on a pre-disposition to a disease, not disease itself
C. Evolutionary Adaptations
    a. Can be helpful in adapting to an environment
        a. came from those cows
        b. We ate those proteins

Study Questions for Transcription and Translation

- Who found the structure of DNA? Who won the Noble prize?
- What are the difference between DNA and RNA? What are the different nucleotides?
- Where does transcription and translation occur?
- What proteins are used in the processes?
- Make complementary strands of DNA, make RNA from DNA, make amino acids from DNA, etc. – what are codons, anticodons, introns, exons,
- Are viruses living? If not, why?
- What are ways that the HIV virus is transmitted?
- Outside of the possibility of a random mutation, the prion that causes Mad Cow was probably passed to other cows via what mechanism?
- What are the statistics for herpes? How can you protect yourself?
- What are the proteins associated with the HIV virus and what are their functions?

I. Mendel and the Black Box

A. Remember:
   a. Genes
   b. Genes come in pairs, residing in pairs of chromosomes (in humans)
   c. Chromosomes

   d. In meiosis; homologous chromosomes line up next to each other and then separate with each member of a pair ending up in a different egg or sperm

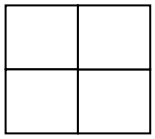
B. Mendel cross-pollinated yellow and green peas with a (fig)
   a. Studies with the Garden pea (*Pisum sativum)*
      i. Life Cycle and Anatomy of the pea plant (fig)
   b. Parental, F_1, and F_2 Generations

   Parental – parents in the experiment

   F_1 – first filial generations
   Appearance:
   Ratio:

   F_2 – second filial generation
   Appearance:
   Ratio:

C. Interpreting Results
   a. Punnett Square (fig)



   b. Characters – attributes
      i. Variation on those characters are called traits
         1. *Phenotype*

      ii. Found matched pairs of genes
         1. *Allele* –

         2. *Genotype* –

   c. Heterozygous and Homozygous Conditions
      i. *Homozygous* –

      ii. *Heterozygous* –

   d. Dominant and Recessive Alleles/Elements
      i. *Recessive* –

         1. Homozygous recessive

      ii. *Dominant* –

         1. Homozygous dominant -

   e. Law of Segregation
      i. Organisms have 2 genetic elements (alleles) that separate in gamete formation → separation of homologous chromosomes

II. Crosses Involving Two Characters

A. Monohybrid Cross

B. Dihybrid Cross

i. Remember 3:1 Ratio for original experiment

C. 9:3:3:1 Ratio

D. Law of Independent Assortment
   a. During gamete formation, gene pairs assort independently of one another

III. Incomplete Dominance

A. White – Red flower cross (snapdragons) → get pink flower 1:2:1 ratio
B. Genes Code for Proteins
   a. Genes contain information regarding the production of proteins
   b. Incomplete dominance

III. Codominance

A. Blood type is the type of protein that covers the surface of the red blood cell (RBC)
B. Two main types of surface proteins – A & B; Two alleles means variation
    a. Mom and Dad both have genes coding for A → Type A
    b. Mom and Dad both B → Type B
    c. One A and one B → Type AB
    d. Code for neither surface protein→ O

II. Pleiotropy

A. Sickle Cell Anemia

B. Why would it stay around?

III. Multiple Alleles and Polygenic Inheritance

A. Multiple alleles

B. Polygenic Inheritance

V. Genes and the Environment

A. Environment can alter phenotype although genotype stays the same
B. Nature vs. Nurture thing

I. X-linked inheritance Autosomal Genetic Disorders

A. Examples of things that can happen through recombination and crossing over
B. X Linked conditions: hemophilia, Duchenne muscular dystrophy, color blindness
    a. X Chromosomes
        i. Females have 2 so it can "cover-up" error
        ii. Males only have one, so if nonfunctional allele is on it, that's it!
    b. Color Blindness – Recessive Condition (fig)
        i. That means probably the mother was heterozygous for colorblindness
            1. More men are colorblind than women

