Good Examples of Learning Goals at UBC and CU

This document is a collection of learning goals for courses in different subjects. The terms "learning objectives" and "learning goals" are used interchangeably and should be interpreted to mean the same thing in the context of this document. As can be seen, they are in various formats, but in all cases, it is clear what the students should be able to do upon completion of the course and how to measure how well students have achieved the goals. Some, if not most, of these courses have goals that are still being refined and hence may be slightly incomplete, as noted. It is normally assumed that these goals will define the substantial majority (70-90%) of the content covered in the course with the remainder being the choice of the instructor. This is stated explicitly in some cases, and in most of the other cases it is an implicit assumption.

At the end is an appendix providing a preliminary summary of a report looking at the use of explicit learning goals, and how these benefited students.

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CU – MCDB 2150 (Principles of Genetics) -complete

Students enrolling in this course should be able to demonstrate achievement of the learning goals for Introductory Biology MCDB 1111, or 1150 and 1151.

Teaching toward the learning goals below is expected to occupy 60%-70% of class time. The remaining course content is at the discretion of the instructors. The relative emphasis placed on the goals below and the order in which they are dealt with may also vary according to the tastes and interests of individual instructors. However, all students who receive a passing grade in the course should be able to demonstrate achievement of the following minimal goals.

* Achievement of starred goals will be aided by work in the accompanying lab course, MCDB 2151.

After completing this course, students should be able to:

1. Analyze phenotypic data and deduce possible modes of inheritance (e.g. dominant, recessive, autosomal, X-linked, cytoplasmic) from family histories.
    - Draw a pedigree based on information in a story problem.
    - Calculate the probability that an individual in a pedigree has a particular genotype.
    - Define the terms "incomplete penetrance," "variable expressivity," and "sex-limited phenotype," and explain how these phenomena can complicate pedigree analysis.

2. Describe the molecular anatomy of genes and genomes.
    - Recognize that a given gene is generally situated at the same chromosomal locus in a species.
    - Differentiate between a gene and an allele.
    - Diagram a typical eukaryotic gene and indicate the locations of (a) regions that are genic but are not coding, (b) regions that are transcribed but not translated, and (c) regions that are both transcribed and translated.
    - Describe the general organization, possible function, and frequency of genes and non-gene DNA sequences in a typical eukaryotic genome.
    - Explain the functional significance of packaging DNA into chromosomes and the lack of correlation between chromosome number and genetic information content.

3. Describe the mechanisms by which an organism's genome is passed on to the next generation.
    - Define somatic and germline cells, and list similarities and differences between them.
    - Recognize why germline mutations can be passed onto the next generation, whereas somatic mutations cannot.
    - *Describe, using diagrams, the sequence of events involving DNA in meiosis from chromosome duplication through chromosome segregation.
    - Describe the phenomena of linkage and independent assortment of alleles during meiosis, and explain why some pairs of alleles exhibit linkage and others do not.
    - *Explain how independent assortment can lead to new combinations of alleles of unlinked genes.
    - Diagram the process of homologous recombination during meiosis and explain how it can lead to new combinations of linked alleles.
    - Explain how a specific combination of linked alleles (haplotype) can persist through many generations.

4. Extract information about genes, alleles, and gene functions from genetic crosses and human pedigree analysis.
    - *Design genetic crosses to provide information about genes, alleles, and gene functions.
    - Explain why it is advantageous to use true-breeding organisms in crosses.
    - Predict progeny genotypic frequencies given the genotypes of the parental gametes.
    - *Identify an allele's mode of inheritance from progeny phenotypes.
    - Place genes in a functional order based on the phenotypes of double mutants, and explain the assumptions that must be made when interpreting these results.
    - Determine gene linkage and genetic map distances by analyzing progeny with recombinant phenotypes.
    - *Use statistical analysis to determine how well data from a genetic cross or human pedigree analysis fits theoretical predictions.
    - *Determine if two mutations affect the same gene using complementation tests, and explain the requirements and the basis for interpreting results from these tests.

5. Describe the processes that can influence the frequency of alleles in a population.

Determine allele frequencies based on phenotypic data for a population in equilibrium.
Explain how natural selection and genetic drift can affect the elimination or maintenance of deleterious alleles in a population.

6. Cite examples of gene dosage variation (ploidy), and explain why it affects phenotype.
Discuss why alterations in chromosome number can be detrimental.
Describe the process of X inactivation in mammals, and explain its function.

7. Compare different types of mutations and describe how each can affect genes, mRNA and proteins.
*Explain, using diagrams, how nucleotide changes result in the alteration of protein activity.
*Explain why some mutations do not affect protein structure or function.
Describe how deletions, inversions, translocations, and the movement of transpositional elements can affect gene function, gene expression, and genetic recombination.
*Describe how mutations arise and how environmental factors can increase mutation rate.
Cite examples of mutations that can be beneficial to organisms.
*Explain why some DNA damage does not result in mutation.
Distinguish between a DNA replication error and a mutation.
Explain what is meant by a single-nucleotide polymorphism (SNP) and how SNPs can be used as genetic markers even if they do not affect protein structure or function.

8. Explain the molecular basis at the protein level for allele types with different genetic behaviors.
Describe the differences between loss of function and gain of function mutations and their potential phenotypic consequences.
Predict the most likely effects on protein structure and function of null, reduction-of-function, overexpression, dominant-negative and gain-of-function mutations.

9. Justify the value of studying genetics in organisms other than humans.
Explain why it is useful to investigate functions of many human genes by studying simple model organisms such as yeast, nematode worms, and fruit flies.
Describe the benefits and limitations of using model systems to study human diseases.
Use bioinformatic data to compare homologous genes in different species and infer relative degrees of evolutionary relatedness.

10. Describe the steps that are taken to determine the molecular identity of a human gene that when mutated can underlie a disease.
Use information from model organisms to identify candidate genes in humans.
Use pedigree information and DNA markers to track a disease trait in a family.
Explain, correctly apply, and interpret results from molecular genetic tools such as DNA sequencing, SNP analysis, and microarrays.

CU – MCDB 1150 (Intro Biology) - complete

Teaching toward attainment of these student learning goals is expected to occupy 60%-70% of class time. The remaining course content is at the discretion of the instructors. The relative emphasis placed on the goals below will also vary according to the tastes and interests of individual instructors. However, all students who receive a passing grade in the course should be able to demonstrate achievement of the following minimal goals.

* Students may work toward starred goals partly or primarily in an associated laboratory course.

After completing an introductory MCDB course, students should be able to:

1. Explain what makes living organisms unique among the complex systems that we are familiar with, in terms of how they process information, matter, and energy.

- Describe the fundamental properties of cells and indicate which properties are unique to living organisms.
- Discuss whether both living and non-living things obey the same laws of chemistry and physics.

2. Contrast the features that distinguish viruses, bacterial cells, and eukaryotic cells from each other.

- Compare the structure of the bacterial nucleoid and the eukaryotic cell nucleus, as well as the organization of the genetic material contained in each.
- Distinguish bacterial cell division from eukaryotic cell division.
- Compare the structures that are required for acquiring and utilizing energy in bacteria and eukaryotic cells.
- Defend the proposition that viruses are not alive.

3. Explain the theory of evolution, and cite evidence that it is an ongoing process affecting our daily lives.

- Explain how variation and natural selection can cause evolutionary change.
- Defend the view that mitochondria and chloroplasts in eukaryotic cells evolved from engulfment of primitive bacteria.
- Predict the results of antibiotic over-use on bacterial populations.
- Explain why it is necessary to get a flu shot every year to guard against influenza instead of only once in childhood like some other vaccines.

4. Recognize structures of the four major classes of building-block molecules (monomers) that make up cellular macromolecules and membranes.

- Identify structures or molecular models of amino acids, nucleotides, sugars, and phospholipids.
- Name the macromolecules or structures that are obtained by linking or associating each of these monomers into a polymer or stable assembly, and describe the bonds that hold them together.

5. Describe how the properties of water affect the three-dimensional structures and stabilities of macromolecules, macromolecular assemblies, and lipid membranes.

- Explain why phospholipids in water tend to form micelles or lipid bilayers.
- Predict the relative solubilities in water of different molecules from their chemical structures.
- Predict whether a given amino acid is more likely to be found on the outside surface or on the inside when the protein containing it folds up.
- Explain what kind of interactions (chemical forces or bonds) contributes to the overall three-dimensional shape of a protein.
- Explain why a folded polypeptide with hydrophobic groups inside is more stable than the same polypeptide unfolded with hydrophobic groups exposed to water.

6. Explain the concept of free energy (G) and how it applies to biological systems.

- State the First and Second Laws of Thermodynamics and how they apply to biological systems.
- Define the change in free energy (ΔG) of a biochemical reaction, in words and in an equation relating ΔG to change in heat energy (ΔH), temperature (T), and change in entropy (ΔS).
- Discuss the relationship between the sign and magnitude of ΔG and the tendency of a reaction to proceed spontaneously.
- Name an important biochemical reaction in the cell with a $-\Delta G$ and one with a $+\Delta G$.

7. *Explain how cells drive energetically unfavorable biochemical reactions.

- Distinguish between equilibrium, non-equilibrium, and steady state biochemical reactions using flow diagrams, and indicate which kind of reactions predominate in living organisms.
- Explain how a steady state could maintain a metabolite at a constant intracellular concentration.
- Defend the proposition that the homeostasis observed in organisms is the result of steady-state processes versus equilibrium reactions.
- Explain how coupled reactions allow an energetically favorable process (e.g. ATP hydrolysis) to drive an energetically unfavorable process (e.g. phosphodiester bond formation).

8. *Explain how an enzyme increases the rate of a biochemical reaction in terms of thermodynamics, kinetics, and molecular interactions.
   - Draw and compare the energy diagrams for an enzyme-catalyzed reaction and the corresponding uncatalyzed reaction.
   - Describe different ways that enzymes lower activation energy for biochemical reactions.
   - Describe how the catalytic activity of enzymes can be regulated allosterically by molecules that are structurally unrelated to enzyme substrates.

9. *Outline the flow of matter and energy in the processes by which organisms fuel growth and cellular activities, and explain how these processes conform to the laws of thermodynamics.
   - Define oxidation and reduction in terms of gain and loss of electrons.
   - Describe the general pathway by which the energy in food molecules is converted to ATP energy and where these events occur in the cell.
   - Identify the molecules that are oxidized and those are reduced in this pathway.
   - Explain the role of oxygen in this pathway and why oxygen is essential for human life.
   - Compare photosynthesis and respiration in terms of reactants/products and energy flow.
   - Describe the principle by which an ionic gradient across a membrane (i.e. H^+) can drive an energy-requiring process and explain how this principle applies in cellular respiration.
   - Compare the functions of NADH and NADPH in cellular metabolism.
   - Explain the roles of NADPH and ATP in biosynthesis of cellular components from small molecules, and why both NADPH and ATP are required for this process.

10. Describe the chemical and physical structures of phospholipid bilayer membranes and their associated proteins in cells, and explain the various mechanisms by which small molecules can traverse them.
    - Compare the building blocks of membrane lipids and their amphipathic characteristics.
    - Compare the general functions of integral, lipid-anchored, and peripheral membrane proteins.
    - Predict, from the structure of a solute whether or not it will diffuse passively across a simple phospholipid bilayer membrane.

    - Compare the processes of passive diffusion, osmosis, facilitated diffusion, and active transport through membranes that contain channel proteins.
    - Predict how a cell will react when placed into a hypertonic or hypotonic medium.
    - Compare transporters and channels in terms of directions of solute movement and energy requirement.
    - Describe the mechanism by which Na^+ and K^+ gradients are established across the plasma membrane.

11. Explain the importance of membranes in compartmentalizing cellular activities and describe the essential functions that are carried out by the major organelles in a eukaryotic cell.
    - Draw and label an animal cell with nucleus, endoplasmic reticulum, and Golgi apparatus and illustrate the relationship between the nuclear and ER membrane.

- Diagram or describe the general process by which molecules (proteins, lipids, neurotransmitters) are moved from a donor compartment to an acceptor compartment.
- Describe the general mechanism by which specific cell “cargo” (proteins, lysosomal proteins, membrane proteins, nuclear proteins, ER proteins) are routed to their proper destinations in the cell.

12. Using diagrams, describe in general terms how the information in a gene is stored, replicated, and transmitted to daughter cells.
    - Diagram a bacterial and a eukaryotic chromosome and compare the important structural and functional regions of each (telomeres, origins of replication, centromeres).
    - Describe how DNA is packaged into the chromosomes in a eukaryotic cell nucleus
    - Identify the nucleotide components in a double-stranded DNA molecule and the bonds that hold them together.
    - Explain how the structure of DNA is particularly suited for storage and replication of genetic information.
    - Interpret the experimental evidence demonstrating that DNA is the genetic material.
    - Interpret the experimental evidence showing that DNA replication is semi-conservative and the evidence showing that DNA replication is bidirectional.
    - Define what is meant by the genetic code, and explain how universal it is among organisms.
    - Design an experiment demonstrating that the genetic code is essentially the same in organisms from two different kingdoms.

13. Using diagrams, describe in general terms how the information in a gene is accessed for expression of a specific protein.
    - Explain in general terms how different types of cells in the same organism can produce different proteins, even though all cells carry the same DNA sequence information.
    - Describe the sequence of events of transcription.
    - Compare the processing events that must occur during eukaryotic transcription and distinguish the function of each.
    - Name the key elements that are required for translational initiation to occur at the correct codon.
    - Explain how a codon in the mRNA base pairs with the anticodon of a tRNA during translation. Identify the sites on the ribosome where translation occurs.
    - Describe the sequence of events in translation.

14. Describe the general mechanisms by which chemical signals from outside a cell are transduced across the cell membrane to influence cell behavior and gene expression.
    - Explain in general how a receptor molecule that binds a ligand from outside the cell is able to influence biochemical processes inside the cell.
    - Describe one way in which an activated receptor at the cell surface can cause transcription of a specific gene in the nucleus, and specify the functions of any intermediates involved.

15. Describe and justify the process of scientific research, and explain the nature of scientific knowledge.
    - *Given a well-designed scientific experiment, identify the positive and negative controls and explain their purpose.
    - *Analyze and draw conclusions from numerical and graphical data.
    - *Explain the difference between a hypothesis and a theory.

<u>Under Discussion for possible inclusion:</u> Distinguish the roles of the soma and the germ line in the life cycle of a typical multicellular organism.

- Compare the similarities and differences between somatic and germline cells.

- Explain how the process of meiosis contributes to genetic diversity and why it is essential for evolution to occur.
- Diagram the sequence of events in meiosis from DNA replication through chromosome segregation, indicating the number of single-stranded and double stranded molecules present in the chromosomes at each step.

Appendix. Chemistry background necessary for understanding of biological systems.

- Compare noncovalent and covalent bonds in terms of stability and the energy required to break them.
- Compare the chemical basis for the three types of noncovalent bonds and describe how they contribute to structure of biological molecules.
- Compare polarized vs. nonpolarized covalent bonds in terms of electron sharing and discuss the chemical basis for the behavior of polar and nonpolar molecules in water.
- Identify the common electronegative atoms contributing to polar covalent bonds in biological molecules.

Describe the types of bonding occurring in, and between, water molecules and how this bonding determines the solvent properties of wa**ter.**

Cell Biology MCDB 3120 (Cell Biology) – nearly complete

Course and Topic Learning Goals

Students enrolling in this course should be able to demonstrate achievement of the learning goals for either Introductory Biology MCDB 1150 and 1151 or 1111, or, as well as Genetics MCDB 2150.

Teaching toward the learning goals below is expected to occupy 60%-70% of class time. The remaining course content is at the discretion of the instructors. The relative emphasis placed on the goals below and the order in which they are dealt with may also vary according to the tastes and interests of individual instructors. However, all students who receive a passing grade in the course should be able to demonstrate achievement of the following minimal goals.

After completing this course, students should be able to:

1. Relate structures and functions of the lipid-bilayer membranes in cells.
   - Defend the proposition that membranes are essential for cellular function.
   - Describe the universal characteristics of cell membranes.
   - Explain how the lipid and protein components of membranes are critical to their functions.
   - Describe the structurally asymmetries of cell membranes and explain why this asymmetry is essential for their functions.
   - Distinguish between the major classes of membrane proteins.
   - Predict how variation in the lipid composition of a membrane affects its fluidity and the mobility of integral membrane proteins.
   - Explain how integral proteins in the cell plasma membrane can affect the cell cytoskeleton.

2. Compare the different ways in which molecules are transported across membranes.
   - Distinguish between simple diffusion, facilitated diffusion, and active transport.
   - Recognize that rates of simple diffusion for a molecule are determined by size and hydrophobicity.
   - Explain how protein transporters (channel proteins or carrier proteins) mediate facilitated diffusion.

- Explain why active transport requires ATP.
- Explain how hyperpolarization and depolarization occur in nerve transmission.

3. Describe the several mechanisms that hold the cells of multicellular organisms together and the functions of the proteins involved.
    - Compare the roles of different types of cell junctions (tight junctions, anchoring junctions, and communication junctions) and the proteins that comprise them.
    - Compare the properties of cells in an epithelium with those of mesenchymal cells.
    - Explain why the locations of the multiple cell junctions made by an epithelial cell are important to the cell's function in the epithelium.

4. Describe how cells respond to stimuli and communicate with each other through trans- membrane signaling pathways.
    - Cite examples of environmental and chemical signals that stimulate cells.
    - Compare the mechanisms by which ion-channel-linked receptors, G-protein-linked receptors, and enzyme-linked receptors transmit signals across the plasma membrane.
    - Identify the steps in signal transduction that account for the specificity of a signaling pathway.

5. Describe the processes that cells use to synthesize and secrete molecules into their environments.
    - Compare the functions of the organelles of the secretory pathway (ER and Golgi) and explain how the directional flow of secreted components is regulated.
    - Explain how the presence or absence of an ER signal sequence in a protein determines whether the protein remains attached to the ER or is released to the cytosol.
    - Describe how proteins synthesized in the ER get to the Golgi apparatus via vesicles.
    - Describe ways glycoproteins are synthesized through glycosylation
    - Describe how phospholipids are synthesized in the ER.
    - Compare the different ways a protein can exit from the trans-Golgi network (regulated vs. unregulated).
    - Describe the different mechanisms by which secretory vesicles fuse with the plasma membrane.

