# 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 – WHAT IS LIFE?

#### Introduction to Science

# Science as a way of learning

# What is Science?

# What is Biology?

# Characteristics of Living Things

# Levels of Organization

# Special Qualities of Biology

* 1. Evolution as Unifying Principle
1. Scientific Method

# How does it work?

# Chemistry & Life

1. How we use Chemistry and Physics
2. The Atom
	1. Background
	2. 3 parts
	3. Forms of matter
3. Chemical Bonding
	1. Definition
	2. Stability
	3. 3 types of bonds
4. Why Water is Important
	1. Cohesion & surface tension
	2. Specific heat
	3. Aqueous solutions
	4. Ice
	5. Hydrophilic/phobic
5. Acids/Bases (pH)
	1. Definitions
	2. How it works
	3. pH scale

## Application of Chemistry: Molecules

# Carbon

# Importance

* 1. Shapes& Forms

# Biological Molecules

# Polymers vs. Monomers

# Carbohydrates, Lipids, Proteins, Nucleic Acids

**The Cell: Working Units of Life**

###### Two Categories: Prokaryotic vs. Eukaryotic

1. Eukaryotic Cell
	1. Two types of Eukaryotic cells
2. Animal Cells
	1. Plasma Membrane
	2. Organelles
3. Plant Cells
	1. Differences between Animal & Plant cells
4. Cellular Communication
	1. Plant Communication
	2. Animal Communication

# How Cells Work: Introduction to Energy

1. Energy is Central to Life
	1. Pathway of Energy
2. What is Energy?
	1. Definition
	2. Forms
	3. Thermodynamics
3. How is Energy Used by Living Things?
	1. Efficiency
	2. Kinds
	3. Up and Downhill
4. The Energy Currency Molecule: ATP
	1. What is it?
5. Efficient Energy Use in Living Things: Enzymes
	1. Lowering the Activation Barrier through Enzymes
6. Membrane Functions
	1. Diffusion & Osmosis
	2. Transport Mechanisms
	3. 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)

**Science as a way of learning**

# 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

# 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

# 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

## Scientific Method - Science as a process (fig )

* Definition: a means of coming to understand the natural world through testing of hypotheses
* 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

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#### 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?

# Chemistry & Life

#### I. Aspects of Physics & Chemistry that Apply to Biology

1. Every thing you see is Matter or Energy
	1. Matter – anything that takes up space and has mass
		1. *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

1. Background
	1. First thought that all matter was earth, air, water and fire by Plato
	2. Democritus - substances were made up of invisible, indivisible “atoms”
		1. Around the same time
		2. Not really indivisible
			1. Stanford’s Linear Accelerator – smashes atoms
2. Three parts of an atom, have electrical charges (fig. )
	1. Protons - positively charge
		1. Tightly packed in the nucleus (core) with neutrons
		2. Number elements have different number of protons
			1. Gold-79
			2. Iron-26
	2. Neutrons – neutral charge
		1. Number can vary, not dependant on the number of protons
	3. Electrons – negatively charged
		1. Move around the core some distance away
		2. If atom is of neutral charge: number of electrons = number of protons
		3. Important for bonding atoms together 🡪 make molecules
	4. *Atomic Number* -the number of protons
		1. Also it’s place on the periodic table
		2. Hydrogen is first, with 1
	5. *Atomic Mass* - only the protons and neutrons, not electrons
3. Forms of Matter
	1. Elements
		1. A substance that cannot be reduced to any simpler set of component substances through chemical processes
		2. Defined by the number of protons in its nucleus
			1. Can’t break the protons/neutrons apart to make other atoms
		3. Alloy – combination of different elements like gold, silver and copper
	2. Isotopes (fig )
		1. 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
		2. Isotopes have the same number of protons, different number of neutrons
		3. *Atomic weight* is the average mass of all the isotopes