II. Chromosomal Theory of Inheritance

a. Definition

b. Linked genes

i. Linkage maps

III. Structural Aberrations in Chromosome

A. Deletions

B. Inversions

C. Translocations

D. Duplications

IV. Incorrect Chromosome Number: Aneuploidy

A. Aneuploidy

a. Nondisjunction

i. Down Syndrome

V. **Aberrations in Chromosomal sets: Polyploidy**

A. Polyploidy

B. Abnormal Numbers of Sex Chromosomes

VI. Autosomal Disorders

C. Autosome - not X or Y chromosomes

D. Recessive Disorder - dysfunction related to autosomes

a. Cystic fibrosis

b. Deafness on Martha's Vineyard

C. Dominant Disorders

a. Means a single faulty allele can cause damage

b. Autosomal dominant disorder

i. Huntington's Disease – brain cell deterioration

1. Doesn't show up until you're an adult, often after you have kids
2. Pass the recessive trait on 50/50 chance

Study Questions for Genetics

- What is a genome?
- What is an autosome? How many pairs of autosomes are present in humans?
- What are X-linked genes? Why would you see more in males than females?
  - What is the difference between sex and gender?
- What is a karyotype?
- How was the father of genetics?
- What are some examples of other genetics disorders? Dominant? Recessive?
  - What is a carrier? If you are a carrier of an X-linked trait, what is your sex?
- What are some possible mutations that could lead to new chromosomes?
- What is an allele? How does it relate to homologous pairs?
  - What does heterozygous mean? Homozygous? Dominant? Recessive?
- Can you complete a Punnett Square for different traits?

I. How and Why Genes are Regulated

a. Why regulate genes?

b. Gene expression

c. Cell Signaling

II. Cloning

a. Regeneration vs. Cloning
   i. Regeneration –

b. Cloning of Animals

c. Therapy & Stem Cells

III. Recombinant Technology & Genomics

a. Recombinant Technology
   i. Plasmids

   ii. Vectors

   iii. Restriction Enzymes

   iv. Genetically Modified Foods

b. Genomics
   i. Human Genome Project

ii. Proteomics

IV. DNA Fingerprinting and Forensics

a. DNA Fingerprinting

b. Polymerase Chain Reaction

c. Short Tandem Repeat Analysis

d. Gel Electrophoresis

V. Biotechnology and Biomanufacturing

a. What is Biomanufacturing?

i. Production of a protein, cell therapy, vaccine, natural hormone, plant extract or animal extract in manufactured using recombinant technology

ii. Remember small changes in proteins can lead to big changes in function
ex. Sickle cell anemia,
ex. Enzyme regulatory activity - problems with insulin resulting in diabetes

iii. Pharmaceutical industry harnessing ideas of recombinant technology and production of proteins to make protein therapeutics or biological medicines

1. Different than chemically synthesized medicines like aspirin

Ex of protein therapeutics

- Enzyme/regulatory activity – ex. Insulin, erythropoietin
- Antibody therapeutics - Targeting specific cells using markers – cancer treatments, nonhodgkins lymphoma
- Protein vaccines against viruses – ex. Hepatitis B, human papilloma virus

VI. Viruses: Genes in Packages

A. Important to distinguish between “germs”

a. Bacteria are cells, make proteins, use energy etc.

b. Viruses are not regarded as living organisms

A. Have to invade living cells to replicate

B. Consist of RNA or DNA enclosed in protein coat

B. Bacteriophages

C. Invade host cell & direct its genetic machinery to churn out copies of virus.

Example: HIV - Like most viruses composed of three structures:

A. DNA or as in HIV two strands of RNA
   a. Life Cycle of HIV – 9 genes
      1. Bind to receptors on T-cell
      2. Releases Protease, Integrase and Reverse Transcriptase
      3. Reverse transcriptase creates DNA copy of viral RNA
      4. Integrase allows integration of viral DNA into host DNA
   b. Can be triggered to enter replication phase
      1. Each time cell divides to form new T-cells, the virus is copied
      2. Once replication starts, protease starts helping pull viral parts together
   c. Virus changes with every infection, nearly impossible to find a vaccine

B. Viral Diversity
   a. Some viruses don't have envelope to fuse to membrane (T4)
   b. Inject itself into cell → thousands can fit in one bacterial cell

C. Effects of Viruses
   a. Cause: smallpox, chicken pox, measles, rabies, polio, herpes, rubella, some cancers, hepatitis & pneumonia, colds and flu
   b. Herpes - 1/5 Americans over 12 years old are infected
      i. *Herpes simplex viruses* (cause chickenpox, shingles, & Epstein-Barr)
         1. Type 1 usually "oral"
         2. Type 2 usually "genital."
   c. Mad Cow – Foot and mouth disease
      i. Misshapen prion proteins live in membrane of cells
      ii. Can change brain cells and then attacks nervous system
         1. *Bovine spongiform encephalopathy* (BSE)
         2. One cow got it, went crazy and died
            a. How did they get it?
               i. Eating sheep and cattle remains
            b. How did we get it?
            c. Eating cow meat that is from carnivorous cows

Study Questions: Genes and Technology

- What is Recombinant DNA technology?
- What are some examples of uses of recombinant technology? Give an example of how a use of recombinant technology might be used by you in your everyday life.
- What is a virus? What is a vaccine you have had to prevent a viral infection

I. Evolution and Its Core Principles

a. Two Main Principles
   i. Common Descent with Modification

   ii. Natural Selection

b. These principles are why we are so alike and why we are different
c. All have the same ancestor, yet need for survival has led to changes

II. Pre-Darwinian Thought

i. Lots of scientists came up with parts of the theory

Charles Lyell and Geology (1830)

Jean-Baptiste de Lamarck and Evolution (1809)

Georges Cuvier and Extinction (Paris, early 1800s)

Impact on Darwin

Darwin took Lyell's book on the boat → why not living things too?