6. Describe the processes by which cells destroy and recycle unwanted components.
    - Describe how vesicles from the Golgi apparatus and endocytic vesicles are transported to lysosomes.
    - Describe how lysosomes can degrade ingested products like bacteria.
    - Explain how the lysosome is used to recycle cellular materials.
    - Describe how proteins can be targeted for degradation by the proteosome.

7. Explain how membrane potentials can be used to drive formation of ATP from ADP.
    - Explain the importance of an electrochemical potential in the generation of ATP.
    - Explain how the compartmentalization of mitochondria is important for energy production.
    - Describe the roles of integral membrane proteins, peripheral membrane proteins, and lipids in the generation of ATP.
    - Explain how the mitochondrial electron transport chain produces an electrochemical gradient across the inner membrane.
    - Propose a way in which drugs that uncouple electron transport from ATP generation could be used to control obesity.

8. Compare proteins encoded by organelle genomes to those encoded by the nuclear genomes.
    - Compare the cellular locations and the mechanisms for synthesis of proteins encoded by nuclear and organelle genomes.
    - Explain why mitochondria and chloroplasts are dependent on proteins encoded by the nuclear genome as well as those encoded in the organelle genomes.

- Describe the kinds of crosstalk that occurs between nuclear and mitochondrial genomes.

9. Compare the processes by which proteins are targeted to different cellular organelles.
   - Differentiate between import of proteins into the ER, nucleus, and mitochondria.
   - Describe how proteins are transported into and out of the nucleus through nuclear pores.
   - Explain how the controlled import or export of specific proteins is used to regulate gene expression in the nucleus.

10. Explain the role of the cytoskeleton in cell shape, positioning of organelles, and cell movement.
   - Differentiate between microfilaments, microtubules, and intermediate filaments.
   - Explain the structural changes in the centrosome and the cytoskeleton that occur during cell division.
   - Compare treadmilling of actin filaments with and dynamic instability of microtubules.
   - Explain the mechanism by which mitotic spindle components position and segregate chromosomes during mitosis.

11. Contrast the role of endogenous signals and exogenous growth factors in the regulation of cell division.
   - Describe how a cell checks whether it is ready to replicate its DNA and divide.
   - Explain how defects in cell cycle checkpoints lead to cancer.

12. Gene expression and environment *(goals unfinished)*

13. Chromatin *(goals unfinished)*

14. Cell cycle *(goals unfinished)*

CU – Physics 3310 (Principles of Electricity & Magnetism) - complete

1. **Math/physics connection:** Students should be able to translate a physical description of a junior-level electromagnetism problem to a mathematical equation necessary to solve it. Students should be able to explain the physical meaning of the formal and/or mathematical formulation of and/or solution to a junior-level electromagnetism problem. Students should be able to achieve physical insight through the mathematics of a problem. *Shall we add something here about applications of E&M and/or experiments?*

2. **Visualize the problem:** Students should be able to sketch the physical parameters of a problem (e.g., E or B field, distribution of charges, polarization), as appropriate for a particular problem. *What type of problem can we give that is too hard without their 3310 knowledge?*

3. **Organized knowledge:** Students should be able to articulate the big ideas from each chapter, section, and/or lecture, thus indicating that they have organized their content knowledge. They should be able to filter this knowledge to access the information that they need to apply to a particular physical problem, and make connections/links between different concepts.

4. **Communication.** Students should be able to justify and explain their thinking and/or approach to a problem or physical situation, in either written or oral form.

5. **Problem-solving techniques:** Students should be able to choose and apply the problem-solving technique that is appropriate to a particular problem. This indicates that they have learned the essential features of different problem-solving techniques (eg., separation of variables, method of images, direct integration). They should be able to apply these problem-solving approaches to novel contexts (i.e., to solve problems which do not map directly to those in the book), indicating

that they understand the essential features of the technique rather than just the mechanics of its application. They should be able to justify their approach for solving a particular problem.

…5a. Approximations: Students should be able to recognize when approximations are useful, and use them effectively (eg., when the observer is very far away from or very close to the source). Students should be able to indicate how many terms of a series solution must be retained to obtain a solution of a given order.

…5b. Symmetries: Students should be able to recognize symmetries and be able to take advantage of them in order to choose the appropriate method for solving a problem (eg., when to use Gauss' Law, when to use separation of variables in a particular coordinate system).

…5c. Integration: Given a physical situation, students should be able to write down the required partial differential equation, or line, surface or volume integral, and correctly calculate the answer.

…5d. Superposition: Students should recognize that – in a linear system – the solutions may be formed by superposition of components.

6. **Problem-solving strategy:** Students should be able to draw upon an organized set of content knowledge (LG#3), and apply problem-solving techniques (LG#4) to that knowledge in order to organize and carry out long analyses of physical problems. They should be able to connect the pieces of a problem to reach the final solution. They should recognize that wrong turns are valuable in learning the material, be able to recover from their mistakes, and persist in working to the solution even though they don't necessarily see the path to the solution when they begin the problem. Students should be able to articulate what it is that needs to be solved in a particular problem and know when they have solved it.

7. **Expecting and checking solution:** When appropriate for a given problem, students should be able to articulate their expectations for the solution to a problem, such as direction of the field, dependence on coordinate variables, and behavior at large distances. For all problems, students should be able to justify the reasonableness of a solution they have reached, by methods such as checking the symmetry of the solution, looking at limits, relating to cases with known solutions, checking units, dimensional analysis, and/or checking the scale/order of magnitude of the answer.

8. **Intellectual maturity:** Students should accept responsibility for their own learning. They should be aware of what they do and don't understand about physical phenomena and classes of problem. This is evidenced by asking sophisticated, specific questions; being able to articulate where in a problem they experienced difficulty; and take action to move beyond that difficulty.

9. **Maxwell's Equations.** Students should see the various laws in the course as part of the coherent theory of electromagnetism; ie., Maxwell's equations.

10. **Build on Earlier Material.** Students should deepen their understanding of Phys 1120 material. I.e., the course should build on earlier material.

Overall Course Objectives: Calculation and Computation

Students will be able to:

- Compute gradient, divergence, curl, and Laplacian
- Evaluate line, surface, and volume integrals

- Apply the fundamental theorem for divergences (Gauss' Theorem) in specific situations
- Apply the fundamental theorem for curls (Stoke's Theorem) in specific situations
- Apply Coulomb's Law and superposition principle to calculate electric field due to a continuous charge distribution (uniformly charged line segment, circular or square loop, sphere, etc.)
- Apply Gauss' Law to compute electric field due to symmetric charge distribution
- Calculate electric field from electric potential and vice versa
- Compute the potential of a localized charge distribution
- Determine the surface charge distribution on a conductor in equilibrium
- Use method of images to determine the potential in a region
- Solve Laplace's equation to determine the potential in a region given the potential or charge distribution at the boundary (Cartesian, spherical and cylindrical coordinates)
- Use multipole expansion to determine the leading contribution to the potential at large distances from a charge distribution
- Calculate the field of a polarized object
- Find the location and amount of all bound charges in a dielectric material
- Apply Biot-Savart Law and Ampere's Law to compute magnetic field due to a current distribution
- Compute vector potential of a localized current distribution using multipole expansion
- Calculate magnetic field from the vector potential
- Calculate the field of a magnetized object
- Compute the bound surface and volume currents in a magnetized object
- Compute magnetization, H field, susceptibility and permeability

Chapter Scale Learning Goals

CHAPTER 1: Vector analysis

TOPICS

- Div, grad, curl
- Line, surface, volume integrals
- Curvilinear coordinates
- Dirac delta function
- Vector fields (potentials)

PREREQUISITES: Students should already be able to…

1. Be able to compute correctly div, grad and curl in rectangular coordinates for any test function
2. Do a path integral along a specific path -- eg. Griffiths 2.20
3. Be able to expand 1/1+e and 1/1-e when e is very small (Taylor series).

Students should be able to:

1. Evaluate the integral from negative infinity to infinity of the delta function, d(x)
2. Evaluate the 3-dimensional divergence of $1/r^2$ in the r-hat direction $[4\pi d^3(\mathbf{r})]$
3. Evaluate the integral of a function times the delta function
4. Be able to evaluate the integral of $1/(x-r)^{3/2}dx$
5. Give a geometrical description of the divergence theorem, and fundamental theorem for curls.
6. Change a multidimensional integral in Cartesian coordinates to one in another coordinate system using the Jacobian.

CHAPTER 2: Electrostatics

TOPICS

- Electric field, Coulomb's law
- Gauss' Law, divergence and curl of E
- Potential
- Poisson & Laplace equation
- Work & energy
- Conductors

PREREQUISITES: Students should already be able to…

1. State Gauss' Law and construct the 3 Gaussian surfaces (sphere, cylinder, pillbox).
2. Use Cartesian, spherical and cylindrical coordinates appropriately when constructing integrals and surface and volume elements.

Electric Field

1. Students should be able to state Coulomb's Law and use it to solve for E above a line of charge, a loop of charge, and a circular disk of charge.
2. Students should be able to solve surface and line integrals in curvilinear coordinates (when given the appropriate formulas, as in the inner-front cover of Griffiths).

Divergence and Curl of E; Gauss' Law

1. Students should recognize when Gauss' Law is the appropriate way to solve a problem (by recognizing cases of symmetry; and by recognizing limiting cases, such as being very close to a charged body).
2. Students should be able to recognize that E comes out of the Gaussian integral only if it is constant along the Gaussian surface.
3. Students should be able to recognize Gauss' Law in differential form and use it to solve for the charge density ρ given an electric field E.

Electric Potential

1. Students should be able to state two ways of calculating the potential (via the charge distribution and via the E-field); indicate which is the appropriate formulation in different situations; and correctly evaluate it via the chosen formulation.
2. Students should be able to calculate the electric field of a charge configuration or region of space when given its potential.
3. Students should be able to state that potential is force per unit charge, and give a conceptual description of V and its relationship to energy.
4. Students should be able to explain why we can define a vector potential V (because the curl of E is zero and E is a conservative field).
5. Students should be able to defend the choice of a suitable reference point for evaluating V (generally infinity or zero), and explain why we have the freedom to choose this reference point (because V is arbitrary with respect to a scalar – its slope is important, not its absolute value).

Work & Energy

- Students should be able to calculate the energy stored in a continuous charge distribution when given the appropriate formula
- Students should be able to explain in words what this energy represents.

Conductors

- Students should be able to sketch the induced charge distribution on a conductor placed in an electric field.

- Students should be able to explain what happens to a conductor when it is placed in an electric field, and sketch the E field inside and outside a conducting sphere placed in an electric field.
- Students should be able to explain how conductors shield electric fields, and describe the consequences of this fact in particular physical problems (e.g., conductors with cavities).
- Students should be able to state that conductors are equipotentials, that E=0 inside a conductor, that E is perpendicular to the surface of a conductor (just outside the conductor), and that all charge resides on the surface of a conductor.

Maxwell's Equations

- Students should be able to interpret the first and second Maxwell's equations for electrostatics ($\nabla \cdot E = \rho/\varepsilon_0$ and $\nabla \times E = 0$) and use them to describe electrostatics (i.e., Gauss' Law is just one application of the first law).

CHAPTER 3: Special Techniques

TOPICS:

1. Laplace's equation
2. Boundary conditions and uniqueness
3. Method of images
4. Separation of variables in Cartesian and spherical
5. Multipole expansion

PREREQUISITES: Students should already be able to…

1. Recognize the wave equation in Cartesian coordinates, and state that e^{ikx} is a solution
2. Recognize the solution to separation of variables in Cartesian coordinates.
3. Recognize that a function can be expanded in terms of a complete basis, such as sin and cos.
4. State that conductors are equipotentials.

Laplace's equation

1. Students should recognize that the solution to Laplace's equation is unique.

Method of Images.

1. Students should realize when the method of images is applicable and be able to solve simple cases.
2. Students should be able to explain the difference between the physical situation (surface charges) and the mathematical setup (image charges).

Separation of variables/boundary value problems

1. Students should be able to state the appropriate boundary conditions on V in electrostatics and be able to derive them from Maxwell's equations.
2. Students should recognize where separation of variables is applicable and what coordinate system is appropriate to separate in.
3. Students should be able to outline the general steps necessary for solving a problem using separation of variables.
4. Students should be able to state what the basis sets are for separation of variables in Cartesian and spherical coordinates (ie., exponentials, sin/cos, and Legendre polynomials.)
5. Students should be able to apply the physics and symmetry of a problem to state appropriate boundary conditions.
6. Students should be able to solve for the coefficients in the series solution for V, by expanding the potential or charge distribution in terms of special functions and using the

completeness/orthogonality of the special functions, and express the final answer as a sum over these coefficients.

Multipole expansions

1. Students should be able to explain when and why approximate potentials are useful.
2. Students should be able to identify and calculate the lowest-order term in the monopole expansion (i.e., the first non-zero term).
3. Students should be able to sketch the direction and calculate the dipole moment of a given charge distribution.

CHAPTER 4: Electric Fields in Matter

TOPICS

- Polarization & dielectrics
- Field of polarized object (bound charges, field inside dielectric)
- Electric displacement
- Linear dielectrics: Susceptibility, permittivity, dielectric constant
- Boundary value problems with dielectrics

Polarization and dielectrics

1. Students should be able to go between two representations of dipoles – as point charges, and as generalized dipole vectors – for simple charge configurations.
2. Students should be able to calculate the dipole moment of a simple charge distribution.
3. Students should be able to name 4 similarities and differences between a conductor and a dielectric (both shield E, conductor shields E completely, dielectric shields via fixed dipoles, conductor shields via mobile electrons).
4. Students should be able to predict whether a particular pattern of polarization will result in bound surface and/or volume charge
5. Students should be able to explain the physical origin of bound charge.

Field of a polarized object

1. Students should be able to sketch the E field inside and outside a dielectric sphere placed in an electric field.
2. Students should be able to explain what happens to a dielectric, when it is placed in an electric field.
3. Students should be able to explain the difference between free and bound charge.
4. Students should be able to identify the appropriate boundary conditions on D given its relationship to E and Q_f.

Electric displacement

1. Students should be able to sketch the direction of D, P, and E for simple problems involving dielectrics
2. Students should be able to calculate the E field inside a dielectric when given epsilon and the free charge on the dielectric.
3. *What else do we want students to know about D?*

Linear dielectrics

1. Students should be able to articulate the difference between a linear and nonlinear dielectric.
2. Students should be able to write down Maxwell's equations (for electrostatics) in matter, when given the appropriate equations in vacuum.

3. Students should be able to identify the appropriate boundary conditions on D, given its relationship to E.

CHAPTER 5: Magnetostatics

TOPICS

- Currents and charge density
- Magnetic fields and forces (Lorentz force law)
- Biot-Savart law
- Divergence and curl of B (Ampere's Law)
- Magnetic vector potential

PREREQUISITES: Students should already be able to…

1. Write down Lorentz force law
2. Know the right-hand rule and how to apply it

Currents and charge density

1. Students should be able to calculate current density J given the current I, and know the units for each.
2. Students should be able to explain, in words, what the charge continuity equation $\frac{\partial \rho}{\partial t} + \nabla \cdot J = 0$ means.
3. Students should be able to state the vector form of Ohm's Law ($J = \sigma E$) and when it applies.
4. Students should be able to calculate the current I, K and J in terms of the velocity of the particle or in terms of each other.

Magnetic fields and forces

1. Students should be able to describe the trajectory of a charged particle in a given magnetic field.
2. Students should be able to sketch the B field around a current distribution, and explain why any components of the field are zero.
3. Students should be able to explain why the magnetic field does no work using concepts and mathematics from 3320.

Biot-Savart Law

1. Students should be able to state when the Biot-Savart Law applies (magnetostatics; steady currents, dp/dt=0).
2. Students should be able to compare similarities and differences between the Biot-Savart law and Coulomb's Law.
3. Students should be able to choose when to use Biot-Savart Law versus Ampere's Law to calculate B fields, and to complete the calculation in simple cases.

Divergence and curl of B (Ampere's Law)

1. Students should be able to draw appropriate Amperian loops for the cases in which symmetry allows for solution of the B field using Ampere's Law (ie., infinite wire, infinite plane, infinite solenoid, toroids), and calculate I_{enc}.
2. Students should be able to make comparisons between E and B in Maxwell's equations (what exactly do we want?)

Magnetic vector potential

1. Students should be able to explain why the potential A is a vector for magnetostatics, whereas it's a scalar (V) in electrostatics. Ie., that the source of magnetic fields (the current) is a vector, whereas the source of electric fields (charge) is not.

2. Students should recognize that A does not have a physical interpretation similar to V, but be able to identify when it is useful for solving problems. *How to phrase this so that it doesn't sound like "A" is just useless mathematics?*

Separation of variables/boundary value problems

1. Students should be able to state the appropriate boundary conditions on B in magnetostatics and be able to derive them from Maxwell's equations

Maxwell's Equations

1. Students should be able to interpret the third and fourth Maxwell's equations for electrostatics ($\nabla \cdot B = 0$ and $\nabla \times B = \mu_0 J$) and use them to describe magnetostatics (i.e., Ampere's Law and Biot-Savart law are just applications of these laws).

CHAPTER 6: Magnetic Fields in Matter

TOPICS

1. Magnetization – diamagnets, paramagnets, ferromagnets
1. Field of magnetized object (bound currents)
2. Auxiliary field H
3. Linear and nonlinear media: susceptibility, permeability

PREREQUISITES: Students should already be able to…

Magnetization

1. Students should be able to calculate the torque on a magnetic dipole in a magnetic field.
2. Students should be able to explain the difference between para, dia, and ferromagnets, and predict how they will behave in a magnetic field.

The Field of a magnetized object

1. Students should be able to predict whether a particular magnetization will result in a bound surface and/or volume current, for simple magnetizations.
2. Students should be able to give a physical interpretation of bound surface and volume current, using Stokes' Theorem.