#### III. Chemical Bonding 🡪 Matter Transformation

1. Process of chemical combination and rearrangement through shifting electrons
2. Quest for stability – need to bond with other atoms
	1. Atoms have energy levels with electrons 🡪 draw it
		1. First has two electrons surrounds the nucleus (protons and neutrons)
		2. Each other has eight electrons
		3. 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

* 1. Unreactive vs. Reactive
		1. Unreactive: outer shell is already full so unlikely to bond with other atoms
		2. Reactive: unfilled outer shell, looking of other atoms to fill unstable
1. Three Main Types of Bonds
2. Covalent Bond
	* 1. Two atoms shared electrons in outer shell
		2. Example: Water
			1. Explain starting with oxygen, point on the number of electrons in outer shell

O

H H

* + - 1. 2 H + 1 O 🡪 8 total electrons in oxygen shared w/ hydrogen
				1. Makes mickey mouse looking molecule

Hydrogen on one end

* + 1. Makes a molecule
			1. A defined number of atoms in a defined spatial relationship
			2. Molecular formula 🡪 H20
		2. Polar and Nonpolar Covalent bonds
			1. In Water Molecule, oxygen has *electronegativity*
				1. Pulls electrons to itself
			2. Polarity
				1. means the molecule has a different electrical charge at one end as opposed to the other (nonsymmetrical)
				2. 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

* + - 1. Nonpolar
				1. Symmetric electrons, around the nucleus
				2. Shared equally between the two + atoms
				3. Ex: Methane 4H + C 🡪 CH4

 H

H C H

 H

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

Na Cl 🡪 Na Cl

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

H H O

 O H H

* 1. Usually oxygen or nitrogen
		1. Both are polar covalent bonds
		2. Remember carbon was non-polar

IV. Importance of Water

### Earth and humans are mostly water (71-66% respectively)

* 1. Cohesion of water where air meets the water
		1. 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
	2. Specific Heat –water holds a lot of energy
		1. 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
		2. Temperature measures heat (movement of molecules)
		3. Water helps us keep homeostasis – constant temperature
			1. Sweat releases heat from the body via water
				1. Droplets can hold a lot of heat
	3. Water as universal solvent – Aqueous solutions
		1. A solute dissolved in a solvent makes a solution!
			1. Solute: what’s being dissolved (salt)
			2. Solvent: in what it’s dissolving (water)
		2. Solution: a homogenous mixture of two or more kinds of molecules, atoms or ions
			1. Nonpolar solutes dissolve in Nonpolar solvents
				1. Water & salt are polar so dissolve
				2. Soap & grease are Nonpolar so soap breaks up grease

### Something’s are water-soluble and some are fat-soluble for structures

* + 1. 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
	1. Ice (fig )
		1. 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
				1. Ice-fishing: fish live under the ice even though the ice is frozen
				2. Keeps the water under the ice warmer than air
	2. Hydrophilic vs. Hydrophobic
		1. Hydrophilic
			1. Compounds that will interact with water Na+ & Cl-
		2. Hydrophobic
			1. Compounds that don’t interact with water
				1. Means they don’t mix (water and oil)
			2. Skin is not water permeable, like gortex

### Acids and Bases

* 1. Aqueous solutions have a certain amount of either acids or bases
		1. Acid
			1. Any substance that yields hydrogen ions when put in solution
		2. Base
			1. Any substance that accepts hydrogen ions in solution
	2. How it works (fig )
		1. HCl + H2O 🡪 dissociates into H+ and Cl-
			1. HCl yields hydrogen ions (H+) so its more acidic
		2. NaOH + H2O 🡪 dissociates into Na+ and OH-
			1. NaOH 🡪 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
				1. Not enough OH/H to keep it all water so it’s basic!
	3. pH scale
		1. pH number:
			1. Concentration of H+ ions in solution
				1. Net effect of hydrogen ion yielding & accepting
				2. How of pH is quantified and given a number
		2. Logarithmic scale
			1. pH of 9 is 10x more basic as 8 & 100x more basic as 7
		3. Terms of pH
			1. Higher pH = more basic
			2. Alkaline also means basic
			3. Acids are also called proton acceptors in biology
		4. Importance of pH
			1. Lots of living things are sensitive to pH
				1. Enzymes will change shape in acidic solutions
				2. Asthmatics have acidic breath,