III. Darwin and the Theory of Evolution

a. What's a Theory?

   i. Other "theories" include: Gravity, Relativity, etc.
   ii. Highly accepted and we're pretty sure these are true

b. Charles Darwin's Background
   i. Dad wanted him to be a doctor → thought it was boring
   ii. Decided to go to Cambridge for theology & did some biology too
c. Voyages on *The Beagle* (1831-1836)
   i. Collected different animals on the Galapagos Islands
      1. Iguana's, turtles, birds, Darwin's Finches
         - Thought he found all these birds (blackbirds, wrens)
   ii. Variations between the islands too
      1. Common mainland ancestor true of plants & other animals

d. After *The Beagle*
    i. Did a lot of other stuff in-between: books, pigeon breeding, etc
    ii. Wrote book in 1859: *On the Origin of Species by Natural Selection*
e. Darwin's Contribution was Two-Fold
    i. Lots of Evidence! Evidence! Evidence! From the Beagle
    ii. Hypothesized that natural selection is force behind evolution

IV. Alfred Russel Wallace

V. Acceptance and Controversy

a. Descent with modification
    i. Easily accepted by the scientific community – made sense
b. Natural selection as the driving force
    i. At the time, no genetics, no understand of what could be used to pass
    ii. Information down to the next generation → Genetics was Unifier
c. If Darwin & Mendel had worked together, might have made it easier to accept

VI. Evidence: Agreement and consistency within and between lines

a. Fossils

b. Biogeography

c. Radiometric Dating

d. Comparative Anatomy and Embryology
    i. Anatomy

    ii. Embryology

e. Molecular Biology

f. Experimental Evidence

Study Questions for Evolutionary Thought and Processes

- What is the difference between a hypothesis and a theory? Why is it an important distinction? How can you explain it? What are the lines of evidence to support it?
- What are the 2 aspects of Darwin's theory?
- Who else thought about these ideas? What fields were they in?
    - Make a chart of the people we talked about
- What is the real meaning of fitness in evolutionary theory? How is it determined?

UNIT THREE – Climbing the Family Tree

The History of Life on Earth

I. Geologic Timescale How did Life Begin?
II. Plate Tectonics
III. Major Events on Timeline
IV. Categorizing Living Things
V. Taxonomy & Cladistics
VI. The Tree of Life

How Did We Get So Much Diversity?

IV. Microevolution
- A. What Evolves?
- B. Five Agents of Microevolution
- C. What is Evolutionary Fitness
- D. Three Modes of Natural Selection

V. Macroevolution
- A. What is a Species?
- B. How Do New Species Arise?

Microbes: Bacteria, Archaea, and Protists

I. Life's Categories and the Importance of Microbes
II. Bacteria
- a. Characteristics
- b. Nutritional Modes
- c. Ecological Impact
  - i. Diseases
  - ii. Chemical Recycling
  - iii. Bioremediation

III. Archaea
IV. Protists and Sexual Reproduction
- a. Animal-Like Protists
- b. Fungi-Like Protists
- c. Plant-Like Protists

Plants and Fungi

I. Movement to Land
II. Plants
- a. Types of Plants
- b. Angiosperm-Animal Interactions

III. Fungi
- a. Structure and Reproduction in Fungi
- b. Categories of Fungi
- c. Fungal Associations: Lichens and Mycorrhizae

Animal Kingdom

I. What is an Animal?
II. Evolutionary Steps that Separate Animal Phyla
III. Major Groups of Chordata (Vertebrates)
IV. What makes it a vertebrate?
V. Evolution of Human Beings

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i. Introduction to Ecology

I. What is Ecology
II. Population Dynamics
III. K and r Selected Epecies
IV. Human Populations
V. Community and Population Interactions
VI. Community Ecology

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ii. Intro to Anatomy and Physiology

I. Basic Characteristics of Humans
II. Review of Organization
III. 4 Types of Tissue
IV. Summary of Systems

I) Geological Time

a) Life's timeline starts about 4.6 billion years ago
b) Divides time into eras, then periods, then epochs
   i) Fossil define a layer (large period of time)
c) Major extinction events seem to mark the layer division
   i) Usually marks the end of an era or period
      (1) Pleistocene

      (2) Cretaceous

      (3) Permian

II) Plate Tectonics & Macroevolution

a) History of Plate Tectonics
   i)