Auxiliary field H

1. Students should be able to calculate H when given B or M
2. Students should recognize that H is a mathematical construction, whereas B and M are physical quantities.
3. Students should be able to use H to calculate B when given J_f for an appropriately symmetric current distribution.
4. Students should be able to articulate in which physical situations it is useful to use H.
5. Students should be able to identify the appropriate boundary conditions on H given its relationship to M and K_f.

CHAPTER 7: Electrodynamics

TOPICS

- Electromotive force (Ohm's Law, emf)
- Electromagnetic induction (Faraday's Law)

- Maxwell's equations

COMMENTS

- There is not a general consensus on whether this chapter should be covered in 3310.
- Most students from 3310 go on to take 3320 and will see Maxwell's equations there
- If this material is covered in 3310, it may still be prudent to review in 3320

CU - IPHY 3470 – Human Physiology I - complete

Course Learning Goals:

Students will be able to:

1. Use basic chemical/biochemical, physical, and mathematical principles to describe the functioning of life processes associated with the topics in this course.
    a. Physiology I: Cell physiology, neurophysiology, endocrinology, muscle physiology, and immunology.

2. Demonstrate the use of the scientific method and quantitative reasoning to the field of physiology.

3. Demonstrate the how and why (the mechanistic and teleologic) understanding of the levels of organization composing the human organism.

4. Diagram and identify the regulated homeostatic variable, sensor, integrator and effector in the homeostatically regulated system and predict how a perturbation to the system will be compensated for.

5. Integrate knowledge of the major systems to outline how these systems interact to maintain homeostasis.

6. Demonstrate an understanding of the physiology and basic regulatory concepts relating to the functioning of life processes.

Course Overview

Reading Assignment: Silverthorn Chapters 1 & 2

Other resources: American Physiological Society Powerpoint Presentation - Introduction to Physiology

Main Goals:
1. Describe the discipline of physiology in relation to other biological disciplines and in terms of the types of questions physiologists explore.
2. Translate physiological data from graphs to words and vice versa.

Terminology:

Physiology
Biology
Cell
Tissue
Organ
Organ systems
Extracellular fluid
Intracellular fluid
Translational research
Control system
Dependent variable
Independent variable
Homeostasis
Equilibrium

<u>Learning Goals:</u>

Students will be able to:

1. Outline the levels of biological organization from atom to system, define physiology and discuss the relation to biology. (Pages 2-3)
2. Describe how the human organism is arranged into functional levels designed to maintain homeostasis and achieve emergent properties such as thought, emotion, locomotion, and communication.
3. Discuss the significance of maintaining homeostasis to the survival of the whole organism.

   -Faculty emphasis: this theme will be revisited throughout the semester (emphasized in more depth in cellular communication section of cell physiology goals)

Scientific Thinking: to be emphasized throughout semester.

1. Determine the dependent and independent variables on a graph.
2. Predict the change in equation outcome based upon manipulation of equation components.
3. Predict the change in physiological outcome based on change in independent variable when presented with a graph (example professor dependent)

<u>Optional Learning Goals:</u>

1. Trace the historical path of key current physiological concepts.
2. List the recent Nobel laureates and their corresponding achievements.

Cell Physiology

<u>Reading Assignment</u>: Silverthorn Text - Chapters 3, 4 & 5

<u>Main Goals:</u>

1. Describe the cellular components and their associated functions
2. Explain how proteins are made from genes.
3. Explain how chemical reactions proceed in a biological setting.
4. Explain the processes and factors involved in cellular transport within a cell and across a cell membrane.

<u>Terminology:</u>

<u>Chapter 3:</u> Compartments: Cells and Tissue

Epithelia	Cell junctions	Cell membrane
Interstitial fluid	Lipid	Golgi apparatus
Carbohydrate	Proteins	Organ
Endoplasmic reticulum (smooth and rough)		Mitochondria
Nucleus	Cytosol	Ribosomes
Mitochondrial matrix	Intermembrane space	Lysosomes
Peroxisomes	Cell	Tissue
Gap junctions	Tight junctions	Desmosomes
Simple epithelia	Stratified epithelium	Squamous epithelium
Cuboidal epithelium	Columnar epithelium	Organelle
Microfilaments	Intermediate filaments	Microtubule
Motor proteins	Cilia	

Chapter 4: Energy & Cellular Metabolism

Kinetic energy	Potential energy	Entrophy
Reaction rate	Activation energy	Free energy
Endergonic	Exergonic	Reactants
Products	Enzyme	Coenzyme
Energy	Chemical work	Mechanical work
mRNA	tRNA	rRNA
Codons	Transcription	Translation
Gene	Transcription factors	Polymerase
Protein synthesis	Amino acid	Peptide
Polypeptide		

Chapter 5: Membrane Dynamics

Permeability	Diffusion	Gradient
Ligand	Receptor	Enzyme
Membrane transport proteins	Chemically gated channel	Active Transport
Voltage gated channel	Hydrophilic	Hydrophobic

Learning Goals:

Students will be able to…

1. Diagram the structure of the plasma membrane indicating where carbohydrates, fats, and proteins are found within and on the plasma membrane. (Pages 53-55)
2. Explain/differentiate the functions of carbohydrates, fats, and proteins found within and on the plasma membrane. (Pages 55-58)
3. Predict the function of a cell based upon the number/concentration of specific organelles such as the nucleus, Golgi apparatus, endoplasmic reticulum, and mitochondria. (Pages 58-68)
   -Faculty note: Improved student buy in to this section occurs when you start with a clicker question they can't answer instead of a reiteration of organelle function.
4. List the three types of cytoskeletal elements and provide one major function of each. (Pages 60-63; Table 3-2)
5. List the four major categories of tissues and provide one major function of each (Pages 68-80)
6. Differentiate between cell junction types in the organization of specialized tissue and how this affects cell-cell communication. (Pages 69-71)
7. Determine the probability a chemical reaction will proceed when presented with various chemical reactions differing in activation energy levels. (Pages 93-95; Figures 4-2, 4-3, 4-4)
8. Explain why it is necessary that living organisms require a catalyst (an enzyme) present to carry out a reaction. (Page 98; Figures 4-3, 4-4, 4-6)
9. Using diagrams, describe in general terms how the information in a gene is accessed for expression of a specific protein. (Pages 114-122)
10. Explain the process by which a protein is synthesized, modified, stored/secreted and the organelles involved in this process. (Pages 114-122; Figures 4-24, 4-25, 4-26, 4-27)
    a. Diagram the Central Dogma of Biology (DNA makes RNA makes protein) and the roles of DNA, RNA and protein within the cell. (Figure 4-24)
    b. Identify the different forms of RNA (ribosomal, transfer, messenger) and their function in protein synthesis. (Figure 4-24)
    c. Describe the role and outcome of transcription and translation in the process of making a protein. (Figure 4-25, 4-26)

11. Identify the diverse roles proteins play in the body and predict what structures/processes can and cannot be affected by genetic mutation. (Page 113)
12. Differentiate between the functional units of a protein (amino acid and peptide bond). (Page 30, Figure 2-9)
13. Differentiate between equilibrium and homeostasis. (Pages 130-132)
14. Differentiate the terms passive diffusion, facilitated diffusion, and active transport based on cellular energy requirements. (Pages 132-148; Figure 5-4)
15. Explain why the cell membrane makes such a good barrier to keep out or in polar molecules. (Pages 138-139)
16. Predict movement of a substance across a cell membrane and explain how and what factors contribute to its movement (hydrophobicity, concentration, electrical gradients). (Pages 132-150)
17. Explain how chemical and electrical gradients are established in the cell. (Pages 158-165; Figures 5-30, 5-31, 5-32)

Cellular Communication

Reading Assignment: Silverthorn Chapter 6: Communication, Integration, and Homeostasis

Main Goal:
1. Describe how cells receive and integrate information to change/direct cell functions.

Terminology:

Electrical signal	Chemical signal	Target cell
Local communication	Long distance communication	Gap junctions
Paracrine	Autocrine	Amplification
Primary messenger	Secondary messenger	Agonist
Antagonist	Specificity	Receptor
Threshold	Afferent	Integrating center
Efferent	Effector	Response
Feedback	Feedforward	

Learning Goals:

Students will be able to:

1. Differentiate between paracrine, autocrine, endocrine, and exocrine signaling. (Pages 75 (endocrine and exocrine), 175-176 (paracrine and autocrine))

2. Describe the common features of cellular signaling cascades in the body. (Pages 177-191)
   a. Determine the interaction between the signal molecule (ligand) and receptor. (Figure 6-7)
   b. Differentiate between the categories of cell surface receptors that activate a cascade in the cell (ligand gated, enzyme receptors, G-protein coupled receptors). (Figure 6-5)
   c. Describe the role of a primary messenger, secondary messenger, and protein kinase in a signal transduction cascade initiated by a plasma membrane receptor. (Pages 177-185)
   d. Differentiate physiological outcome to a stimulus based upon receptor specificity, amplification, and desensitization. (Pages 177-191)
   -*Faculty emphasis: student thinking is to focus on the message sent vs. receiving cell response.*
   e. When presented with a graph of receptor affinity differentiate between a low and high affinity receptor. (Pages189-190 – *topic discussed, but not in graphical form*)

f. Compare and contrast the role of a ligand versus a receptor in directing a change in cell response.

3. Compare and contrast the stimulus and outcomes of positive and negative feedback (Pages 199-200, 222-228)

Endocrinology

Reading Assignment: Silverthorn Chapter 7: Introduction to Endocrine System

Other Resources: InterActive Physiology CD (or online): Endocrinology (Anatomy Review: Endocrine System Review; Biochemistry, Secretion, and Transport of Hormones; The Actions of Hormones on Target Cells, The HPA axis, Response to Stress)

Main Goals:
1. Differentiate between cell signaling and hormonal signaling.
2. Compare and contrast the three main types of hormone signaling (synthesis through mechanism of action).
3. Describe the conditions under which hormones can or cannot maintain homeostasis.

Terminology:

Hormone	Hypothalamus	Anterior pituitary
Posterior pituitary	Pancreas	Thyroid
Pineal	Adrenal gland	Hydrophilic
Hydrophobic	Steroid	Cholesterol
Peptide	Amine	Catecholamine
Cortisol	Insulin	Hyposecretion
Hypersecretion		

Learning Goals:

Students should be able to…

1. Explain the interaction between the organs and glands of the endocrine system, including the hypothalamus, anterior and posterior pituitary, pancreas, thyroid, pineal, and adrenal. (Pages 214-215, 225-226, 229; Figure 7-2)
   -Faculty note: gonads--leave to Phys II (reproduction section), maybe brief mention as hypothalamus releasing hormones.
2. Differentiate between the two main types of secreted factors (lipid soluble and water soluble), including how each leads to a change in cell function. (Pages 217-222)
3. Differentiate between peptide, steroid and amine hormone synthesis, release, signal reception and action on cell. (Pages 217-222; Table 7-1; Figures 7-3, 7-5, 7-6, 7-7, 7-8)
4. Explain why it is important that hormones are broken down (metabolized) and predict consequences on the target cell if high concentrations of hormones are maintained over time (chronically). (Pages 216-218, 220, 232-233)
5. Explain the mechanism of how target cells stop responding to the signal when hormone concentration remains high overtime (chronically). (Pages 216-218, 220, 232-233)
6. For insulin, cortisol, and thyroid hormone, list the metabolic/physiologic action and stimulus for secretion and site of secretion. Explain how negative feedback regulates these pathways and where regulation occurs. (Pages 225-230; Table 7-2 (insulin); Figures 7-9 (insulin), 7-13 (insulin), Figures 7-15 (cortisol), 7-19 (cortisol))

-Can extend knowledge by having students predict pathways and feedback mechanisms with thyroid hormone/ on homework.

7. Given a set of data determine if hormones are acting as synergists, antagonists or permissive hormones. (Pages 230-232; Figure 7-18)
8. Predict how abnormalities in the hypothalamic-pituitary-adrenal axis will alter hormone secretion and feedback. (Pages 234-235; Figures 7-20, 7-21 (Prediction question))

Optional Learning Goals:

1. Predict the physiological outcome from disorders such as hypo/ hypercortisolism, Turner syndrome, hypoglycemia, diabetes, obesity (with leptin and ghrelin feedback to brain and appetite, in w/insulin, etc.), thyroid disease-consequences to other systems, and growth hormone deficiencies.
2. In predicting the consequences of abnormalities in hormones secreted from the HPA axis (goal #8), predict the effects of exogenous drugs (pharmacology) that target the HPA axis.

Neurophysiology: General

Reading Assignment: Silverthorn Chapter 8:Neurons: Cellular & Network Properties

Other Resources: InterActive Physiology CD (or online): Nervous I (Anatomy Review)

Main Goals (All Neurphysiology Sections):

1. Describe how the anatomy of a neuron does and does not vary with the type of signal it propagates.
2. Explain how graded potentials and action potentials are generated and propagated in a neuron.
3. Predict whether a signal will continue to be propagated given a set of conditions.
4. Explain the mechanism by which neurons can transmit signals from one to another and describe the factors that contribute to efficiency of the signal transfer.
5. Describe the system level organization of the nervous system in terms of both anatomy and function.

Terminology:

Central nervous system	Brain	Spinal cord
Peripheral nervous system	Neuron	Nerve
Dendrite	Soma (cell body)	Axon
Axon hillock (trigger zone)	Axon terminal	Synapse
Afferent	Efferent	Unipolar neurons
Bipolar neurons	Sensory neuron	Motor neuron
Innervation		

Learning Goals:

Students will be able to:

1. Explain the major differences between the central and peripheral nervous systems by the structures and functions of each. (Pages 244-246)
2. When presented with a representation of a neuron, explain the main function of the dendrites, soma, axon hillock, axon, axon terminal, and synapse. (Pages 247-249; Figure 8-3)
3. Compare and contrast the function of the three major classes of neurons: afferent, interneuron, and efferent. (Pages 245-248; Figures 8-1, 8-2, 13-7 (imbedded in patellar tendon reflex)) -*Not well represented in text.*

4. Describe the direction and function of information flow through the regions of a neuron in response to input from another neuron. (Pages 247-249)

Neurophysiology: Electrical Signal Propagation within a Neuron

Reading Assignment: Silverthorn Chapter 6 (page 160-166) & Chapter 8

Other resources: InterActive Physiology CD (or online): Nervous I (Ion Channels, The Membrane Potential, The Action Potential)

Terminology:

Ions	Ion channels	Leaky channels
Concentration gradient	Electrical gradient	Myelin
Nodes of Ranvier	Permeability	Resting membrane potential
Electrochemical gradient	Graded potential	Action potential
Gating	Refractory periods	Saltatory conduction
Oligodendrocytes	Schwann cells	Depolarization
Repolarization	Hyperpolarization	Threshold
Activation gate	Inactivation gate	

Learning Goals:

Students will be able to:

1. Diagram the factors that are responsible for the resting membrane potential of a neuron, indicating where the concentrations of Na^+, K^+, and Cl^- are high and low, and the direction of the electrical and chemical forces acting on each ion. (Pages 160-166).
2. Identify the structures/factors at the plasma membrane that influence permeability. (Pages 165, 252-254)
3. Explain how the charge separation across the plasma membrane (resting membrane potential) is maintained and what influences the electrical gradient, chemical gradient and permeability have on the resting membrane potential. (Pages 160-165)
4. Explain how changes in channel activation/inactivation, chemical and electrical gradients influence the membrane potential and signal propagation. (Pages 255-261)
5. Compare and contrast the structure and function of the three types of ion channels found in the plasma membrane (mechanical, chemical, voltage gated). (Pages 254-256)
6. Compare and contrast graded and action potentials in terms of the relative strength of signal and length of travel in a neuron. (Pages 255-259; Table 8-3; Figures 8-7, 8-8 (Compare the result of 3rd graph on left and right side of figure))
7. Explain why the cell needs both graded and action potentials in order to integrate information and allow for appropriate cellular communication/neural signaling. (*i.e Why an action potential is not a good integrator of signals and why a graded potential is not a good long distance signal)* (Page 255, *not fully addressed in text)*
8. When presented with a graph of an action potential, indicate when the membrane is being depolarized, repolarized, and hyperpolarized, and identify the major ions contributing to each phase. (Pages 258-260; Figures 8-9, 8-10)
9. Graph an intracellular recording of an action potential as a change in membrane potential over time, indicating zero membrane potential, resting membrane potential, and voltage threshold. (Pages 257-262; Figures 8-9, 8-10)

10. Match membrane events (channel activation/inactivation, ion flow) during a single action potential to changes in membrane polarization as represented by the action potential graph. (Page 258-262; Figures 8-9, 8-10, 8-12)
    a. I.e: When presented with a graph of sodium and potassium permeability, explain how these contribute to the phases of the action potential and how activation/inactivation of the respective ion channels contribute to the shape of these curves. (Figures 8-9, 8-10, 8-12)
11. Given alterations in the duration or amplitude of an action potential predict the cellular properties that contributed to that change and vice versa. (Pages 258-262; Figures 8-10, 8-12)
12. Explain how the phases of the action potential allow for propagation of the signal along an axon uni-directionally in normal conditions. (Pages 262-264; Figures 8-12, 8-15)
13. Explain the influence of myelin and nodes of Ranvier in transmitting an action potential along the axon of a neuron by saltatory conduction. (Pages 266-268)

Student Misconceptions:

1.The Na/K ATPase generates the resting membrane potential.
2. Chemical gradients change when electrical gradients change.
3. It takes a lot of ions to change the membrane potential when in fact it's only a few!
4. The ligand/neurotransmitter is the determinant of generating an EPSP or an IPSP. Instead of the receptor being the determinant (i.e. that there are in fact many receptor types for the same chemical).