Acidity increases airway restriction

* + 1. Buffer systems
			1. Most things live at ~ pH 6-8
			2. Body has systems to keep the pH more constant
				1. Work to neutralize the infusion of an acidic or basic solution
				2. Usually involves the accepting or donating of H+
				3. Digestive system
				4. 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:

### Application of Chemistry: Molecules

### Organic means it’s made of Carbon

* 1. Life is based on carbon compounds in water (like flour in baking)
	2. Bonding capacity
		1. Since it has 4 valance electrons, it can bond 4 more electrons
		2. Bonds are covalent – more stable because they share electrons
	3. CH4
	4. Chain - C3H8
	5. Isomers
		1. Two forms of the same chemical formula
	6. Benzene Ring – C6H6
		1. Double bonds between C and C

### Biological Molecules

* 1. Monomers are the small building blocks of Polymers
		1. Hydrolysis – too break with water
	2. Carbohydrates (end with –ose) - Contains carbon, oxygen and hydrogen:
		1. Have 2x the H as O
		2. Monosaccharides: Glucose: C6H12O6
			1. Most important energy source
			2. Can be built into disaccharides: lactose, sucrose
		3. Polysaccharides (fig ) – many sugars together
			1. Starch
				1. How plants store carbohydrate
				2. Potatoes, rice (seeds), corn, wheat, carrots (roots)
			2. Glycogen
				1. How animals store carbohydrates
				2. Carbohydrate loading: glycogen loading
			3. Cellulose
				1. Cellulose is not digested by enzymes, only bacteria
				2. Insoluble fiber: move things through GI tract
			4. Chitin
				1. Forms the exoskeleton of arthropods
	3. Lipids
		1. Still oxygen, carbon and hydrogen: just has more H than O than Carbs
		2. Fats, oils, cholesterol, hormones
		3. No monomer that they are all made up of
		4. Relatively water insoluble: make good internal containers
		5. Three Classes of Lipids
			1. Glycerides - most common kind of lipid
				1. Two parts

Head = glycerol

Tail = fatty acids chain of C & H

* + - * 1. Glycerol to Glyceride

Alcohols have OH group on it

Together = Glyceride

2 = diglyceride; 3 = triglycerides

* + - * 1. R chain determines Saturation level (fig )

How many Hydrogens they contain

Saturated = no double bonds

Linked to heart disease via high cholesterol

Monounsaturated = one double bond

Polyunsaturated = more than one double bond

* + - * 1. Fats (margarine) from Oils (vegetable oil)

Hydrogenation: decreases the number of double bonds

Saturated fats line up so they “stack” better & make things more solid

Polyunsaturated fats don’t stack so they stay liquid at room temperature

* + - * 1. Energy Storage (fig )

Can be used to store energy and insulate body

* + - 1. Steroids (fig. )
				1. Smaller lipid with a slightly different structure 🡪 4 Carbon rings
				2. Cholesterol (not all bad!)

Breaks down fats

Builds outer membranes of cells

Precursor to steroid hormones:

Testosterone (male hormone)

Estrogen (female hormone)

Commercial steroids = male hormones

* + - 1. Phospholipids (fig )
				1. Like triglycerides but has two fatty acid tails (not three)

Hydrocarbon tail = hydrophobic

* + - * 1. Phosphate group (phosphorus atom with 4 oxygens around it) attached to the OH group of glycerol

Phosphate group (has charge) so its hydrophilic

* + - * 1. Becomes phospholipids bilayer for cells to contain water
	1. Proteins
		1. Types of Proteins
		2. Parts of proteins
			1. Amino acid chains (monomer) – building block
				1. Amino group and a carboxyl group attached to a carbon
				2. R group defines amino acid (fig )
				3. 20 total amino acids that all proteins