III) Major Events in Geologic Time

a) Earth formed 4.6 bya by meteors
b) 3.5 bya – first prokaryotic cell
c) 2.7 bya – Oxygen accumulation
d) 2.2 bya – first eukaryotic cell
e) Cambrian Explosion

IV) Categorization of Living Things

a) Carolus Linneaus (Carl von Linne)
   i) Swedish scientist that started naming everything in Latin
   ii) Is a way that we can talk to people in other countries and all use the same name

b) Binomial Nomenclature
   i) *Genus (genera) species* – always italicized

c) Degree of Relatedness
   i) Members of the same species are more related than members of the same Genus
   ii) Systematics

   iii) Taxonomic System

V) Taxonomy and Cladistics

a) Phylogeny

b) Variations in Morphology that make it hard to label
   i) Homologous Structures

   ii) Analogous Structures

   iii) Convergent Evolution

c) Classical Taxonomy
   i) Concerned with special qualities of an organisms, not descent

d) Cladistics (means branching in Greek)
   i) Brings about a Cladogram

   ii) Ancestral Characters

   iii) Derived Characters

VI) The Tree of Life

a) Universal ancestor

b) Three Domains
   i) Bacteria

   ii) Archea

   iii) Eukarya

Study Questions: Geologic Time/Taxonomy

- Most of the Eras and periods we use to define geologic times were determined by what?
- What is the role in plate tectonics in evolution?
- Which is the period when all the present phyla are first present in the fossil record?
- The Earth is approximately how old?
- When do we see high accumulation of oxygen on the Earth probably happened
- What is Taxonomy? Who is consider its inventor?
- What does phylogeny mean? What are different ways of looking at it?
- What is the different between Homologous and Analogous structures?
- What is the tree of life?

I. What Evolves?

a) Species
   i)

b) Population
   i)

c) Genes
   i) Terms:
      (1) Genotype –

      (2) Phenotype –

      (3) Alleles –

         (a) Represent potential for change, evolution
   ii) Individual has 2 alleles for each trait or "gene" coding for trait
   iii) Populations
      (1)

         (a) **gene pool** -

      (2)

d) **Evolution** is a change in frequency of alleles in a population
   i) Frogs populations separated by a river different predators, environment → evolve differently to best fit where they live

   ii) Microevolution
      (1)

      (2)

   iii) Macroevolution
      (1)

II. Five Agents of Microevolution

a) Five Agents

i) Mutation

(1) Two main ways

(a) Point mutation

(i)

(b) Deletions

(i)

(2) may be more common than we think, depends on who you ask

ii) Gene flow

(1) Movement of genes from 1 population to another via *migration*

(a)

(2) Works for both animals and plants (seed dispersal)

iii) Genetic Drift

(1)

(2) Two Main types

(a) Bottleneck Effect

(i)

(ii) Ex: Elephant seals & cheetahs

(b) Founder Effect

(i)

iv) Non-random mating- not all members have same chances of reproducing

(1) Sexual Selection

(2) Assortative mating

(i) Like mates with like, may not have huge effects

v) Natural Selection

(1) The fit of an organism with its environment selects those traits that will be passed on with greater frequency from one generation to the next

(2) Adaptation is key concept

(a)

III. What is Evolutionary Fitness

a) Fitness

i)

(1)

(2)

b) Not that something is better than other – survival of the fitness is not always understood correctly

IV. Three Modes of Natural Selection

a) Most characteristics are polygenci – a range of choices are available (ex: height)

b) Natural Selection operates on polygenic characteristics in 3 ways (fig 17.10)

i) Stablizing Selection

(1)

(a)

ii) Directional Selection

(1)

(a)

iii) Disruptive Selection

(1)

(a)

V. Macroevolution

a) What is a Species?

i) *Biological species* –

ii) Doesn't work for things like bacteria that don't have breeding behaviors, just have cell division

VI. How Do New Species Arise?

a) Speciation

b) Two Main Modes
   i) Cladogenesis
      (1)

   ii) Anagenesis
      (1)

c) Occurs when populations cease to interbreed through various means
   i) Two populations may exchange genetic information through cross breeding
   ii) Then migration between them stops, yet both are still changing now in different directions and stop interbreeding!

d) Reproductive Isolation Mechanisms
   i) Def:

   ii) Two Main Mechanisms
      (1) Extrinsic Isolation Mechanisms
         (a) Allopatric speciation –

      (2) Intrinsic Isolation Mechanisms
         (a) Sympatric speciation –

e) 6 Intrinsic Reproductive Isolation Mechanisms

   i) Ecological Isolation

   ii) Temporal Isolation

      (1)

   iii) Behavioral Isolation

      (1)

   iv) Mechanical Isolation

      (1)

   v) Gamete Isolation

      (1)