Neurophysiology: Neuron-Neuron Communication

Reading Assignment: Silverthorn Chapter 8

Other Resources: InterActive Physiology CD (or online): Nervous II (Anatomy Review, Ion Channels, Synaptic Transmission, Synaptic Potentials and Cellular Integration)

Terminology:

Synapse	Presynaptic cell	Postsynaptic cell
Neurotransmitter	Synaptic cleft	Interneuron
Post-synaptic potential	Excitation	Inhibition
Receptor	Exocytosis	

Learning Goals:

Students will be able to:

1. Explain how neurotransmitters communicate information across chemical synapses from the axon terminal to a post-synaptic neuron (one neuron to the next). (Pages 271-276)
2. Describe the three mechanisms (uptake, enzyme clearance, diffusion) used to deactivate neurotransmitters. (Pages 277-278)
3. List some basic neurotransmitters (acetylcholine, norepinehphrine, dopamine, serotonin, GABA and glutamate; Optional: histamine and orexin) and the types of receptors to which they bind. (Pages 272-275; Table 8-4)
4. Graph an excitatory post-synaptic potential (EPSP) and an inhibitory post-synaptic potential (IPSP) as a change in membrane potential over time and explain how these potentials sum to influence the membrane potential. (Pages 277-281)

Neurophysiology: System Level

Reading Assignment: Silverthorn
Chapter 9: The Central Nervous System (Pages 312-320)
Chapter 11: Efferent Division: Autonomic and Somatic Motor Control (Pages 377-380, 385-389)

Terminology:

Sympathetic	Parasympathetic	Central nervous system
Peripheral nervous system	Autonomic	Somatic
Fight-or-flight	Rest-and-digest	Muscarinic
Nicotinic	Adrenergic	

Learning Goals:

Students will be able to:

1. Illustrate the branches of the nervous system; central and peripheral nervous systems, autonomic, sympathetic, parasympathetic, and somatic. (Pages 245; Figure 8-1)
2. Explain the brain processes associated with sleep, learning, and memory. Indicate what structures match the appropriate functions in a general mechanism (the stimulus, integrator, effector, and response/output). (Pages 312-320; Figures 9-20-22)
3. Determine when the parasympathetic and sympathetic nervous systems will dominate over the other (rest and digest vs. fight or flight responses). (Pages 377-380; Figure 11-1)
    a. Differentiate the type of receptors (muscarinic, nicotinic, adrenergic) and neurotransmitter (norepinephrine (NE) and acetylcholine (Ach)) involved in activating the pre and post-ganglionic fibers of the parasympathetic and sympathetic nervous system. (Pages 382, 385-386; Figures 11-7 and 11-11)
    b. Determine how activation of these receptors will differentially affect the response of the same target tissue (e.g., constriction vs. dilation of the pupil, increased or decreased heart rate, breathing rate, digestion, bladder control, insulin release). (Pages 378-380, 387-389; Figures 11-5, 11-11

Sensory Systems

1. Diagram and describe the structures and mechanisms involved in the flow of information that allows for sound and sight (okay to select two other sensory systems, these are the two Steve chose).

Muscle Physiology

Reading Assignment: Silverthorn
Chapters 11: Efferent Division: Autonomic and Somatic Motor Control
Chapter 12: Muscles

Other Resources: InterActive Physiology CD (or online): Muscle Physiology (Anatomy Review: Skeletal Muscle Tissue, Neuromuscular Junction, Sliding Filament Theory, Contraction of Motor Units, Contraction of Whole Muscle)

Main Goals:

1. Relate structure to function involved in the mechanisms of muscle contraction at both the molecular and organ levels of organization.

2. Predict changes in muscle contraction based on changes to molecular structure and/or nervous input.

Terminology:

Neuromuscular junction	Motor end plate	Motor neuron
Acetylcholine	Acetylcholinesterase	Nicotinic receptor
Calcium channel	Excitation-contraction coupling	
Sliding filament theory	Myosin	Actin
ATP hydrolysis	Power stroke	Tropomyosin
Troponin	Rigor	End plate potential
Sarcoplasmic reticulum	T-tubules	Action potential
DHP receptor	Twitch	Contraction
Relaxation	Motor unit	Gross motor action
Fine motor action	Isotonic	Concentric action
Eccentric action	Isometric	Spatial summation
Temporal summation	Tetanus	Fast-twitch (II) fibers
Slow twitch (I) fibers	Myoglobin	Oxidative
Glycolytic	Atrophy	Hypertrophy
Monosynaptic reflex	Polysynaptic reflex	Afferent
Efferent	Interneuron	Agonist
Antagonist	Inhibition	Excitation
Central nervous system	Peripheral nervous system	

Learning Goals:

Students will be able to…

1. Explain the anatomy and function of the motor end-plate. (Pages 390-391; Figures 11-12, 11-13)
2. Diagram the sequence of events involved in muscle contraction, from neuronal action potential through cell signaling to force output. (Pages 403-409; Figures 12-7, 12-9, 12-10, 12-11, 12-12)
3. Explain the molecular basis of a muscle contraction based on the sliding filament theory. (Pages 403-407; Figures 12-9, 12-10)
4. Differentiate between muscle fiber types, based on size, fuel source, contraction velocity, fatigue resistance, and mitochondria. *Myoglobin and capillarity – (optional).* (Pages 412-414; Table 12-2)
5. Graph and explain the length-tension relation with corresponding sarcomere alignment. (Pages 413-414)
6. Compare the processes of temporal and spatial summation in generating force in the muscle to temporal and spatial summation of graded potentials in the neuron. (Pages 278-281, 413, 415; Figure 8-28, 12-16, 12-17)
7. Differentiate between fused and unfused tetanus. (Page 415; Figures 12-17c, 12-17d)
8. Define motor unit and explain how the type and number of motor units influences muscle force. (Pages 415-417; Figure 12-18)

9. Describe the different types of muscle contraction-isotonic, isometric, eccentric, concentric. (Pages 417-420; Figures 12-19, 12-20)
10. Predict a change in force according to the force-velocity relation. (Pages 419 and 421; Figure 12-23) (*Note: Text uses load in lieu of force*.)
11. Differentiate between atrophy and hypertrophy. (*Not discussed in depth in text*) (Pages 67, 233, 420, 528)
12. Compare and contrast the morphological and contractile properties of smooth and cardiac muscle to skeletal muscle. Faculty note: tie cell phys in here including both cell adhesions and organelle concentration. (Pages 397, 421-429; Figure 12-1; Table 12-3)

Optional Learning Goals:

1. Diagram origin of muscle during embryonic development (ecto/endo/mesoderm).
2. Describe the effects of aging on muscle tissue. (*Not discussed in text*)
3. Describe the special sensory receptors affecting motion sickness.
4. Differentiate between muscle fiber types on myoglobin and capillarity.

Student Misconceptions:

1. Myosin and actin can change length during contraction.

Immunology

Reading Assignment: Silverthorn Chapter 24: The Immune System (pg. 776 – 793)

Other Resources: InterActive Physiology CD (or online): Immune System (Immune System Overview, Anatomy Review)

Main Goals:
1. Differentiate between the functions, anatomy, and cell types of the two major branches of the immune system.

Terminology:

Acquired immunity	Antibody	Antigen
B lymphocyte	Basophil	Bone marrow
Basophil	Cytotoxic T cell	Dendritic cell
Eosinophil	Granulocyte	Helper T cell
Immune response	Immunity	Inflammation
Innate immunity	Lymph node	Macrophage
Mast cell	Monocyte	Natural killer cell
Neutrophil	Pathogen	Spleen
Thymus gland	Tonsils	T lymphocyte

Learning Goals:
Students will be able to….

1. Describe in general the three major functions of the immune system: how the body protects itself from invaders (pathogens), how it removes dead or damaged cells, and how it removes abnormal cells. (Page 777)
2. Explain the differences between a virus and a bacteria in terms of structure, living conditions, and susceptibility to drugs. (Page 778; Table 24-1)
3. Identify the two major branches of the immune system (acquired, innate), and describe how each of these branches differs in the specificity of a response, the timing of a response, and the effector cells used to eliminate a potential pathogen. (Page 779)
4. Identify primary vs. secondary lymphoid organs. (Pages 780-782; Figure 24-2)
5. Compare and contrast the functions of the six major cell types of the immune system. (Pages 782-785, 787-788, 791-793; Figure 24-4)

Optional Learning Goals:
1. Diagram the steps in the process of fighting viral infections. (Page 795-796; Figure 24-18)
2. Diagram the steps in the process of an allergic reaction. (Page 797; Figure 24-19)
3. Compare and contrast the antigens and antibody characteristic of each blood type. (Page 798; Figure 24-20; Table 24-3)
4. Autoimmune diseases (Page 799-800; Table 24-4)
5. Describe how stress alters immune system function. (Page 802)

CU- IPHY 3410 (Anatomy) - complete

Students will be able to:

OVERALL COURSE GOALS

1) Demonstrate understanding of structure/function relationships.
2) Integrate multiple systems to explain how an organ works.
3) Predict the epithelial cell type present in a tissue based on function.
4) Connect different concepts presented at different times on the same structure
5) Predict the location or meaning of the word based on the roots that comprise

CELLS, HISTOLOGY, AND TISSUE TYPES (1 lecture)

1) Describe the functions and characteristics of plasma membrane, ER, Golgi, lysosomes, and mitochondria.
2) Interpret the cell type based on the abundance of certain organelles
3) Describe the function of three specialized contacts/junctions
4) Predict the location of specialized contacts base on their functions
5) Describe the function of three cytoskeletal elements
6) Compare and contrast the three cytoskeletal elements
7) Define tissue and illustrate the definitions of cell, organ, and organ system using examples from Chapters 1 and 2.
8) List the four types of tissues found in the body.

EPITHELIUM (1 Lecture)

1) Describe the characteristics of epithelium that distinguish it from other types of tissues.
2) Describe structural classifications of epithelial tissue by layering: simple or stratified.

3) Illustrate epithelial tissues by shape: squamous, cuboidal, or columnar.
4) List epithelial cell types and their function.
5) Predict which epithelial cell type you would expect to find in an organ given the tissue functions.
6) Name the specialized structures associated with the lateral, basal, and apical surfaces of epithelial cells.

CONNECTIVE TISSUE (1 lecture)

1) Name the # of unique components of connective tissue.
2) Identify components of living and nonliving matrix.
3) Predict if a tissue is a connective tissue based on the definition.
4) Compare and contrast the structure and functions of epithelial and connective tissue.
5) Predict the function of the connective tissue based on its matrix composition (compression, tension, elasticity; pulling, squashing, stretching)
6) Define connective tissue.
7) Classify and compare the 3 general types and # subtypes of connective tissues in terms of characteristic cells, matrix, and general features.
8) Describe areolar connective tissue as a model of connective tissue proper.

MEMBRANE, INTEGUMENT AND HAIR (1 lecture)

1) Define, compare and contrast two serous and mucosal membranes.
2) List the components of the integumentary system.
3) Explain how skin and its appendages are organs of the integumentary system.
4) Describe the # functions of the integument.
5) List the tissue types that compose epidermis and dermis.
6) Describe the structure and function of all 5 layers of the skin, from deep to superficial; list the key functions and cell types of each stratum.
7) Explain why the superficial part of the skin is dead
8) Distinguish between thick skin and thin skin; indicate which is hairy and which is hairless.
9) Describe the anatomy of dermis and structures found within dermis
10) Describe the structure and function of the hypodermis.
11) Explain how variations in melanin distribution in human skin creates different skin tone
12) List the parts of a hair and a hair follicle; explain how the structure of the hair shaft contributes to hair type, including color and shape.
13) Illustrate the differences in the length of hair growth cycles, comparing hair of the head to hair of the arms or legs.
14) Identify major disorders of the integumentary system, including skin cancer and burns.
15) Predict the consequence of skin loss (e.g., burn victim)

Optional:

16) Differentiate terminal hairs from vellus hairs.
17) Compare and contrast oil glands and sweat glands; identify locations, secretions, and special modifications.
18) Explain the structure and function of nails.

CARTILAGE AND BONE (2 lectures)

1) Identify the specific locations of cartilages in the adult body; explain the functional properties of cartilage as a tissue.
2) Define the unique characteristics and locations of hyaline, fibro-, and elastic cartilages.
3) Compare the three kinds of cartilage, including column notes on structure, function, and location.
4) Explain why bones are considered organs. Select a specific bone, such as the femur, and discuss the tissues comprising it.
5) List and explain the main functions of the bony skeleton.

6) Classify bones according to shape; include several bony examples for each category.
7) Describe the gross anatomy of a typical long bone.
(optional: and a typical flat bone)
8) Describe where compact and spongy bones are located in a long bone.
9) Differentiate the histology of compact and spongy bone.
10) Explain why spongy bone and compact bones are found where they are in a long bone.
11) Describe the structure, function, and relationship among Haversian canal, Volkmann canal, lamallae, lacuna, and cannaliculi.
12) Diagram the microscopic structure of compact bone tissue; include the osteon (Haversian system), central canal, lamellae, canaliculi, and osteocytes.
13) Explain the processes of endochondral and intramembranous bone formation.
14) Explain the difference between epiphyseal plate and epiphyseal line.
15) Explain the anatomy of epiphyseal growth areas. Describe how the presence of epiphyseal plates determine whether bone is still growing in length.
16) Explain the process of longitudinal bone growth.
17) Describe the cause of osteoporosis, osteomalacia, and Paget's Disease and predict their pathologies.
18) Summarize the organic and inorganic composition of bone.
19) Describe the role of osteoblasts and osteoclasts in bone tissue remodeling.

Optional

20) List some diagnostic features of osteoporosis, osteomalacia, rickets, Paget’s disease, and osteosarcoma.
21) Identify the basic steps in the healing of a bone fracture.

INTRODUCTION TO JOINTS AND ARTICULATIONS (2 lectures)

1) Define *joint (articulation)*.
2) Define the movement types of joints: synarthrotic, amphiarthrotic, diarthrotic.
3) List the three general categories of joints.
4) Describe the general structure of fibrous joints; identify the three main types of fibrous joints and give examples of each, indicating the degree of movement for each type.
5) Describe the general structure and function of cartilaginous joints; identify the two main subtypes of cartilaginous joints and give examples of each, indicating the degree of movement for each.
6) Describe the general structure and function of synovial joints; identify the six main subtypes of synovial joints and give examples of each, indicating the degree of movement for each.
7) Demonstrate all movements allowed by synovial joints including one type of gliding, 5 types of angular movements, 3 types of rotation, and 11 special movements that do not fit into the previous categories.
8) Differentiate between circumduction and rotation.
9) Explain and diagram the following basic structural features of synovial joints: articular cartilage, joint cavity, articular capsule, synovial membrane, synovial fluid, reinforcing ligaments, nerves, vessels, and articular disc or meniscus.
10) Explain the function of synovial fluid.
11) Compare bursae and tendon sheaths; explain the structure and function of these associated synovial joint structures.
12) Explain how joints are classified by shape. Name the six classes, describe permitted movements of each class, and give specific examples of these joints. Explain how the shape of the joint influences the movement permitted by the joint.

Optional:

13) Discuss disorders of joints and compare physical injuries, such as sprains, with inflammatory and degenerative conditions, such as arthritis.
14) Explain the etiology and symptoms of each type of arthritis.

15) Based on the structure of the synovial joints, predict why they are capable of certain types of movement (e.g., hinge joint can only do extension/flexion).
16) Identify several important synovial joints. Describe the type of joint based on shape, explain movements allowed, describe location, structure, and function, and any other significant features.

SKELETAL MUSCLE (1 lecture)

1) Explain how muscles are classed into several functional types; give specific muscle examples and describe the functions of prime movers (agonists), antagonists, synergists, and fixators.
2) List four functional properties that distinguish muscle tissue from other tissues, and briefly relate the structural features of muscle to functional properties.
3) Name the layers of connective tissue that occur in and around a skeletal muscle.
4) List # general characteristics of skeletal muscle fibers.
5) Define *muscle fascicles.*
6) Describe and explain the structural and organizational levels of skeletal muscle. Begin with the muscle as an organ followed by the fascicle, muscle fiber, myofibril, and sarcomere, then end with the myofilament.
7) Diagram the structural organization of a muscle (e.g., biceps) in the descending (or ascending) anatomical order.
8) Explain the sliding filament theory in the simplest form.
9) Describe the role of titin in the sarcomere.
10) Define motor unit.

Optional:

11) Describe the various ways in which muscles attach to their origins and insertions. Explain attachments of muscles to bones through tendons, aponeuroses, and direct and indirect attachments.
12) Explain some symptoms of myofascial pain syndrome and fibromyalgia.

SMOOTH AND CARDIAC MUSCLES (1 lecture)

1) Describe the characteristics of cardiac muscle tissue. Compare its structure and function to skeletal muscle tissue.
2) Describe the characteristics of smooth muscle tissue. Compare its structure and function to skeletal muscle tissue.
3) Describe the basic arrangement of the layers of the alimentary canal wall: mucosa, submucosa, muscularis externa, and serosa (visceral peritoneum), or adventitia.
4) Describe the histological, structural, and functional features of the layers of the alimentary canal wall.
5) Compare and contrast skeletal, cardiac, and smooth muscle tissue. Devise a comparison chart for key characteristics such as location, cell shape, type of innervation, and function.

AXIAL SKELETON (1 lecture)

1) Distinguish between axial skeleton and appendicular skeleton.
2) Describe the general structure of the vertebral column by listing the three different regions and the number of vertebrae in each region from superior to inferior.
3) Explain the development of primary and secondary spinal curvatures and consider the significance of each.
4) Describe the gross anatomy of a typical thoracic vertebra.
5) Explain how vertebrae articulate with each other, as well as with the ribs and the occipital bone.
6) List the components of the bony thorax.
7) Describe the sternum and its two types of articulations.
8) Distinguish between true and false ribs.
9) Describe scoliosis, kyphosis, and lordosis.
10) Know joints between bodies, between articular processes, ribs and thoracic vertebrae, ribs and

sternum.

Optional:
11) Explain the sacrum and coccyx.

THE APPENDICULAR SKELETON (1 lecture)
1) Identify the bones associated with the shoulder, hip, elbow, and knee joints.
2) List the joint types, joint movements and supporting structures of the shoulder, hip, elbow, and knee.
3) Compare and contrast the movement type, stability, supporting structures, and shapes of articular surfaces between joints in the following pairs: shoulder/hip and elbow/knee.

Optional:
4) Add pelvic girdle to LGs 1& 2.
5) Explain the anatomical differences between a male pelvis and a female pelvis.