Acid chain are in different orders

Join together in the same way (fig )

Lose water

* + - 1. Polypeptide (polymer) – chain of amino acids
			2. Folded in 3D way 🡪 protein
		1. Shapes of proteins
			1. Function of the protein is based on it’s configuration
				1. Needs to fit with the receptor correctly to do it’s job
		2. Four Levels of Proteins (fig. )
			1. Primary – chain of amino acids
				1. The order determines the rest of the shape
			2. Secondary – simple shapes
				1. Alpha helix of DNA
				2. Pleated sheet
				3. Random coil
			3. Tertiary – folded polypeptide chain
			4. Quaternary – two + polypeptide chains
		3. Denature
			1. Changes the shape of protein 🡪 changes function
				1. Alcohol changes the shape and function of bacteria
		4. Lipoproteins and Glycoproteins
			1. Lipoproteins
				1. Made up of a protein capsule surrounded by fat
				2. Two types based on ratio of protein to lipid

HDL – high density lipoprotein

Carry cholesterol: outlying cells 🡪 liver

LDL – low density lipoprotein

Carry cholesterol: liver 🡪 outlying cells

Brings to coronary arteries of the heart and builds “plaque”

* + - 1. Glycoproteins
				1. Carbohydrates and proteins

Receptor of proteins

Sit on cell surface

Ex: insulin

* 1. Nucleotides & Nucleic Acids
		1. Nucleotides, like adenosine phosphates, serve as energy carriers
			1. Ex: ATP
		2. Where does the cell get information to make proteins, etc?
			1. DNA – deoxyribonucleic acid
				1. Information center of a cell: directions for everything

3 billion nucleotides in our main DNA molecules

Each cell has a copy

* + - 1. Ribonucleic acid (RNA)
				1. Moves the DNA encoded information to the place in the cell where proteins are made
			2. Nucleotide
				1. Structural unit (monomer) for DNA (fig 3.25)
				2. Three parts

Phosphate group

Sugar (deoxyribose)

Base

* + - * 1. One links to another and forms a chain
				2. Two chains come together to form double helix

Chains “run” in opposite directions

* + - * 1. This is what Rosalind Franklin didn’t figure out

**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?

**The Cell: Working Units of Life**

###### General Information

* 1. Must be produced by other cells
		1. Can’t be made in a lab
		2. Linked to cells 3.5 billion years ago
		3. Cells are specialized for different jobs

###### Two Categories: Prokaryotic vs. Eukaryotic

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

###### Eukaryotic Cell

* 1. Two types of Eukaryotic cells:
		1. Animal cells
		2. Plant cells
	2. Both have:
		1. Nucleus – a membrane-lined compartment that serves as the cell’s information center
		2. Organelles – outside nucleus
		3. Cytoplasm – region outside nucleus
		4. Cytosol – protein-rich; jelly like outside nucleus
		5. Cytoskeleton – a kind of internal scaffolding that has different kinds of units
		6. Plasma membrane – outer boundary of cell
1. **Boundary of the Cell**
	1. Plasma Membrane (Fluid Mosaic) Functions
		1. Keeps important things in
		2. Keeps bad stuff out
		3. Controls passageway of necessary molecules
		4. Interprets signals from other cells
	2. Phospholipid Bilayer (fig )
		1. 2 long fatty-acid chains – hydrophobic
		2. Phosphate bearing group – hydrophilic
			1. Point outward, toward water of extracellular fluid and cytosol
		3. Only hydrophobic molecules (and small hydrophilic molecules) can pass
			1. Lets things like steroids in
			2. Keeps hydrophilic substances out: ions, polar molecules, etc.
	3. Cholesterol
		1. Act as a patch substance on the bilayer, keeps out small molecules
		2. Keep the membrane at an optimum level of fluidity
	4. Proteins
		1. 2 major types
			1. Integral -from side to side or partway in membrane
			2. Peripheral - lie on either side of membrane
		2. Functions
			1. Structural Support
				1. Peripheral proteins help connect membrane to cell by being attached to cytoskeleton
			2. Recognition/Transport
				1. Binding sites tell molecules if they can pass, or not
				2. Certain proteins respond to certain molecules, not all