      (2) Polyploidy

   vi) Hybrid Inviability or Infertility

VII. When is Speciation Likely to Occur?

a) **Often comes down to flexibility of organism**

b) Comes down to:

Speciation via specialization (of food source or environment)
Migration to a new environment

c) Specialists vs. Generalists

i) Generalists

ii) Specialists

iii) Adaptive Radiation

Study Questions for Evolutionary Processes

- What are the different mechanisms of microevolution? Macroevolution?
  - What are the extrinsic & intrinsic mechanism?
  - What are the types of selection? Why would one be favored?
  - What is genetic drift? Founder Effect? Bottleneck?
- What is the difference between homologous and analogous structures?
- How do we make evolutionary trees? How do we decide who is more closely related?
- What is a generalist? Specialist?

I. **Prokaryotes**

a. Bacteria
   i. Characteristics of bacteria:

b. Archaea

II. Modes of Nutrition

A. Autotrophs
   a. Photoautotrophy (plants, some bacteria and many protists)

   b. Chemoautotroph (some bacteria & archea)

B. Heterotrophy—obtain energy from organic material
   a. Photoheterotrophy (Some bacteria & archea)

   b. Chemoheterotrophy (animals, all fungi, most bacteria, many protists, & a few plants)

III. Ecological Impact of Bacteria

A. Mutualism:

B. Resident bacteria that line our linings
   a. 100 trillion bacteria in digestive tract – most in large intestine
      i. 600 species of bacteria in mouth alone
      ii. Number of individual bacteria in mouth may exceed number of people ever existed
   b. Without bacteria, may require 30% more calories to maintain weight
      i. Have a lower number of intestinal cells that move nutrients
      ii. Metabolize sugars we cannot digest and produce some vitamins
      iii. One-quarter of feces by weight consists of bacteria

C. Bacteria and Human Disease
   a. Pathogenic

b. Damage comes from substances secreted or left behind (toxins)
    i. **Toxins -**

    ii. ***Bacillus anthracis*** – secretes 3 toxins →causes blood vessels in lungs & brain to hemorrhage
    iii. ***Botulism bacterium*** – toxins stop signals from moving from nerves to muscles (paralysis)
c. Antibiotics – kill bacteria

D. Chemical Recycling

E. Bioremediation

IV. **Protists**
a. Origin of Eukaryotes

Animal-Like Protists

A. (Formerly protozoa), do not obtain nutrients from photosynthesis, instead from consumption and internal digestion.
    a. Paramecium –

B. Ameboid protists – use pseudopods to take in foods by Endocytosis
    a. Ameboid protists
        i. *Giardia lamblia*

Fungi-Like Protists

A. Two Step Food Gathering Process of Fungi

B. Fungus-like protists, oomycetes, operate the same way
C. Examples:
    a. Irish Potato Famine, *Phytophthora infestans* → killed off all the potato farms
    b. Water mold (saprobes)

c. Plasmodial slime mold: several forms during its life-cycle.

d. *Dictyostelium discoideum*, “cellular slime mold”

Plant-Like Protists (algae)

A. “Golden” alga, freshwater *Synura scenedesmus*

B. *Volvox, green* algae

C. *Brown* alga

D. Phytoplankton – (golden and *Volvox)*

Study Questions for Microbes

- Bacteria can be what shapes?
- How are bacteria used in human bodies, recycling nutrients, etc.
- What is bioremediation?
- What are Archaea? Where do you find them?
- What are the possible origins of organelles in the eukaryotic cells
- What are the feeding types for protists? What are they related too?

Terrestrial Movement from Water to Land

How do you go from Algae to Plants?

Alternation of Generations

Types of Plants

A. Mosses: bryophytes easy to overlook, but common in wet terrain

B. Ferns: seedless vascular plants appear next in fossil record

C. Seed plants developed two main evolutionary designs—pollen and seed**.**

The Flowering Plants: Nature's Grand Win-Win Invention

A. Appeared in Cretaceous and soon replaced gymnosperms as dominant vegetation flourishing by 80 Mya.
B. Efficient pollination made for runaway reproductive success.

C. Seeds containing endosperm are unique to angiosperms.

D. Fruit production is other important reason for angiosperm success (along with flower formation). Allows co-opting of animals a second time.

Plant Diversity: What Else do we use Plants for?