DIGESTIVE SYSTEM: GASTROINTESTINAL TRACT, PANCREAS, AND LIVER (3 lectures)
1) Define *alimentary canal* (also called *gastrointestinal tract*), naming its organs and distinguishing it from the accessory digestive organs.
2) Define the six essential food-processing activities that occur during digestion: ingestion, propulsion, mechanical digestion, chemical digestion, absorption, and defecation.
3) Describe how the process of digestion is an extracellular process that occurs outside the body.
4) Define and distinguish between *peristalsis* and *segmentation*.
5) Distinguish between the visceral peritoneum and parietal peritoneum.
6) Define and describe *mesentery*, including functions.
7) Describe the function and location of nerve plexuses of enteric nervous system
8) Describe the four major layers and their sublayers of the alimentary canal wall
9) Describe the location and gross anatomy of the pharynx, esophagus, stomach, small intestine, and large intestine.
10) Describe the microscopic anatomy and functions of the pharynx, esophagus, stomach, small intestine, and large intestine.
11) Differentiate the epithelial lining of the oral cavity through the large intestine
12) Describe the location, gross anatomy, microscopic anatomy, and digestive functions of the liver and pancreas.
13) Describe the location, gross anatomy, and digestive functions of the gallbladder.
14) Trace the flow of bile through the system of ducts ultimately into the duodenum, explaining the role bile plays in the digestive process.
15) Trace the flow of blood through the vascular system from the small intestine, through the liver, and to the heart.

Optional:
16) Describe disorders of the digestive system: intestinal obstruction, inflammatory bowel disease, viral hepatitis, cirrhosis, or the effects of cystic fibrosis on the pancreas.
17) Classify the teeth of adult dentition and describe the anatomical layers of teeth
18) Describe the location and gross anatomy of the oral cavity and salivary glands.
19) Describe the microscopic anatomy and functions of the oral cavity and salivary glands.

RESPIRATORY SYSTEM (2 lectures)
1) Identify the respiratory tubes and passageways in order, from the nose to the alveoli in the lungs.
2) Identify the three regions of the pharynx and discuss the passage of air and/or food through the pharynx during breathing and swallowing.
3) Distinguish the structures of the conducting zone from those of the respiratory zone.

4) Distinguish between mucous cells and serous cells, explaining their locations and the significance of their secretions to the respiratory system.
5) Describe the structure of the epiglottis and the larynx, including thyroid and arytenoid cartilages true and false vocal cords.
6) Describe how sound is produced.
7) Differentiate between the epithelial lining of each segment of the respiratory tract, and how that contributes to the function of each segment.
8) Describe the structure of a lung alveolus and of the respiratory membrane.
9) Describe the gross structure of the lungs (including lobes, lobules, fissures, and segments) and the pleurae.
10) Explain the relative roles of the ventilatory muscles (diaphragm, external intercostals) and lung elasticity in the act of ventilation.
11) Define *surfactant*, and explain its function in ventilation.
12) Locate the peripheral chemoreceptors and list what they detect.

Optional:

13) List the respiration causes and consequences of asthma, chronic bronchitis, emphysema, lung cancer, pneumonia, tuberculosis, cystic fibrosis, sinus infections, and nosebleeds.
14) Describe the framework of the nasal septum, roof, and floor of the nasal cavity.
15) Describe how peripheral chemoreceptors control ventilation rate.

CARDIOVASCULAR SYSTEM (2 lectures)

1) Describe the orientation and location of the heart in the thorax; define *mediastinum*.
2) Describe the structural coverings of the heart; distinguish between the pericardial sac, parietal pericardium, and visceral pericardium. Why is pericardium a serous membrane?
3) Identify the layers of the heart wall.
4) Identify the four chambers of the heart.
5) List the important anatomical features of each chamber (papillary muscles, chordae tendineae).
6) Name the heart valves; describe the locations and functions.
7) Describe the mechanism for opening and closing of heart valves during ventricular contraction.
8) Distinguish between *pulmonary circuit* and *systemic circuit* (including coronary flow). Trace a drop of blood through the heart, pulmonary, and systemic systems.
9) Identify the components of the conducting system of the heart (SA node, gap junctions, AV node, bundle of His, left and right bundle branches, and Purkinje fibers)
10) Trace the electrical conduction pathway of the heart.
11) Identify the main types of blood vessels (arteries, veins, capillaries); define direction of blood flow and state of oxygenation.
12) Identify the three tunics that form the walls of arteries and veins; indicate the specific functions of each.
13) Compare and contrast the locations, structures, and functions of elastic arteries, muscular arteries, and arterioles.
14) Describe the structure and function of capillaries (continuous, fenestrated, and sinusoidal) and their permeabilities.
15) Explain the pathway of blood flow through capillary beds, and the role of precapillary sphincters.
16) Identify the anatomical features and locations of sinusoids.
17) Define a portal system and its function.
18) Explain how to distinguish a vein from an artery in histological sections.
19) Identify the different types of veins; explain the structural and functional features of veins.
20) Explain the function of valves in veins.

Optional:

21) Discuss the causes and consequences of coronary artery disease and heart failure, conduction pathway disorders, valve disorders (murmurs), and hypertension.

NERVOUS SYSTEM: GENERAL (1 lecture)

1) Identify the main functions of the nervous system and summarize the relationships between sensory input, integration, and motor output.
2) Name the basic divisions of the nervous system and list the basic structural components of the CNS and PNS.
3) Distinguish functionally between the terms afferent and efferent.
4) Describe the functional organization of the PNS. For the sensory (afferent) division, compare somatic sensory and visceral sensory subdivisions; for the motor (efferent) division, compare somatic motor and visceral motor subdivisions.
5) Define *neuron*. Identify the structural features of the cell body and cell processes; describe their functional roles.
6) Classify neurons by structure (unipolar, bipolar, multipolar); relate the structure (shape) of the neurons to their functional classifications (motor, sensory, interneurons).
7) Define *synapse;* explain the structural components and describe how a synapse functions.
8) Draw and label a simplified illustration of a synapse.
9) List six types of supporting cells (astrocytes, ependymal cells, microglia, oligodendrocytes, Schwann cells, satellite cells) in nervous tissue; distinguish supporting cells in terms of location, shape, and function.
10) Define *myelin sheath* and describe its structure and functions; distinguish between development in the CNS and PNS.
11) Define *nerve;* describe the structural components of nerves. Explain why a nerve is also an organ.
12) Distinguish between neuron, nerve fiber, nerve tract, ganglion, and brain nucleus.
13) Explain why a nerve can contain both afferent and efferent messages, and why a neuron cannot.

NERVOUS SYSTEM I: BRAIN / SPINAL CORD (2 lectures)

1) List and describe the gross anatomical features of the spinal cord. Be sure to include the arrangement of the gray and white matter.
2) Identify the major segments of the developing brain, starting from telencephalon, diencephalon, mesencephalon, metencephalon, and myelencephalon.
3) Identify the major regions (parts) of the adult brain that arise from each brain segment: cerebral cortex, basal ganglia, hypothalamus, thalamus, epithalamus, midbrain, pons, cerebellum, and medulla. Define which areas make up the brain stem.
4) Name and identify the locations of the ventricles of the brain.
5) Explain how the skull, meninges, cerebrospinal fluid, and the blood-brain barrier protect the CNS.
6) Trace the pathway of CSF circulation from its formation in the choroid plexuses to its absorption at the arachnoid villi into the dural sinuses.
7) Describe the functions and locations of the divisions of the human cerebral cortex: frontal lobes, parietal lobes, temporal lobes, occipital lobe, and the insula
8) Name and distinguish between the tracts of cerebral white matter: commissural tracts, projection tracts, and association tracts.
9) Identify specific examples, functions, and locations of deep gray matter (basal ganglia) of the cerebrum.
10) Describe the location of the diencephalon. List the individual parts (the thalamus, the hypothalamus, and the epithalamus), and describe functions and locations of each part.
11) Describe the relationship of the brain stem to the rest of the brain; list the individual components (the midbrain, the pons, and the medulla), and describe the functions and locations of each part.
12) Describe the functions and location of the cerebellum.
13) Compare and contrast the two important functional brain systems—the limbic system and the reticular formation—then describe the locations and functions of each system.

Optional:
14) Discuss the disorders of Alzheimer's, Parkinson's, meningitis, Huntington's chorea, and personality disorders.

PERIPHERAL NERVOUS SYSTEM AND AUTONOMIC NERVOUS SYSTEM (1 1/2 LECTURES)

1) Define *peripheral nervous system*. Contrast components of the PNS and CNS; identify the basic divisions and subdivisions.
2) Compare locations of cranial nerves and spinal nerves.
3) Classify sensory receptors based on stimulus detected (mechanoreceptors, thermoreceptors, chemoreceptors, nociceptors, photoreceptors).
4) Differentiate between *root* and *ramus*.
5) Define *nerve plexus;* name the four major nerve plexuses (cervical, brachial, sacral, and lumbar) and identify body regions served by major nerves from each plexus.
6) Describe the causes and symptoms of paraplegia, quadriplegia, shingles, migraine headaches, myasthenia gravis, polio, and postpolio syndrome.
7) Define *autonomic nervous system;* identify its effectors, describe its basic functions, and explain the relationship of the ANS to the PNS as a whole; stress that ANS is not a part of the CNS.
8) Describe the autonomic nervous system in terms of types of effectors, number of neurons forming the pathway, speed of conduction along fibers, types of ganglia associated with each system, and neurotransmitters released.
9) Identify the basic divisions of the ANS. Describe the functional differences between the sympathetic and parasympathetic divisions; explain "fight, flight, or fright" and "rest and digest."
10) Describe the basic anatomical features of the parasympathetic division; explain how the parasympathetic system relates to the brain, cranial nerves, and sacral spinal cord.
11) Describe the basic anatomical features of the sympathetic division; explain how the sympathetic division relates to the spinal cord and spinal nerves.
12) Compare and contrast the effects of parasympathetic and sympathetic divisions on the following organs: heart, blood vessels, gastrointestinal tract, and (optional) lungs.
13) Explain the role of the adrenal medulla as a major organ in the sympathetic division.

Optional:
14) Explain how dermatomes are related to the sensory innervation regions of the spinal nerves.
15) Discuss ANS disorders such as Raynaud's.

THE SPECIAL SENSES (1 1/2 LECTURES)

1) Define the four special senses (taste, smell, sight, hearing).
2) Identify and describe the anatomical and functional features of the three tunics of the eye, the lens, and the humors of the eye.
3) Describe the structure and function of the retina (pigmented and neural layers), photoreceptors (rods and cones), and bipolar and ganglion cells. Emphasize that photoreceptors are the only cells that detect light.
4) Trace the pathway of light as it passes through the cornea, aqueous humor, lens, vitreous humor, ganglion cells, bipolar cells, and then is detected by the photoreceptors.
5) Explain how light is focused for close vision in the context of hyperopia, myopia.
6) Trace the pathway nerve impulses travel from the retina to the optic nerve.
7) Describe the features of the external ear (auricle, external acoustic meatus, and tympanic membrane) that accommodate the gathering of sound waves and transmission of sound waves to the middle ear.
8) Describe the bony location of the middle ear; explain the function of the associated structures: the pharyngotympanic tube and the ossicles (malleus, incus, stapes), round window, and oval window.
9) Differentiate between the bony and membranous labyrinths of the inner ear.

10) Categorize the structures of the bony labyrinth according to their locations and functions, including semicircular canals, vestibules, and cochlea.
11) Categorize the structures of the membranous labyrinth according to their locations and functions, including semicircular ducts, utricles, saccules, and cochlear ducts.
12) Explain the events occurring in the cochlea that participate in the mechanism of hearing.
13) Describe the three chambers of the cochlea (scala vestibuli, scala media, scala tympani), and the fluids within these chambers (perilymph, endolymph).
14) Describe the structures and functions of the spiral organ of Corti (tectorial membrane, hair cell/stereocilia, basilar membrane, supporting cells).
15) Trace the pathway of a sound wave, starting from the tympanic membrane, auditory ossicles (malleus, incus, stapes), oval window, perilymph (scala vestbuli, scala tympani), endolymph (scala media), until it dissipates at the round window.

Optional:
16) Identify the causes and symptoms of motion sickness, Ménière’s syndrome, and deafness.
17) Distinguish between static equilibrium and linear acceleration.
18) Explain how the maculae and otoliths contribute to the sense of static equilibrium.
19) Describe the structures of the maculae (otolithic membrane, hair cells, stereocilia, and supporting cells).
20) Describe the structures of the crista ampullaris (cupula, hair cells, stereocilia, and supporting cells).
21) Define *taste;* describe taste bud histology and explain the gustatory pathway.
22) Identify five basic taste sensations.
23) Define *smell;* describe olfactory epithelium, explain how smell is relayed to the brain.

THE LYMPHATIC AND IMMUNE SYSTEMS (INTEGRATE INTO OTHER SYSTEMS IF NOT DONE AS SEPARATE LECTURE)
1) Define and distinguish between the *lymphatic system* and the *immune system*.
2) Distinguish between primary and secondary lymphoid tissues.
3) Describe the location and function of the thymus gland.
4) Describe where white blood cells are produced.
5) Identify the location of B and T lymphocyte production. Identify the location of B and T cell maturation.
6) Compare and contrast blood and lymph circulation.
7) Identify where blood and lymph can exchange fluid/material.
8) Compare and contrast blood filtration by the spleen and liver.
9) Describe the tissue structure, location, and function of GALT and peyer’s patches.
10) Describe the tissue structure, location and function of BALT.

THE URINARY SYSTEM (1 LECTURE)
1) Describe the location of the kidneys and other organs of the urinary system, and summarize the basic functions of the urinary system.
2) Describe the internal gross anatomy of the kidney, identifying structures of the renal cortex and renal medulla.
3) Define and describe the main structural and functional unit of the kidney, the *uriniferous tubule*, noting its two major parts: the nephron (including proximal convoluted tubules, Loop of Henle, distal convoluted tubules) and the collecting duct (tubule).
4) Explain and define the three major interacting mechanisms of urine formation: *filtration*, *reabsorption*, and *secretion*, using a single, generalized uriniferous tubule.
5) Trace the path of the filtrate throughout the long tubular section of the nephron, naming each section and continuing into the collecting tubules.

6) Explain in detail the microscopic anatomy (including epithelial lining) and function of the renal corpuscle of the nephron.
7) Trace the path taken by the filtrate (urine) from the glomerulus to the collecting duct, describing the changes in epithelial linings along the path.
8) Explain the microscopic blood vessels, including peritubular capillaries and vasa recta, associated with uriniferous tubules.
9) Describe the location, gross anatomy, and epithelial lining of the ureters.
10) Describe the urinary bladder in the following ways: location, shape, epithelial lining, and function.
11) Describe the location, structure, and function of the urethra of both sexes.

Optional:
12) Describe the basic features of one or more disorders of the urinary system: urinary tract infections, renal calculi, urinary bladder cancer, or kidney cancer.

THE REPRODUCTIVE SYSTEM (1 LECTURE)
1) Describe basic functions of the male and female reproductive systems.
2) Define *genitalia*, *gonads*, and *gametes*.
3) Describe the gross anatomy of the scrotum, distinguishing between the dartos muscle and the cremaster muscles.
4) Describe the location, gross anatomy, and function of the testes.
5) Describe the formation of immature sperm within the testes and the maturation of the sperm in the epididymis.
6) Describe the location and function of the epididymis, ductus deferens, spermatic cord, and urethra.
7) Trace the route traveled by sperm cells from the testis, through the epididymis, ductus deferens, ejaculatory duct, urethra, external urethral orifice.
8) Describe the location, structure, and function of the ovaries.
9) Describe that oogenesis occurs in the ovaries.
10) Describe the location, structure, and function of the uterine tubes, including how an ovulated oocyte enters the tube, as well as how it is propelled along the tube.
11) Describe the location, anatomy, and function of the uterus.
12) Describe the location, anatomy, and functions of the vagina.

Optional:
13) Identify the location, structure, and functions of the accessory glands involved in semen production: the seminal vesicles, the prostrate, and the bulbourethral glands.
14) Identify examples of disorders of the reproductive system.

CU General Chemistry I and II (1111 and 1131) - complete

Overall Course Learning Goals

These goals reflect the attitudes, understandings, and thinking skills that students should develop by the end of the course

ATTITUDES TOWARD CHEMISTRY AND LEARNING CHEMISTRY:

A1. Students will view chemistry as an integrated and logical science.
A2. Students will recognize and explain how chemistry concepts apply to everyday phenomena.
A3. Students will take personal responsibility for their learning.

BIG IDEAS:

B1. **Mole concept:** Students will relate masses, volumes, and concentrations to amounts of substances involved in chemical reactions. They will apply the concept of mass, charge, and energy balance when representing chemical reactions.

B2. **Equilibrium:** Students will describe the reversibility of chemical reactions and predict the major substances present when a chemical system is at equilibrium.

B3. **Energy:** Students will describe how energy is released or consumed in a chemical system.

B4. **Structure and reactivity:** Students will apply their knowledge of atomic structure and chemical bonding to represent the structure of atoms, ions, and molecules, and to make predictions about the behavior and reactivity of substances.

B5. **Periodic Table:** Students will identify and explain patterns within the Periodic Table. They will use these patterns to make predictions about physical and chemical properties of elements.

B6. **Sense of scale:** (size of atoms; time scales of reactions; ability to ask whether a value makes sense on an orders of magnitude basis)

B7. **Epistemology**—how do we know what we know in chemistry? And how certain are we of this knowledge? What don't we know?

SCIENTIFIC WAYS OF THINKING AND OF ARTICULATING UNDERSTANDING:

C1. Visualizing matter and processes at the molecular level
C2. Logical approach to problem solving
C3. Using, translating, and producing representations (words; macroscopic observations; molecular view drawings; Lewis dot structures; graphs; mathematical expressions; chemical symbols and equations)
C4. Other scientific abilities? (Experimental design; coordinating evidence and theory, etc.)
C5. Other laboratory skills (not yet done)
C6. Anything else? Communication skills (writing, oral)?