Very specific with what they interact with

* + - * 1. A cell with a *foreign* set of binding sites will be destroyed by the immune system
			1. Communication
				1. Receptor proteins – for cells to communicate with each other

Hormones, electrical charges, etc.

* + - * 1. Changes cells activity
	1. Glycocalyx – “sugar coat”
		1. Carbohydrate or Sugar-side chains
		2. 3 Main Functions
			1. Serve as binding sites for proteins
			2. Lubricate cells
			3. Keep cells in place by sticking to something
1. **What’s inside the Cell**
	1. Good Way to Learn Parts 🡪 Protein Export (fig. )
		1. 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)
		2. mRNA – Messenger RNA
			1. DNA instruction is copied onto the mRNA,
			2. Leaves nucleus through the nuclear pores
		3. 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:
				1. Ribosome moves to Endoplasmic Reticulum (ER)
		4. Rough Endoplasmic Reticulum -
			1. Means: *network within the cytoplasm*; rough has ribosomes attached
			2. Produces an amino acid inside ER membrane
				1. Cisternal Space 🡪 where the polypeptide chain folds up and sugar side chain is added

Cisternae – membranous sacs

* + - * 1. Also gets rid of chains that are defective
				2. Protein in membrane can *bud off* and then fuse to another membrane-bound organelle
		1. Transport Vesicles 🡪 endomembrane system
			1. Moves proteins around
		2. 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
				1. Exocytosis – leaves cells
	1. Other parts
		1. Smooth ER
			1. No ribosomes, not for protein synthesis
			2. Lipid synthesis & detoxification
		2. 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
		3. Mitochondria (fig. )
			1. Place where ATP, water & carbon dioxide is made from food & oxygen
	2. What gives an Animal cell structure? Cytoskeleton (fig. )
		+ 1. Proteins strands that give cells there shape
			2. 3 component parts
				1. Microfilaments – slender shape
				2. Intermediate filaments

Stabilizes position of organelles & nucleus, cell shape

* + - * 1. Microtubules

Determine cell shape

Move vesicles between organelles

Underlying structure for cilia & flagella for cell movement

1. **Plant Cells (fig. )**
	1. Differences btwn Animal & Plant cells
		1. Thick Cell Wall
			1. Plasma membrane is thin and frail
			2. Cell wall is thick & rigid 🡪 plants are stationary
				1. Provide structure strength
				2. Limit water absorption
				3. Protect plant from outside influences
			3. Made of cellulose & lignin (very strong)
			4. Can be sites of metabolic activity too
		2. 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
		3. Plastids (chloroplasts)
			1. Only in plants and algae
			2. Give color to plants 🡪 Chloroplasts
				1. Contains chlorophyll
				2. Sites of photosynthesis:

Sunlight + CO2 🡪 Glucose + H20 + O2

1. **Cellular Communication (fig. )**
	1. Remember cells together make up tissues
		1. Have to talk amongst themselves
	2. Plant Communication
		1. Talk through plasmodesmata - channels in the cell wall
			1. Cytoplasm is continuous between cells
	3. Animal Communication
		1. 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 How Cells Work: Introduction to Energy