A. Fungi are **absorptive heterotrophs**
    a. Thought to be like plants
        i. Sessile, have cell wall (chemically different from plants)
    b. Now known to be quite different. 77,000 species identified so far
B. Characteristics

Structure and Reproduction in Fungi

A. Hyphae have porous cross-walls (**septae**), allowing rapid growth & quick exchange of materials.
    a. Gills on a mushroom are collection of hyphae with a reproductive structure called a basidium at their tip
    b. Tens of millions of spores
        i. **Spore –**

B. Reproduction:
    a. Almost always multicellular—with both **haploid** and **diploid** phase in life cycle
    b. **Dikaryotic** cells as part of sexual reproduction

Diversity of Fungi

A. Grouping of Fungi is mainly based on reproduction

Ecological Impact

A. Decomposers

B. Parasites

C. Commercial Uses

Fungal Associations: Lichens and Mycorrhizae

A. Ecologically important symbiotic relationships.
    a. Lichens

    b. Mycorrhiza

Study Questions for Fungus and Plants

- After the fusion of two mushroom hyphae, what is the ploidy level?
- What are some food that come from fungi
- What do we call the slender filaments that connect their internal area of fungus? In mass?
- A symbiotic association between a algae and a fungus is referred to as a what?
- Which animal moved onto land first? What about plants?
- These plants still hugged the ground and were dependant on water for reproduction
- Gymnosperms were able to spread to more land environments because they developed what?
- Angiosperms are now the dominant plant type on the planet, mainly due to animal attraction.
- Which of the following is not a way Angiosperms *attract* animals

What is an Animal?

A. Characteristics

B. Big steps in Geologic Time
   a. Cambrian Explosion

Evolutionary Steps that Separate Animal Phyla

A. Phyla are defined by body plan → shared common ancestor
   a. Common ancestor probably protist called choanoflagellate, then split to yield Porifera (sponges); lack tissues and symmetry.
   b. All the rest have some kind of symmetry

   c. Body cavities in which organs are suspended called coelom

   d. Protostomes, meaning “mouth first,” and Deuterostomes, “mouth second” differ in what blastopore develops into during embryonic development

B. Major Steps that lead to divisions
    a. Phyla *Porifera* – Sponges

    b. Phyla -*Cnidarians* - jellyfish
        i. Two Stages of LIfe

    c. Phyla *Platyhleminthes* – flatworms

    d. Phyla Nematoda - roundworms, parasitic, trichinosis, hookworm

    e. Phyla Annelida - earthworms

f. Phyla Arthropoda 3 groups

g. Phyla Mollusca - Probably 50,000–100,000 species, 8 totally different classes

h. Phyla Echinodermata

i. Phyla Chordata

Vertebrate Groups

A. Phyla

a. Cephalochordata

b. Urochordata

c. Vertebrata

B. Evolution

a. Development of jaws:

b. Cartilage to bone

c. Transition to land-dwelling vertebrate

d. Amniotic egg:

e. Major Evolutionary of Land Vertebrate

i. Reptiles

ii. Mammals

1. Characteristics

a. Mammary Glands

b. Endothermic

c. Viviparous
    i. Oviparous

    ii. Ovoviparous

2. 3 Lines Evolutionary Lines of Mammals – embryonic development
    a. Monotremes

    b. Marsupials

    c. Placental Mammals

C. **Evolution of Primates**
a. What makes a primate?

b. Emergence of Humankind
    i. Misconceptions:

    ii. All are hominids but of different genera
        1. *Ardipithecus*
        2. *Parathropus*
        3. *AustralopithecusA. afarensis* - "lucy"
            a. *A. garhi* may have used to tools to kill something and eat it
        4. *Homo*
            a. *H. habilis* – used tools but isn't that different from A.
            b. *H. ergaster* – tall, larger brain, modern face and limb length

5. How did we get everywhere?

iii. Hominids had to travel around
    1. Found *H. erectus* in both China and Indonesia
    2. Two views
        a. One that says *H. sapien* was the end result of all others
        b. *H. sapien* out-competed the others
            i. Actually lived with *H. neanderthal* for 10,000 years

c. How do we know whose related to whom?
    i. Skeletal structure can tell us more about how they moved around, DNA

Study Questions for **Animal Kingdom**

- Phyla in the Animal Kingdom are characterized by their what? What are they phyla (example)?
- What are the characteristics of animals? What is a coelom?
- Why do mammals have fur? What other organism has mechanisms to keep warm?
- What are the reproductive options in mammals? What are those names specifically?
- All of our ancestors originated from which continent?
- Which species left Africa first?
- Where did *H. sapiens* originate?

I. Study of Ecology

A. Ecology
    a. Study of interactions that living things have with each other and their environment
B. Ecologists Organism life from population to Biosphere
    a. Populations
        i.

    b. Community

        i.

    c. Ecosystem

        i.

    d. Biosphere

        i.