CU-CHEM 1111 (General Chemistry I) -Learning goals from Robert Parson – nearly complete

INSTRUCTIONAL OBJECTIVES

On the following pages you will find a list of performance objectives for each unit of Chemistry 1111. These objectives outline some of the skills you should master. They should provide an answer to the student who asks, "I read the chapter and think I understand it, but what specifically should I be able to do?" Of course, the assigned problems provide another important way of enhancing your ability to use the concepts you read about in the text and hear about in lecture.

How should you make use of these objectives? When studying by yourself, you should be able to design questions from each objective to see if you have mastered the concept. For example, in Unit I, Concept Area 2, the objective is "Given any decimal number, you should be able to write it in scientific notation." After reading the relevant section of the text, invent some numbers (like 1,276,000 and

0.082) and express them in scientific notation (1.276×10^6 and 8.2×10^{-2}). If you have trouble or are unsure of your answer, re-read the text. If still unsure, consult a friend, your TA or your instructor. Many students find studying to be more fun and more productive in small study groups, where you get together with one or two other students. In this case, one student invents problems based on the listed objectives, and the other student or students independently write down their answers. Then compare answers and reconcile any differences. Most students find that they learn as much making up the questions as they do answering them.

I - MATH AND CONCEPT REVIEW

Reading Assignment: Silberberg, Chapters 1 and 2.
Problem Assignment: Silberberg, Ch. 1: 1, 2, 4, 15, 17, 19, 27, 36, 38, 41, 42, 46, 51, 54, 59, 63. Ch. 2: 1-3, 7, 12, 20, 24, 28, 34, 43, 46, 50, 56, 60, 64, 66, 68, 74, 76, 83, 85, 87, 90, 104.

Concept Area 1 - Metric System

1. Using the information about metric prefixes, symbols and multiples, you should, given one of the three items: prefix, symbol, or multiple, be able to write down the other two:

Prefix	**Symbol**	**Multiple**
tera	T	10^{12}
giga	G	10^{9}
mega	M	10^{6}
kilo	k	10^{3}
deci	d	10^{-1}
centi	c	10^{-2}
milli	m	10^{-3}
micro	µ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}

2. You should be able to identify the common metric units for length, mass, temperature, volume and density.

Concept Area 2 - Exponents and Scientific Notation

1. Given any decimal number, you should be able to write it in scientific notation.
2. Given a set of numbers in scientific notation and a set of required mathematical operations involving those numbers, you should be able to calculate the correct exponent in the answer after performing the specified mathematical operations.

Concept Area 3 - Significant Figures

1. The following abilities need to be demonstrated in handling significant figures using the procedure described in the Laboratory Manual.
   a. Given any decimal number, correctly identify the number of significant figures in the number.
   b. Given any decimal number, be able to round it off to any given number of significant figures.
   c. Given a set of decimal numbers, and a set of prescribed mathematical operations between them, be able to determine correctly the number of significant figures in the answer.

Concept Area 4 - Basic Definitions

1. You should be able to identify and/or write the definition of, or distinguish between the following terms: pure substance, mixture, element, compound, homogeneous, heterogeneous, solution, physical property or change, chemical property or change, ion, phase, atomic number, mass number, atomic weight or atomic mass, nucleus, electron, ionic, covalent, reactant and product, isotope, extensive property, intensive property.

Concept Area 5 - Precision and Accuracy

1. You should be able to write a definition of the terms precision and accuracy, and be able to distinguish between the two concepts given a particular experimental situation.

Concept Area 6 - Nomenclature

1. You should be able to write correctly from memory the symbol and/or the name of the following 39 elements.

Element	***Symbol***	***Element***	***Symbol***	***Element***	***Symbol***
Aluminum	Al	Fluorine	F	Nitrogen	N
Antimony	Sb	Gold	Au	Oxygen	O
Argon	Ar	Helium	He	Phosphorus	P
Barium	Ba	Hydrogen	H	Platinum	Pt
Boron	B	Iodine	I	Potassium	K
Bromine	Br	Iron	Fe	Silicon	Si
Cadmium	Cd	Lead	Pb	Silver	Ag
Calcium	Ca	Lithium	Li	Sodium	Na
Carbon	C	Magnesium	Mg	Strontium	Sr
Chlorine	Cl	Manganese	Mn	Sulfur	S
Chromium	Cr	Mercury	Hg	Tin	Sn
Cobalt	Co	Neon	Ne	Uranium	U
Copper	Cu	Nickel	Ni	Zinc	Zn

2. You must learn the diatomic elements H_2, O_2, N_2, F_2, Cl_2, Br_2, and I_2.

Concept Area 7 - Conversion Factors and Simple Equations

1. Given a relationship where two quantities are related by a constant (a conversion factor) and the value of one of the quantities you should be able to calculate the value of the other one.

2. You should know the equations that convert temperature on one scale to temperature on another scale for the conversions: $^{o}F \rightarrow {}^{o}C$, $^{o}C \rightarrow {}^{o}F$,
$^{o}C \rightarrow K$, $K \rightarrow {}^{o}C$. You should then be able to use the appropriate equation to convert a given temperature on one scale to a needed temperature on the other.

Concept Area 8 - Elementary Facts about Atoms

1. You should understand how the nuclear observations by Thomson, Milliken, and Rutherford challenged Dalton’s atomic theory.

2. Given a neutral atom and its atomic number and mass, you should be able to write down or state: the number of protons and neutrons in the nucleus, the value of the nuclear charge and the total number of electrons in the atom.

3. Given the abundance ratio of isotopes of a particular element in a naturally occurring sample, you should be able to calculate the atomic weight of the naturally occurring sample (and vice versa).

4. Given a periodic table, you should be able to identify an atom as a metal, nonmetal, metalloid, alkali metal, alkali earth metal, transition metal, halogen, or noble gas.

Concept Area 9 - Formulas for Common Compounds

1. You should be able to write the formula for any compound in the grid on the following pages. You should also be able to give the name of the compound from its formula. You should be able to determine the molecular mass for a compound.

Concept Area 10 - Energy

1. You should be able to state the difference between kinetic energy and potential energy, and to give examples in which one form of energy is converted to another.

II - THE MOLE, COMPOSITION, AND STOICHIOMETRY

Reading Assignment: Silberberg, Chapter 3; Chaper 4 (omit 4.5).

Problem Assignment: Silberberg, Ch. 3: 2, 3, 8, 14, 18, 23, 26, 28, 30, 32-34, 38, 40, 44, 48, 52, 57, 64, 66, 69, 75, 80, 82, 91, 94. Ch. 4: 3, 4, 6, 7, 14, 17, 20, 23, 25, 29, 33, 41, 47, 51, 77, 85, 89.

Concept Area 1 - The Mole

1. You should know the definition of a mole. Given the number of molecules in a sample, you should be able to calculate the number of moles and vice versa.

2. Given the chemical formula for a substance, you should be able to calculate the molecular mass of the substance. Given the molecular mass, you should know how to calculate the number of moles in a sample from the number of grams and vice versa.

Concept Area 2 - The Quantitative Meaning of a Formula

1. Given the chemical formula for a compound, you should be able to calculate the percentage by mass of each element in the compound.

2. Given the percentage composition of a compound or combustion data, you should be able to calculate the empirical formula of the compound. Given the molecular mass and the empirical formula, you should be able to determine the molecular formula.

3. You should be able to recognize and state the difference between empirical formula, molecular formula and structural formula.

4. Given the appropriate analytical data and formula of a compound containing element X and another element of known atomic weight, you should be able to calculate the atomic weight of X.

Concept Area 3 - Balancing Simple Equations

1. Given the reactants and products of a simple chemical reaction, you should be able to balance the chemical equation for their reaction.

Concept Area 4 - Quantitative Calculations from Chemical Equations

1. Given the amount in grams or moles of a reactant used (or product formed) in a reaction, you should be able to calculate from the balanced chemical equation the amount of any other reactant used (or product formed) by the reaction.

2. Given a balanced chemical equation and the starting amounts of two or more reactants, you should be able to determine which is the limiting reactant, how much of any product can be produced by the reaction, and the mass of the excess reagent.

3. Given the percent yield for a reaction, you should be able to calculate how much of a certain product can be obtained from a given amount of reactants. You should also be able to determine how much of a certain reactant is needed to produce a given amount of a product.

Concept Area 5 - Basic Principles of Solutions

1. You should be able to state and/or recognize definitions or descriptions of the following terms:

   a. solution
   b. solvent
   c. solute
   d. dilute solution
   e. concentrated solution
   f. electrolyte
   g. nonelectrolyte
   h. spectator ion
   i. precipitate
   j. molarity

2. Given a particular system that is at equilibrium you should be able to describe what molecular processes are taking place and how the balance between these processes leads to the equilibrium state.
3. You should be able to do quantitative calculations analogous to those in Concept Area 4 (above) when the substances involved in the reaction are in solutions of known molarity, and the term quantity refers to volumes of the solutions.

4. You should be able to perform dilution calculations.

Concept Area 6 - Reaction Types

1. Given a set of reactants and products that ionize in solution, you should be able to write and balance the net ionic equation for the reaction.
2. You should be able to recognize combination and decomposition reactions and be able to complete displacement and combustion reactions.

III - GASES

Reading Assignment: Silberberg, Chapter 5.
Problem Assignment: Silberberg, Ch. 5: 1-5, 10, 12, 17, 21, 29, 33, 41, 47, 50, 53, 54, 58-60, 63, 65-67, 71, 80, 86, 89, 104.

Concept Area 1 - Solving Gas Law Problems

1. You should know the various units for pressure, and given the appropriate conversion factor, be able to interconvert the units. You should understand how a barometer and manometer work.

2. You should know Avogadro's hypothesis and be able to demonstrate its significance by doing calculations where, given the relative volumes of two samples of gas at the same temperature and pressure you can calculate the relative numbers of molecules in the two samples and vice versa.

3. You should know Charles' Law, Boyle's Law, Avogadro's Law, and the combined gas law equation.

4. You should know the ideal gas law. Recognize that the ideal gas law involves 4 quantities, P, V, n, T, and that given 3 of these quantities one can calculate the fourth. You need to be able to do this for all possible permutations of three given quantities.

5. You should know the definition of partial pressure and Dalton's law of partial pressures. Given a mixture of gases, the total pressure and the partial pressures of all but one of the gases, you should be able to calculate the partial pressure of the remaining gas. For a gas collected over water, you should be able to calculate the pressure exerted by the gas given the total pressure and the vapor pressure of water at the temperature of the experiment.

Concept Area 2 - Gas Densities and Molecular Weights

1. Given the density of an ideal gas at known T and P, you should be able to calculate the molecular weight of the gas, and vice versa.

Concept Area 3 - Gases and Stoichiometry

1. You should be able to carry out quantitative calculations when the balanced equation involves gases and the calculations involve the temperature, pressure, and volume of the gases.

Concept Area 4 - Kinetic Theory of Gases

1. You should understand how the absolute temperature T is a measure of the average kinetic energy of the gas molecules.

2. You should be able to reproduce the general shape of a graph showing the distribution of molecular kinetic energies or speeds at a given temperature. Be sure you can state exactly what is being plotted on each axis. You should be able to show how the shape of this curve changes when the temperature is changed.

3. On a graph of the distribution of molecular kinetic energies or speeds, you should be able to identify that quantity that defines the number of molecules with a speed equal to or greater than some given speed and point out how this quantity changes if the temperature is increased.

4. You should know Graham's law and be able to predict which of two gases would have the fastest rate of effusion. You should be able to calculate relative effusion and diffusion rates between two gases.

5. You should understand the differences between a real gas and an ideal gas. You should be familiar with the van der Waals equation and should be able to explain the physical significance of the two terms which make it different from the ideal gas law.

6. You should be able to describe in molecular terms why the ideal gas law becomes a better description of real gas behavior at low pressures and high temperatures.

IV - THERMOCHEMISTRY

Reading Assignment: Silberberg, Chapter 6.
Problem Assignment: Silberberg, Ch. 6: 2, 6, 17, 18, 21, 23, 25, 27, 31, 32, 34, 35, 40, 43, 46, 55, 57, 64, 77.

Concept Area 1 - Heat

1. You should know the definitions of the following terms.

heat	system
work	surroundings
enthalpy (H)	heat capacity (C_p, C_v, specific heat)
exothermic	endothermic
standard enthalpy or heat of formation (ΔH_f^o)	calorimetry
joule	state function
calorie	standard state
specific heat capacity	

Concept Area 2 - The First Law of Thermodynamics

1. You should know the first law of thermodynamics.

2. In a constant pressure process, given the initial and final volumes of a gaseous system (or some data from which they can be calculated) and the value of the pressure, you should be able to calculate the sign and magnitude of the work, w, done on the system by the surroundings. You should understand the meaning of a negative value for w.

3. Given the appropriate heat capacity for a constant pressure or a constant volume process, the initial and final temperatures of the system and any necessary enthalpies of phase changes, you should be able to calculate the sign and magnitude of the heat **absorbed** by the system from the surroundings, q. You should understand the meaning of a negative value for q.

4. Given the values of the heat absorbed and the work done in a particular process (or the data to calculate these as in objective 1 and 2), you should be able to calculate ΔE, the change in internal energy for the process.

5. Given a balanced chemical equation, you should be able to discuss qualitatively the differences between ΔH and ΔE for that reaction. You should also know the experimental conditions necessary for the measured heat of the reaction to equal ΔE and ΔH.

Concept Area 3 - Enthalpy Changes in Chemical Reactions

1. Given the enthalpy changes for two or more chemical reactions that can be combined to give a final reaction, you should be able to calculate the enthalpy change for the final reaction.

2. Given a table of standard enthalpies of formation for a number of substances, you should be able to calculate the enthalpy change for any reaction involving those substances. (This objective is a special case of objective 1.)

3. Given heat of combustion data for any component X, and ΔH_f^o for all of the products of combustion of X, you should be able to calculate the standard enthalpy of formation of X.

4. Given the molar enthalpy change for a reaction, you should be able to calculate the heat released or absorbed from given quantities of reagents, and vice versa.

V - ATOMIC STRUCTURE AND THE PERIODIC TABLE

Reading Assignment: Silberberg, Chapters 7 and 8.
Problem Assignment: Silberberg, Chapter 7: 5, 12, 15, 16, 18, 23, 25, 29, 33, 35, 40, 47, 49, 51, 67. Ch. 8: 2, 6, 8, 9, 15, 25, 27, 31, 33, 34, 37, 45, 48, 49, 55, 66, 68.

Concept Area 1 - Properties of Light

1. You should be able to diagram the electromagnetic spectrum and be able to order the following regions correctly according to increasing wavelength, frequency or energy: X-ray, ultraviolet, visible, infrared, microwave, radio frequency.

2. You should know the equation, $\lambda\nu = c$, and be able to define each quantity in it and given the wavelength of a light wave, be able to calculate its frequency and vice versa.

3. You should be able to state what is plotted against what in a **spectrum** and state the basic difference between an absorption and an emission spectrum.

4. You should know the equation $\Delta E = h\nu$, define each quantity in the equation, and given ν calculate ΔE and vice versa. You should know the Planck formula for the energy of a photon, $E = h\nu$, and define each quantity in the equation. You should understand the relationship between this energy of a photon and the energy change, ΔE, of the atom or molecule absorbing or emitting the photon. You should be able to combine this equation with $\lambda\nu = c$, so that given λ, you can calculate ΔE, and vice versa.

5. You should know and understand the deBroglie equation and the uncertainty principle.

Concept Area 2 - Historical Background of Quantum Mechanics

1. You should understand what assumptions in a new theory of the structure of matter and light are required by the following experimental results: the photoelectric effect and the fact that atomic spectra contain discrete, very sharp lines. You should be able to state the deBroglie relationship and use it to calculate the wavelength associated with a particle of given momentum, and vice versa. You should understand the Bohr atom model and its limitation.

Concept Area 3 - The Hydrogen Atom

1. You should know how the allowed energy levels of the hydrogen atom depend on the quantum number n and be able to sketch schematically the allowed energies in order of increasing energy showing approximately the relative spacing between levels as n goes from 1 to ∞.

2. You should be able to draw arrows on the diagram produced in objective 1 showing how various lines arise in the spectrum of atomic hydrogen and calculate the energy difference, ΔE, and the wavelength of the light emitted or absorbed for each arrow drawn.

3. You should be able to draw on the energy level diagram of objective 1 the arrow with energy corresponding to the ionization potential of a ground state hydrogen atom and calculate the ionization energy.

Concept Area 4 - Quantum Mechanics and the Atom

1. You should be able to list the four quantum numbers that arise when the hydrogen atom problem is solved quantum mechanically, their significance in terms of the allowed wave function, and any limitation on the values they can assume.

2. You should be able to match the nomenclature for atomic orbitals (1s, 3d, 4p, etc.) with correct values of the quantum numbers n and l. You should be able to show how the number of orbitals of each type is related to the quantum number n.

3. You should be able to make a qualitatively correct drawing of the probability of finding an electron in a thin spherical shell at a distance r from the nucleus for an electron in a 1s orbital of hydrogen.

4. You should be able to draw qualitatively correct shapes of s, p, and d atomic orbitals.

Concept Area 5 - Complex Atoms

1. You should be able to state the Pauli exclusion principle.

2. Using the Pauli principle and the results of the quantum mechanical picture of atomic orbitals, you should be able to write the lowest energy electronic configuration for any atom (thru n=4) and give the values of the 4 quantum numbers for each electron in this configuration. You should be able to identify valence electrons.

3. You should be able to use Hund's rule to identify atoms which should have unpaired electrons in their lowest energy electron configurations and state how many unpaired electrons there should be.

4. You should be able to write the lowest energy electron configuration for simple ions.

5. Given an electron configuation for a particular element, you should be able to tell if the configuration corresponds to:

   (a) the neutral atom or an ion.
   (b) the lowest energy electron configuration or an excited configuration.

Concept Area 6 - The Periodic Table

1. You should be able to identify definitions and/or examples of the following terms.

   - family
   - group
   - halogens
   - transition elements
   - metal, non-metal and metalloid
   - inner transition elements (rare earth, lanthanides, actinides)
   - alkali metals
   - alkaline earth metals

2. You should be able to state how the first ionization energy changes as you go from left to right across a period or down a group of the periodic table. You should understand the significance of a large increase in successive ionization energies for an atom.