1. **What is Energy?**
2. Energy 🡪 Capacity to do work
	1. Bring about movement against an opposing force & bring about change
	2. Food calories 🡪1 calorie is the amount of energy that can raise the temperature of 1 gram of water 1 degree Celsius
		1. 1 Calorie (or 1kcal) = 1000 cal
3. Forms of Energy
	1. Potential energy – stored energy
	2. Kinetic energy – energy in motion
		1. Potential becomes kinetic with action
4. The Study of Energy: Thermodynamics (bioenergetics)
	1. The First Law 🡪 Transformation (Conservation) of Energy
		1. Energy is never created or destroyed, it is transformed
		2. Losses energy through transformation via heat produced by reaction
	2. The Second Law 🡪 The Natural Tendency toward Disorder
		1. Energy transformations will run from greater order to lesser order
			1. Not all of the energy created is useful, some is dissipated
		2. Energy transfer results in a greater amount of disorder in the universe
			1. Entropy – measure of the amount of disorder in a system
5. **How is Energy Used by Living Things?**
6. Efficiency – how well it converts energy without loss
7. Kinds of Work for Living Things
	1. Mechanical work – contracting muscles
	2. Transport work – moving sodium ions against the gradient
	3. Synthetic work – buildup complex molecules (proteins) from simpler ones (amino acids)
8. Energy In versus Energy out
	1. Downhill /Exergonic – energy out
		1. Breakdown of molecules 🡪 Energy is released
	2. Uphill/Endergonic – energy in
		1. Runs uphill because you need energy to build stuff
		2. What you make holds the energy in bonds
	3. Coupled Reactions
		1. When exergonic reactions “fund” endergonic reactions

## 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

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

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

## VI. Lowering the Activation Barrier through enzymes

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

#### VII. Regulating Enzymatic Activity

1. Factors that influence the amount of “product” an enzyme turns out
	1. Amount of substrate
	2. Enzyme can be occupied by another molecule and therefore can’t function
2. Regulation of Enzymes (fig )
	1. Negative feedback – home heating system
		1. Kicks on heat when house is cold
	2. Inhibitors or Allosteric (allo - other; steric – shape)Enzymes
		1. 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
	1. Moves down a concentration gradient
	2. Movement through membranes
		1. If permeable, both water & solutes can move across membrane
		2. If semipermeable, water moves freely, solutes don’t
	3. Plasma Membrane is semipermeable
		1. its permeable to water and lipids, not charged substances

B. Osmosis

1. Passive Transport of water across a selectively (semipermeable) membrane
	1. Osmosis moves water across the membrane, not solutes
2. Plants take as much water in the cell as will fit (turgid vs. flaccid/wilted)
	1. Plasmolysis – not enough water, so cell dies off
3. Animal cells would burst if too much water enters
	1. Osmoregulation – control of water balance in animals
4. Terms:
	* 1. Hypertonic – a fluid has a higher concentration of solutes than another, water flows out of cell
		2. Isotonic – same concentration of solutes inside and out
		3. Hypotonic – a fluid that has a lower concentration of solutes than another, water flow into cell
5. **How Do Materials Move In and Out**
	1. Some materials need forces and special protein channels or they need protein channels and energy to cross the membrane
	2. Passive Transport
		1. Two Kinds – both required No Energy
			1. Simple Diffusion
				1. Doesn’t require special protein channels
				2. Water, oxygen, carbon out of cell
			2. Facilitated Diffusion
				1. The passage of materials through the plasma membrane, using both a concentration gradient and a channel made by a transport/integral protein
	3. Active Transport (fig )
		1. Sometimes molecules need to be higher concentration inside the cell
		2. Molecules need to move against the concentration gradient
		3. ATP required to *“pump”* molecules across membrane
6. **Moving Big Things In and Out**
	1. Movement Out: Exocytosis
		1. The movement of materials out of the cell through a fusion of vesicles with the plasma membrane
		2. Cells use exocytosis to export protein
	2. Movement In: Endocytosis
		1. The movement of relatively large materials into the cell by infolding of the plasma membrane
		2. Three Forms
			1. Pinocytosis
				1. Plasma membrane creates an enclosure that pinches off to become a vesicle that moves into the cell
			2. Receptor-Mediated Endocytosis
				1. 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
				1. Certain cell engulfs whole cells, fragments of them or other organic materials

**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?