II. Populations Dynamics

A. How and why its size changes over time
B. Estimating Populations
    a. Necessary for understanding ranges of animals, dependence on water, etc
    b. Trees are easy, just count 'em. Animals are more of a challenge →Estimate
C. Growth and Decline
    a. Arithmetical increase
        i.

    b. Exponential increase
        i.

    c. Shape of Growth Curves
        i. Exponential Growth
            1. J-Shaped growth
        ii. Logistic Growth
            1. S- Shape growth form
            2. Grows exponentially, then evens out at Carry Capacity (K)
                a.

        iii. Environmental resistance
            1. Forces of nature that limit population size
    d. Calculating Exponential Growth
        i. Growth Rate
            1.

            2. r –

                a. Zero population growth r = 0

iii. **III. K-selected and r-Selected Species**

A. K-Selected or Equilibrium

B. r-Selected or Opportunistic

C. Most are a combination, more of a range (turtles are long-lived with no parental care)
   a. Die at anytime, constant lost

IV. Human Populations

A. Survivorship Curves from Life Tables
   a. Life tables
      i. Separate species' life span into suitable units of time
      ii. Notes survivorship for each unit of time
         1. How likely are you to live to be 10, 20, 30, etc
         2. Developed by life insurance agencies

B. Population Pyramid
   a. Separates life span into groups of years, then counts how many people fit group

C. Immigration and Emigration
   a. Immigration –

   b. Emigration –

D. Increase in World Population
   a. Exponential growth after the industrial revolution
   b. United States r = 0.4%; Parts of Africa r = 3% unequal growth
   c. 2 billion in 1927; 4 billion in1974; 6 billion now

E. Impact on the environment
   a. We may have a smaller growth rate, but we utilize more resources
   b. May not be human numbers, but utilization that impacts the environment
   c. China less CO_2 overall, way less CO_2 per capita
   d. Americanization of the planet is not such a good thing for nature

IV. Communities: Interaction of Populations

A. Ecological Community
   a. Diversity

   b. Vegetation

   c. Stability

B. Ecological Dominants

C. Keystone Species

IV. Communities and Ecosystems

A. Interspecific Interactions in Communities
    a. Interspecific Competition
        i. Resource Partitioning

    b. Habitats and Niches
        i. Habitat

        ii. Niches

B. Predation
    a. Predator

    b. Prey

    c. Defenses

    d. Coloration

C. Symbiotic Relationships
    a. Parasitism

    b. Mutualism

D. Disturbances of Communities
    a. Succession
        i. Primary

        ii. Secondary

E. Ecosystem Dynamics
    a. Trophic Levels
        i. Food chains

        ii. Food Webs

F. Chemical Cycling in Ecosystems
    a. Biogeochemical Cycles

    b. examples

G. Biomes
    a. How climate affects biomes
        i. Terrestrial

        ii. Freshwater

        iii. Marine

    b. Coevolution

H. Human Impact on the Environment
    a. Impact on Communities & Ecosystems

    b. Biodiversity

    c. Conservation Biology

Study Questions for Ecology and Population Dynamics

- What is Ecology? What does Ecology study?
- How do we study population dynamics? What are survivorship tables?
- What is the carrying c capacity? What does r and K mean for population growth?
- What is the fundamental unit of ecology? What defines each level?
- What is habitat versus niche?
- What is the difference between abiotic and biotic?
- What is a food web? What are trophic levels?
- What is chemical cycling? Give some examples

I. Science of Studying Animals

a. Zoology – study of animals
b. Anatomy – study of internal and external structure
c. Physiology – study of how those structures work (function)

II. Three Basic Characteristics of Humans

A. Internal Body Cavity – Coelom
    a. Two Main Cavities
        i. Dorsal Cavity
            1. Spinal and Cranial
        ii. Ventral Cavity
            1. Thoracic "chest" – lungs and heart
            2. Abdominopelvic – stomach, liver, pancreas, intestines
B. Internal Skeleton
    a. Vertebrae protect the spinal cord
    b. Skull protects brain by forming the cranial cavity
C. Internal Temperature Regulation
    a. Endothermic – stable internal temperature

III. Review of Organization

A. Organ Systems – groups of interrelated organs and tissues that serve a particular set of functions in the body

IV. 4 Types of Tissue

A. Epithelial
    a. Lines the areas exposed to air to protect from outside world
        i. Keratin protein in skin is "waterproof"
        ii. Ex: skin, nose, lining of GI tract
    b. Forms Glands
        i. Organs or groups of cells that secrete one or more substances
        ii. Two Types
            1. Exocrine
                a. Secrete material through tubes or "ducts" onto the epithelial surface (ex: sweat)
            2. Endocrine
                a. Secrete from cell directly into the tissue
                b. Hormones – substances that when released in 1 part of an organism prompt physiological activity elsewhere
    c. Types of Epithelial Tissue
        i. Squamous - flat
        ii. Cubodial - square
        iii. Columnar - rectangular
        iv. Stratified Squamous – 2+ layers
    d. Attached to basement membrane
        i. Dense network of protein fibers & filaments that attach to deeper tissues
B. Connective (not exposed to air)
    a. Two Jobs
        i. Supports and protects other tissues
        ii. Secretes extracellular material directly from cells
    b. Classified by surrounding extracellular material
        i. Loose connective tissue
            1. Fluid like ground substance and fibers of protein (collagen) to provide strength and flexibility
            2. Adipose Tissue (fat)