3. You should be able to write the chemical equation that defines the electron affinity of an atom. You should be able to state where in the periodic table elements with the highest (most negative) electron affinity can be found.

4. You should know two effects that can be used to explain relative atomic or ionic sizes. Given a set of ions and/or atoms, you should be able to rank them in order of increasing or decreasing size.

5. You should recognize the difference between a diamagnetic and a paramagnetic atom or ion.

6. You should be able to predict trends in metallic properties.

VI - CHEMICAL BONDING AND MOLECULAR STRUCTURE

Reading Assignment: Silberberg, Chapters 9, 10, and 11.
Problem Assignment: Silberberg, Ch. 9.: 3, 13, 19, 21, 24, 42, 53, 55, 56, 58, 60, 65, 70, 71.
Ch. 10: 11, 15, 18, 24, 26, 27, 30, 37, 39, 49, 50, 55, 56, 61, 65, 76.
Ch. 11: 2, 3, 10, 13, 15, 21, 42, 43, 48, 53.

Concept Area 1 - Introductory Matters

1. You should be able to write down the Lewis electron dot symbol for an atom of any of the main group elements.

2. You should be able to predict whether or not a bond is likely to be ionic, covalent or metallic from the positions of the bonded atoms in the periodic table. You should know the distinguishing ionic, covalent, and metallic properties.

3. You should be able to list three important energetic factors that affect the strength of an ionic bond and tell how the magnitude of each one affects the ionic bond strength.

4. You should be able to draw a qualitatively correct potential energy-vs-distance curve that shows the formation of a diatomic molecule and use this diagram to define: dissociation or binding energy, and equilibrium internuclear distance.

Concept Area 2 - Structure of Simple Molecules

1. You should be able to write Lewis dot structures for any given molecule involving single bonds. (Typical examples: F_2, H_2O, NH_3, CH_4)

2. You should be able to write Lewis structures for molecules with double and triple bonds. (Typical examples: CO_2, N_2, $CH_2=CH_2$, $HC\equiv CH$)

3. You should be able to identify molecules or ions where a single Lewis structure is not sufficient and be able to draw the "resonance" structure for these species. You should be able to calculate formal charge.

4. You should be able to identify and/or describe the following: an electron deficient compound, a free radical, and an expanded octet.

Concept Area 3 - Polar and Non-Polar Bonds and Molecules

1. You should be able to describe how electronegativity varies across the Periodic Table and within groups of elements.

2. Given a list of molecules you should be able to identify those that have a dipole moment and those that do not.

3. You should be able to describe the relationship between electronegativity of two bonded atoms and the polarity of a bond between those atoms.

4. You should be able to describe the relationship between symmetry and polarity in a given molecule.

Concept Area 4 - Molecular Architecture: Hybrid Orbitals, Molecular Orbitals, and the Structure of Some Simple Organic Molecules

1. Given a molecule, you should be able to draw the Lewis structure and determine the hybridization, the number of lone pairs, and the electronic and molecular geometry around the central atom.

2. You should be able to name the hybrid orbitals that can be formed from s, p, and d orbitals and state what angles result when each of these hybrids form bonds with other atoms.

3. You should be able to describe the structures of ethylene and acetylene in terms of σ and π bonds. You should be able to tell what kind of hybrids are used and what the bond angles are.

4. You should be able to describe the structure of SO_2, CO_3^{2-}, NO_3^- and the carboxylate anion RCO_2^- in terms of hybrid orbitals, resonance and π bonds.

5. You should be able to explain why the bonds in ozone have equal lengths and why the carbon-carbon bonds in benzene have equal lengths.

Concept Area 5 - Bond Energies

1. Given the necessary enthalpy data, you should be able to diagram a Born-Haber cycle and calculate lattice energy.

2. Given a table of average bond energies (such as Table 9.2), you should be able to estimate the enthalpy change for any reaction that involves breaking and forming of bonds listed in the table.

VII - ORGANIC CHEMISTRY

Reading Assignment: Silberberg, Chapter 15, p. 457-474 and p. 483-485.
Problem Assignment: Silberberg, Chapter 15: 2, 4, 5, 7, 10, 12, 19, 26, 33, 36, 45, 46, 53, 60, 62, 65, 66, 81.

Concept Area 1 - Structure and Bonding in Organic Molecules

1. You should be able to write names and structural formulas for alkanes, their isomers, and cycloalkanes (up to C_{10} hydrocarbons).

2. You should know names and structural formulas for alkenes and alkynes (up to C_{10} hydrocarbons).

3. You should be able to draw resonance structures for benzene and name substituted benzene derivatives.

4. You should be able to recognize a chiral center and an optically active molecule.

5. You should recognize the structural difference between *cis* and *trans* geometric isomers.

6. You should be able to recognize a substitution, an elimination, and an addition reaction.

7. You should recognize the functional groups that are listed in Table 15.5. In addition, you should recognize the functional groups phenol and acid halide.

8. You should be able to recognize the monomer(s) in a polymer, and understand the difference between addition polymerization and condensation polymerization

VIII - MOLECULAR INTERACTIONS

Reading Assignment: Silberberg, Chapter 12, p. 347-371.
Problem Assignment: Silberberg, Ch. 12: 1, 3, 5, 13, 15, 18, 21, 22, 23, 26, 31, 34, 43, 46, 50-52, 58, 59, 65, 76, 83.

Concept Area 1 - Intermolecular Forces

1. You should be able to explain and give at least two examples of each of the following types of intermolecular interaction.

   (a) ion-dipole
   (b) dipole-dipole
   (c) dipole-induced dipole
   (d) dispersion
   (e) hydrogen bonding

2. You should be able to predict relative melting points and boiling points in a series of related compounds.

Concept Area 2 - Nomenclature

1. You should know the meaning of each of the following terms.

crystal lattice	triple point
unit cell	boiling point
vaporization	normal boiling point
fusion (melting)	melting point
sublimation	supercooling
heat of vaporization	equilibrium
heat of fusion	phase diagram
heat of sublimation	critical point
vapor pressure	surface tension

capillarity viscosity
Van der Waals radius

Concept Area 3 - Liquids and Solids

1. You should know the properties which distinguish gases, liquids, and solids, both in terms of their macroscopic properties and in terms of a molecular picture.

2. You should be able to calculate the heat associated with a phase change and a heating or cooling curve.

3. You should understand the unusual properties of water in terms of the hydrogen bonding and structure of the liquid and solid.

4. You should be able to recognize and list the three different types of cubic unit cells and know their coordination number and the number of atoms per unit cell.

Concept Area 4 - Phase Diagrams

1. You should be able to draw schematically correct phase diagrams for water and label each region, line, and intersection of lines with the correct phases present.

2. You should be able to identify on the phase diagram the freezing point, triple point, critical point, normal boiling point or sublimation point as appropriate.

IX - CHEMICAL EQUILIBRIUM

Reading Assignment: Silberberg, Chapter 17.
Problem Assignment: Silberberg, Ch. 17: 4, 7, 9, 18-20, 25, 27, 29, 30, 39, 45, 46, 50, 56, 62, 67, 69, 73, 80.

Concept Area 1 - Equilibrium Expressions

1. Given a balanced, homogeneous, gas phase reaction, you should be able to write down the equilibrium condition in terms of the partial pressures (or in special cases the concentrations) of reactants and products and the equilibrium constant.

2. Given K for a particular homogeneous gas phase reaction, and a particular set of experimental partial pressures (or concentrations), you should be able to determine whether the reaction is at equilibrium or not and, if not, in which direction it will proceed to reach equilibrium.

3. Given K for a particular reaction, you should be able to calculate K when that reaction is reversed or when the stoichiometric coefficients are multiplied through by a common factor. You should be able to determine K for coupled reactions.

Concept Area 2 - Heterogeneous and Solution Equilibria

1. Given a reaction at equilibrium that is heterogeneous or is taking place in solution, you should be able to write correctly the equilibrium condition using partial pressures or concentrations as appropriate.

Concept Area 3 - Le Chatelier's Principle

1. Consider a homogeneous gas phase reaction at equilibrium. Assume that all gases can be regarded as ideal. Given one of the perturbations:

a. Increasing the concentration of one of the reactants or products while keeping the volume and temperature constant, or

b. Increasing or decreasing only the volume of the system keeping the temperature constant you should be able to determine whether a parameter that measures the extent of the reaction increases, decreases, or stays the same.

2. Given any reaction at equilibrium and the standard enthalpy change for that reaction, you should be able to determine whether the K increases, decreases, or stays the same if the temperature is increased or decreased, and the resulting direction of the equilibrium shift.

Concept Area 4 - Equilibrium Calculations

1. Given a set of equilibrium composition data, or a means of calculating such data for a particular reaction, you should be able to calculate the equilibrium constant for that reaction.

2. Given the equilibrium constant and a set of initial compositions for a particular reaction, you should be able to calculate the compositions when that system has come to equilibrium.

CU- CHEM 1131(General Chemistry II) – 75% complete

Specific Learning Goals for CHEM 1131 (separated by three units)

1. Learning Goals: Acids and Bases

Topic area: acid-base reactions
Topic-level goal: identify and classify acid-base reactions.

Detailed objectives:

- Given a chemical reaction, decide whether is an acid-base reaction.
- Given an acid-base reaction, identify which compound is the acid and which is the base.
- Given the chemical formula or molecular structure of an acid, draw the formula or structure of its conjugate base, and vice versa.
- Explain how many compounds can act as either an acid *or* a base, depending upon what other compounds are present.

Distinguish among the Arrhenius, Bronsted, and Lewis definitions of acids and bases. Explain why a given compound is or is not an acid or a base according to each of these definitions.

Topic area: acid-base equilibria in aqueous solution
Topic-level goals: apply the principles of chemical equilibrium to solutions of acids and bases in water.

Detailed objectives:

- Explain how the terms "strong" and "weak" are used when describing aqueous solutions of acids or bases. Relate the "strength" of an acid or base to its dissociation constant, K_a or K_b.
- Given the dissociation constant K_a of an acid in water, calculate the dissociation constant K_b of its conjugate base (and vice versa).

- Calculate the pH of an aqueous solution from the hydronium or hydroxide ion concentrations in that solution.
- Given two or more acids with different strengths, predict the relative strengths of their conjugate bases.
- Given a solution containing a weak acid or base, identify all of the ions that are present in solution, and without carrying out detailed calculations, decide which ions are present in relatively high concentrations and which are present in low concentrations.
- Calculate the concentrations of all of the ions in solution when a *strong* acid or base is dissolved in water.
- Calculate the concentrations of all of the ions when a *weak* acid or base is dissolved in water.
- Given the chemical formula for a salt, predict whether an aqueous solution of that salt will be acidic, basic, or neutral.
- Calculate the concentrations of all of the ions in solution when a salt is dissolved in water.

Topic area: molecular properties and acid strength
Topic-level goal: predict the relative strengths of aqueous solutions of acids and bases.

- Describe how the strength of an acid is affected by bond strength and bond polarity.
- Predict the relative strengths of a series of acids having similar molecular structure.
- Predict the relative strength of a series of bases having similar molecular structures.

Topic area: Buffers and Titrations
Topic-level goals: Apply the principles of chemical equilibrium to explain how buffer solutions are able to keep the pH of a solution within a desired range, and to describe what happens to the pH of a solution during a titration.

Detailed Objectives:

- Explain what happened to the concentrations of ions in solution when a small amount of strong acid or base is added to a buffer solution.
- Design (by choosing components and their concentrations) a buffer solution that will maintain a pH close to a desired value.
- Calculate the change in pH and in ion concentrations when a small amount of strong acid or base is added to a buffer solution.
- From the shape of a titration curve, determine whether it represents the titration of a strong acid by a strong base; a strong base by a strong acid; a weak acid by a strong base; or a weak base by a strong acid.
- Use a titration curve to determine the concentration of a solution containing an unknown acid or base.
- Use a titration curve to determine the acid dissociation constant K_a of an unknown acid (or the K_b of an unknown base.)

High-level goals that span topic areas:
Develop a more sophisticated qualitative and quantitative understanding of the principles of chemical equilibrium by applying them within the context of acid-base reactions.

Develop more sophisticated appreciation of the role of definitions in science by understanding how a particular compound can be an acid according to one definition but not according to another. Understand that concepts like “acid” and “base” are categories that we impose to help organize our understanding, rather than predefined ideals.

2. Learning Goals: Electrochemistry

Based on "Study Sheet #3" from the 1131 Study Guide (p. 23 in the Fall 2006 version)
Nested in two levels as suggested by the FDI Workshop notes.

Topic Level Learning Goals:

1. An oxidation-reduction reaction (commonly abbreviated to "redox reaction") involves a net transfer of electrons from one chemical species to another. Students should be able to distinguish a redox reaction from other types of reactions, and to identify which species lose electrons and which ones gain electrons.
2. Students should be able to show how a redox reaction can be used to generate an electrical current, by separating the oxidation process from the reduction process in an electrochemical cell. Students should also be able to show how a chemical reaction that would not occur on its own can be *driven* by an electrical current.
3. Students should be able to predict which reactions are spontaneous using tabulated electrochemical potentials, and relate these to chemical equilibrium properties.
4. Students should analyze various real-world applications of electrochemical processes, such as batteries, corrosion, electrolysis, and electrochemical concentration measurements.

Detailed Learning Objectives, grouped under the above headings:

1. An oxidation-reduction reaction (commonly abbreviated to "redox reaction") involves a net transfer of electrons from one chemical species to another. Students should be able to distinguish a redox reaction from other types of reactions, and to identify which species lose electrons and which ones gain electrons

1.1. Assign "oxidation numbers" to the individual atoms within molecules and molecular ions, and use them to track the flow of electrons in a reaction.
1.2. Determine whether a chemical reaction is an oxidation-reduction (redox) reaction.
1.3. Analyze a redox reaction by breaking it into oxidation and reduction"half reactions"
1.4. Construct new oxidation-reduction reactions from a set of specified half-reactions.
1.5. Balance a redox reaction, and determine how many electrons are transferred in the reaction.

2. Students should be able to show how a redox reaction can be used to generate an electrical current, by separating the oxidation process from the reduction process in an electrochemical cell. Students should also be able to show how a chemical reaction that would not occur on its own can be driven by an electrical current.

2.1. Given a sketch of an electrochemical cell, including electrode materials and ions in solution, state what chemical reaction is taking place in that cell.
2.2. For a given redox reaction, design an electrochemical cell in which that reaction could be used to generate an electrical current.
2.3. Show the direction in which electrons, ions, and electrical current move when an electrochemical cell is producing electrical power, and when the cell is being driven by an external power source.
2.4. Predict what happens to the components in an electrochemical ell (does an electrode grow or shrink, do the concentrations of ions in solution increase or decrease) when the cell is producing power, and when it is being driven by an external source.
2.5. Calculate how much product will be made when a measured electrical current passes through an electrolytic cell; equivalently, how much current is required to produce a desired amount of product.

3. **Students should be able to predict which reactions are spontaneous using tabulated electrochemical potentials, and relate these to chemical equilibrium properties.**

   3.1. Use tabulated "standard reduction potentials" to predict the direction in which a chemical reaction will take place, given components and their concentrations.
   3.2. Use standard reduction potentials to calculate the voltage produced by an electrochemical cell, given the cell components and their concentrations.
   3.3. Construct an electrochemical cell that is capable of producing a specified voltage.
   3.4. Calculate the equilibrium constant of a reaction from standard reduction potentials.
   3.5. Predict the products that will be formed when an electrical current is passed through a mixture of ions (an aqueous ionic solution, or a mixture of molten salts.)

4. **Students should analyze various real-world applications of electrochemical processes, such as batteries, corrosion, electrolysis, electrochemical concentration measurements, and biological electron transport.**

   4.1. Sketch the components of a typical dry cell battery.
   4.2. Given the components of a typical rechargeable battery (e.g. a car battery), identify which reactions are taking place while the battery is producing power, and which are taking place when the battery is being charged.
   4.3. Describe the chemical reactions involved in the corrosion of metals. Predict the effect of environmental conditions (humidity, acids, dissolved ions) on corrosion. Choose an appropriate "sacrificial anode" to retard the corrosion of a given metal.
   4.4. Show how an electrochemical cell can be used to measure the concentration of ions in a solution. Predict what happens to the components of a concentration cell as the cell operates. Construct a cell that is capable of measuring the concentration of a particular ion. Explain how a pH meter works.
   4.5. Describe the role of redox reactions in biochemical energy conversion processes (the electron transport chain.)

High-level Goals that span topic areas: Appreciate the role played by oxidation-reduction reactions in the interconversion of electrical and chemical energy.

<u>3. Learning Objectives for Kinetics:</u>

Topic Area 1: Reaction rates and Rate Laws.
Topic Level Goals: Given the rate law for a chemical reaction, students should be able to predict the time dependence of the concentrations of reactants and products. Given experimental data on reaction rates, students should be able to infer the rate law.

Detailed Learning Objectives

- Correctly use the terms "rate", "rate constant" and "rate law" as they are used in chemical kinetics.
- Given a balanced chemical equation, express the rate of the reaction in terms of the rate of change of any reactant or product.
- Calculate the rate of a reaction from a graph of reactant or product concentrations versus time.
- Determine the rate law and rate constant for a reaction from experimental measurements of the dependence of rates on reactant concentrations (the "method of initial rates").

- Determine the rate law and rate constant from measurements of concentration versus time ("integrated rate law").
- Use integrated rate laws for first, second, and zero order reactions to predict how the concentration of a reactant depends on time

Topic Area 2: Temperature Dependence of Reaction Rates.
Topic Level Goals: Students should be able to predict the dependence of rates on temperature and to extract parameters that control temperature dependence from experimental data. Students should be able to explain the significance of kinetic parameters such as "activation energy" in terms of molecular-level pictures of reactions.