a. Type of LC that contains fat cells
b. Provides cushioning, insulation and energy stores

ii. Fibrous and Supporting Connective Tissue
1. More collagen, less ground substance → tougher and stronger
2. Forms:
a. Tendons that attach skeletal muscle to bones
b. Ligaments that connect bone to another bone
c. Capsules that surround organs and enclose joint cavities
3. Supporting Connective Tissue
a. Most rigid form, less fluid, more fiber
b. Cartilage (in nose, ear) – support and flexibility
i. Found between bones of spine, at end of limb bones as shock absorber
ii. No blood vessels
c. Bones
i. Ground substance contains mineral deposits (calcium) →calcified
ii. Make bones strong and resistant to shattering

iii. Fluid Connective Tissue
1. Blood
a. Population of cells and plasma (ground substance)
2. Lymph
a. Comes from Interstitial Fluid (fluid pushed out of capillaries into space around tissues)
b. Recheck, then brought back to blood

C. Muscle
a. Specialized tissue – can shorten and contract
b. Interaction of 2 contractile proteins (fibrils: actin and myosin)
c. Striated Muscle
i. Actin and myosin are regularly arranged
1. Skeletal Muscle - can have many nuclei, mainly for movement, associated w/bones
2. Cardiac Muscle - can also have 2 nuclei
d. Nonstriated Muscle
i. Lack regular arrangement
1. Smooth Muscle – mainly contractions, lungs, GI tract, etc.

D. Nervous
a. Specialized for rapid conduction of electrical impulses
b. Two type
i. Neurons – functional unit of nervous tissue
ii. Neuroglia – provide support, nourishment and insulation, defend neurons from infection
c. Structure of Neuron
i. Cell body – with nuclei
ii. Axon – long extension that transmits information
iii. Dendrites – information transmitted to another neuron
iv. Synapse – site where neuron connects with another cell

V. Summary of Systems - 11 systems in the body → 3 groupings

1. Body Support and Movement
   a. Integumentary System – skin, glands, hair and nails
      i. Protects body from external environment & assists in temperature regulation
   b. Skeletal System – Internal supporting framework
      i. Bones, cartilage, connective tissue, ligaments
      ii. 206 bones along with lots of cartilage
      iii. Bones store minerals, protect soft organs
      iv. Some store lipids, produce red blood cells and other blood elements
   c. Muscular System - Movement
      i. All skeletal muscle (700 –voluntary) not cardiac or smooth muscle
      ii. Posture, balance, support soft tissue, help maintain body temperature
2. Coordination, Regulation and Defense
   a. Nervous System –brain, spinal cord, sense organs (ears, eyes), nerves
      i. Nervous tissue
   b. Endocrine System - hormones
      i. Travel through the blood stream and often function to maintain stability in the body, water conservation, temperature regulation, metabolism
   c. Lymphatic System
      i. Collect interstitial fluid and return it to the blood stream
      ii. Includes lymphoid organs
         1. Produce or support specialized immune cells
         2. Lymph nodes, tonsils, spleen, thymus, peyer's patches
3. Transport and Exchange with the Environment
   a. Cardiovascular System – heart, blood, blood vessels, bone marrow (RBC production site)
      i. Transports nutrients, dissolved gases, hormones to tissues throughout the body
      ii. Carries wastes to kidneys from filtration
   b. Respiratory System – lungs, air passageways
      i. Nasal cavities, pharynx, larynx, trachea
      ii. Transport of Oxygen to lungs
   c. Digestive System – GI tract
      i. Mouth, esophagus, stomach, Intestines, etc.
      ii. Salivary glands, digestive enzymes
      iii. Break down food into usable particles to turn into energy
   d. Urinary System – kidneys, ureters, bladder, urethra
      i. Elimination of waste products from blood via urine
   e. Reproductive System
      i. For offspring production

Study Questions for Basic Anatomy/Physiology

- What do we call "a group of closely associated cells that are adapted to carry out specific functions"
- What are the types of epithelial tissue? How can you tell?
- What are the types of connective tissue? What are some examples
- Which type of muscle tissue lacks striations and is involuntary?
- What is the cell type that forms nerve tissue?