Detailed Objectives:

- Describe how a reaction rate depends upon temperature, and the role of "activation energy" in this.
- Given a rate measured at one temperature and an activation energy, determine the rate at a different temperature. Given measured rates at several temperatures, determine the activation energy.
- Explain activation energy and temperature dependence in terms of kinetic molecular theory and molecular collision pictures.
- Use reaction coordinate diagrams to illustrate the transformation of reactants into products in a reactive collision, and to explain activation energy and temperature dependence.

Topic Area 3: Reaction Mechanisms
Topic Level Goals: Students should be able to use reaction mechanisms to predict the results of experimental measurements of reaction rates. Given experimental measurements, students should be able to construct a mechanism consistent with the data.

- Describe the "elementary steps" of a reaction using molecular pictures.
- Assemble a mechanism for a complex reaction from elementary steps.
- Given a mechanism for a complex reaction, and information about the rates of the steps, determine the rate law.
- Given an experimentally measured rate law, construct a mechanism that could give rise to that rate law.
- Given a mechanism, sketch a reaction coordinate diagram consistent with that mechanism.
- Describe the effect of a catalyst on the reaction rate and on the equilibrium properties of a reaction.
- Describe how catalysts work in atmospheric chemistry (ozone depletion) and biochemistry (enzymes).

High Level Goals that span topic areas:
Distinguish between kinetic properties and thermodynamic (equilibrium) properties of chemical reactions. Identify which external factors influence the rate of a reaction, which factors influence the equilibrium properties, and which factors influence both.

Other chem 1131 topics for which learning goals are incomplete. Topic areas 1-3 above cover about 75% of the course. The remaining topics are solubility equilibria and transition metal chemistry (mainly coordination complexes, which mainly emphasizes the overall course goals related to structure and bonding, and crystal field theory). Thermodynamics (delta G and entropy) is also likely to be shifted from 1111 to 1131.

CU-GEOL 2100 (Environmental Geology) - complete

Current "motto" for the class: "Get informed – Use it – Share it"

The "get informed" part is learning through lecture, in-class exercises, readings, and repeatedly asking the students to dig around for more/external information in the homework assignments. The "use it" is asking the students to take our major environmental topics one step further and make their own assessments, using geological information as a guide but not providing a definitive answer. The "share it" is learning how to convey geological information to others so that they can develop their own assessments and be part of the decision making process.

Attitudes Towards Environmental Geology and Learning Environmental Geology:

A1. Students will recognize that newsworthy events related to Environmental Geology occur every day.

A2. Students will develop ways to learn Environmental Geology on their own, beyond the scope of material covered in the class.

A3. Students will feel confident in their ability to invoke geological information to decide how humans should best use (or not use…) the landscape that surrounds them.

Big Ideas:

B1. Students will discover that the relationships between geologic processes and environmental quality are continually changing and should be repeatedly reassessed.

B2. Students will be able to theorize about how humans can affect geological cycles, particularly due to the rate humans transform water, energy and mineral resources at both a local and global scale.

B3. Students will be able to assess how the history of our past water, energy and mineral use guides any efforts to develop new resources.

Scientific Ways of Thinking & Expression

C1. Students will be able to generate conceptual sketches of geological rock and water cycles

C2. Students will be able to identify the geologic processes that generate and replenish water resources, and the timescales over which they operate.

C3. Students will be able to recognize that rocks have both physical and chemical properties, and be able to illustrate how these properties control how rocks interact with water.

C4. Students will be able to analyze the geologic factors that cause or mitigate threats to water quality.

C5. Students will be able to evaluate the risks associated with waste disposal in geologic media.

C6. Students will be able to use primary data to determine the potential cause of an environmental problem, and be able to discuss the limitations of the data.

Topic-level Learning Objectives for Module 1:

Introduction to Physical & Environmental Geology

This module should be designed to create sufficient familiarity with geologic terms, processes and materials that there will be a framework in place for then discussing specific topics in Environmental Geology such as Water Resources, Soils, Mineral Resources, and Water Quality. More details on rock properties, mineralogy, and tectonic activity will be introduced as needed.

Big ideas (not written as a LG): Geologic resources, such as water, minerals, fuels, specific rock-types, are heterogeneously distributed on Earth. This distribution directly reflects longterm geologic processes linked to Plate tectonics. In contrast, current day plate tectonics controls the location of many natural hazards, particularly Earthquakes, Volcanoes, and Tsunamis. Students should develop an understanding of how rocks are "recycled" at the surface of the Earth and the timescales over which these processes operate.

Topic level Learning Objectives

- Students will know that the surface of the Earth is composed of rocks that are chemically and physically distinct from the interior of the Earth (*i.e.* crust vs. mantle and core).
- Students will be able to recall that the surface of the Earth is fragmented into numerous "plates" and these plates move (*i.e.* dynamic planet)
- Students will be able to identify at least two or three types of geologic information used to reconstruct the movement of tectonic plates
- Students will be able to illustrate how at least two types of plate boundaries will move
- Students will be able to explain why the majority of rocks at the surface of the Earth are younger than the age of the Earth (i.e. <4.5 bya).
- Students will be able to recall the names of several common types of rocks
- Students will be able to generalize about the properties of the three major rock types
- Students will be able to choose the types of environments where each of the major rock types should form.
- Students will be able to analyze a series of geologic processes (e.g. erosion, burial, subduction) and determine how a rock might be continuously transformed from one type to another (e.g. sediment to metamorphic rock) – in no preordained order.

<u>Topic-level Learning Objectives for Module 2:</u>
Water Resources

Includes 3 Weeks of Lecture: Surface water (week 4), Ground water (week 5, plus in-class exercise) and Water Use/Consequences/Decisions (week 6).

Big ideas (not written as a LG): This module should convey why knowledge of underlying geology (as well as climate) informs us about the distribution of water resources. Hopefully students will become familiar not only with the numerous water reservoirs on the surface and in the subsurface, but understand why the movement of water between reservoirs can often be faster/too much (i.e. flooding) or slower/too little (i.e. loss of groundwater storage) than optimal for human purposes. In turn, human activities, such as urbanization and changes in land-use (e.g. agriculture) – as well as the construction of dams or other water diversions – have altered the hydrologic cycle in very pronounced ways.

Topic level Learning Objectives

- Students will be able to identify the major water reservoirs on earth and describe their relative magnitude.
- Students will be able to discuss several processes responsible for transferring water between these different reservoirs.
- Students will be able to describe the factors that lead to flash vs. distributed floods.
- Students will be able to identify geologic evidence used to infer past flooding events.
- Students will be able to calculate a recurrence interval for a flood of a given magnitude.
- Students will be able to illustrate the difference between a 20-year vs. 100-year flood (i.e. explain the magnitude-frequency concept).
- Students will be able to appraise how humans might use a 20-year vs. 100-year floodplain.
- Students will be able to identify rocks that could form aquifers (i.e. store water)
- Students will be able to differentiate between a rock's porosity and permeability
- Students will be able to recognize how different layering of rocks would create confined vs. unconfined aquifers.
- Students will be able to explain the factors that influence aquifer recharge and discharge (i.e. how groundwater moves through rocks).

- Students will be able to analyze the rock characteristics of a simple geologic basin to determine where ground water would be stored and how ground water would flow.
- Students will be able to illustrate how pumping of wells can change groundwater flow and availability
- Students will know how to find out where their local water comes from, and whether or not there is a changing balance between surface water and ground water use.
- Students will be able to classify several different types of water use and their relative magnitudes.
- Students will be able to explain adverse consequences of lowering the water table.
- Students will be restate examples where humans have chosen to move water from areas of abundance to scarcity and assess some of the unintended consequences.
- Students will be able to theorize about why water shortages might become one of the most pressing environmental concerns humans face.

<u>Topic-level Learning Objectives for Module 3:</u>
Mineral Resources

Big Ideas (not written as a LG): This segment seeks to make students more aware of the enormous consumption of mineral resources that occurs in all of our daily activities -- and how our global need for mineral resources is increasing, rather than diminishing, at an astonishing rate. We will explore past practices in mineral exploration and extraction, the legacy of waste generation and environmental contamination, and growing efforts to increase conservation and recycling efforts, in order for students to participate in decisions about how we should pursue the future extraction of both abundant and trace metals.

Topic-level Learning Objectives
- Students will be able to differentiate between an element, a mineral and a rock
- Students will be able to identify uses for several types of abundant and trace metals
- Students will be able to explain our daily dependence upon minerals in our home and industrial environments
- Students will be able to breakdown the reasons behind the recent increases in mineral claims in the Western US
- Students will be able to describe some of the geologic environments where “minerals of interest” form, and explain why the distribution of mineral resources is heterogeneous
- Students will be able to generalize about why mineral resources are not considered renewable
- Students will be able to analyze whether or not a mineral deposit is economically important at any given time (i.e. determine whether ore grade or not?)
- Students will be able to describe processes used to extract minerals from the landscape
- Students will be able to compare and contrast the types of wastes and environmental impacts associated with different extraction techniques
- Students will be able to explore the fate of abandoned mines & assess land-reclamation efforts
- Students will be able to appraise potential benefits from mineral recycling strategies
- Students will be able to formulate suggestions about how we can handle future shortages in a mineral resource, using historical examples to support their ideas.
- Students will be able to evaluate new efforts to locally develop a mineral resource, and be able to propose a “cradle-to-the-grave” strategy that they would be willing to support.

<u>Topic-level Learning Objectives for Module 4</u>:
Waste Disposal

Big Ideas (not written as a LG): This segment seeks to make students more aware of how difficult it is to dispose of waste in an environmentally responsible manner, whether it be municipal waste, agricultural waste, mining waste, hazardous waste, nuclear waste etc.. Any method or site we chose has a critical geologic and hydrologic context, so what are the criteria we use and what are the potential consequences of our choices?

Topic-level Learning Objectives

- ❖ Students will be aware of the magnitude of municipal, industrial, agricultural, mining, and highlevel waste generated in the US annually
- ❖ Students will be able to suggest geologic criteria necessary to isolate various types of wastes from the environment
- ❖ Students will be able to question the choices we regularly make about disposal methods
- ❖ Students will be able to select a site for municipal waste using geologic and hydrologic information
- ❖ Students will be able to explore the fate of worrisome disposal byproducts, such as “leachate” and methane gas.
- ❖ Students will be able to identify whether a waste is considered hazardous or not
- ❖ Students will be able appraise the timeframe that different types of hazardous wastes need to be isolated from the environment
- ❖ Students will be able to assess the pros and cons of the disposal choices we face for High-level Nuclear waste
- ❖ Students will be able to formulate criteria for building a geologic repository for High-level waste

<u>Topic-level Learning Objectives for Module 5:</u>
Water Quality

Big Ideas (not written as a LG): There are numerous toxic compounds – some naturally derived, and some generated from human activity – that significantly degrade the quality of our surface waters and groundwater when they are released into the environment. It can be incredibly difficult to determine their source (natural vs. anthropogenic, point vs. non-point source), residence time, and level of toxicity. Moreover, it is an enormous task to regulate their dispersion, define acceptable levels in drinking water, or choose remediation strategies to clean the water.

Topic-level Learning Objectives

- ❖ Students will be able to question what the idea of “safe” or “clean” water means to them
- ❖ Students will be able to explain the basis of several types of water pollution
- ❖ Students will be able to illustrate the difference between point sources and non-point sources of water pollution.
- ❖ Students will be able to critically assess the importance of pathogen-free water relative to other pollution threats.
- ❖ Students will be familiar with how (and when) the EPA establishes drinking water standards and establishes control over sources of water pollution.
- ❖ Students will be able to classify the threats posed by pollutants that have long residence times and/or are magnified within the food-chain
- ❖ Students will be able to diagram the potential mobility of contaminants in groundwater.
- ❖ Students will be able to compare and contrast current groundwater remediation methods.
- ❖ Students will be able to integrate geologic and hydrologic information to theorize about epidemiological phenomena (e.g. mass-poisonings from contaminated water).

<u>Topic-level Learning Objectives for Module 6:</u>
Energy Resources

Big Ideas (not written as a LG): We are facing a new frontier in the development of renewable and non-renewable energy resources. This module seeks to introduce students to future decisions to be made in the exploitation of “conventional” fossil fuels, such as oil, gas and coal, as well as “marginal” fossil fuels that are abundant in Colorado, such as oil shale. Effort will be made to encourage students to

differentiate between resource limitation issues associated with fossil fuels and environmental impacts such as release of greenhouse gases or other air pollutants. We will also explore the idea of geological carbon sequestration, which will likely require a broad introduction to the global carbon cycle. We will then turn our attention to the growing portfolio of renewable sources under development in the U.S., with a particular focus on energy sources that require consideration of the geologic context (e.g. geothermal, nuclear*).
**note: nuclear already addressed previously this semester but will be returned to this segment in future years.*

Topic-level Learning Objectives

- Students will be able to classify various energy resources as renewable vs. non-renewable
- Students will be able to describe the geologic environments necessary for the production and storage of various fossil fuels
- Students will be able to contrast the global distributions of oil, gas, coal and oil shale.
- Students will be able to estimate the lifetime of reserves vs. resources for non-renewable energy resources and analyze the variability in these terms.
- Students will be able to appraise the barriers that might impede extraction of different types of fossil fuel resources.
- Students will be able to formulate potential environmental impacts that might result from the extraction and use of various fossil fuel resources when provided with the geologic setting and technology used.
- Students will be able to specify why carbon storage technology is so intimately tied to geologic processes.

UBC – CPSC 111 (Introduction to Computation) - complete

Course level learning goals

After completing this course, students should be able to:

1. Write and modify code to "express understanding" of basic programming constructs (including sequential execution, conditional execution, iteration, arrays, methods/parameter passing, object-orientation and inheritance principles).
2. Read and hand-execute (trace) provided code to "express understanding" of basic programming constructs and memory models (including sequential execution, conditional execution, iteration, arrays, methods/parameter passing, object-orientation and inheritance principles).
3. Write code to solve moderately-difficult problems (moderately difficult will be defined through example in an appendix)
4. Recognize, create, and manipulate various models of programs including memory tracing and UML class diagrams
5. Explain Java language features (e.g. classes, visibility, fields, and methods) which support OO design principles such as modularity, encapsulation, abstraction and inheritance.
6. Explain the major components of a computing system and how a program compiles and executes to a non-computer scientist.

Topic level learning goals (F=Final, M1/M2=Midterm1, Midterm 2, L=Labs, A=Assignment)

Computing Systems

A. Define and give real world examples of key components of the computer (input, output, processor, memory).- assessed in M1
B. Can distinguish and describe how layers of abstraction are supported in computing problem solving through algorithms, programming languages, assembly, and computer hardware.

C. Apply with basic competence simple programming constructs such as sequential execution, variable typing and declaration, naming, algebraic operations, operation precedence. – assessed in M1, M2, F, L, A

Programming Language Basics

D. Create programs which translate explicit English problem statements (an algorithm) into short series of sequential Java instructions. – assessed in M1, M2, F, L, A
E. Describe the multiple ways in which a natural language paragraph can be interpreted and contrast to the single way an algorithm can be interpreted.
F. Explain why a particular numeric type can only represent numbers in a particular range.

Classes and Objects

G. Define the relationship between classes and objects. – assessed in M1, M2, F
H. Read and write code utilizing the API of key Java classes (e.g. String, Scanner). Explain how control flow and data pass on a method call. – assessed in M1, M2, F, L, A
I. Identify specific standard methods like accessors and mutators and describe why these operations are needed for non-primitive data types.

Conditionals

J. Hand-trace and create programs which use if-statement conditionals to model behavior of input-driven programs. – assessed in M2, F, L, A
K. Utilize Boolean expressions, relational, and logical operators to control conditional execution. – assessed in M2, F, L, A
L. Utilize block statements, short-circuit evaluation (?), and nested ifs to create code to solve problems in Java. – assessed in M2, F, L, A

Designing and Defining Classes

M. Create a simple class (with instance variables, accessors and setters) utilizing basic components of OO design (including encapsulation, visibility modifiers, and overloading) to model a real world entity (including its actions and state). – assessed in M1, M2, F, L, A
N. Use that class in a simple program.- assessed in M2, F, L, A
O. Apply their understanding of references and objects by writing standard constructors and drawing diagrams of memory after an object is constructed. – assessed in M2, F
P. Explain how encapsulation (as implemented with visibility modifiers) supports data integrity and good interface design.
Q. Apply with more expert competence simple programming constructs such as sequential execution, variable typing and declaration, naming, algebraic operations, operation precedence. – assessed in M2, F, L, A
R. Describe how reference objects differ from primitive variables and describe problem solving scenarios which are best supported by each.

Iteration

S. Solve problems by creating code where repeated actions are controlled with looping structures (for and while loops). – assessed in M2, F, L, A
T. Identify and debug a loop that never stops (an infinite loop). – assessed in M2, F, L, A
U. Solve problems which requires a loop within a loop where the inner loop iteration does not depend on the outer loop iterator (e.g. to draw a rectangle of stars). Solve problems which requires a loop within a loop where the inner loop iteration does depend on the outer loop iterator (e.g. to draw a triangle of stars). - assessed in M2, F, L, A

Arrays

- V. Solve problems with collections of same-type data using arrays (including primitive type collections (e.g a collection of class grades) and collections of objects (e.g. a collection of String names or a deck of cards). - assessed in M2, F, L, A
- W. Apply with more expert competence branching, looping, and nested loops through practice solving problems using arrays and 2-D arrays. - assessed in M2, F, L, A
- X. Solve problems by creating code which require the creation and use of 2-D arrays (e.g. graphics and averaging scores of students and other data that can be stored in matrix form). - assessed in M2, F, L, A

Sorting

- Z. Identify a simple sorting algorithm. – assessed in F
- AA. Explain that a simple sorting algorithm can be analyzed through simple techniques such as comparison counting and that different sorting algorithms can have different execution time costs and that the number of elements sorted is important in making these analyses. – assessed in F

Advanced Class Design

- AB. AB1 create codes which require the use of advanced class syntax and semantics including static methods and variables, scoping, primitive and non-primitive parameter passing.
  AB2 explain the difference between static and non-static fields and give an example of when each should be used.
  AB3 explain the difference between static and non-static methods and give an example of when each should be used.
  AB4 given a piece of code, identify the scope of a variable (locals, class-level, or global).
  -assessed in M2, F, L, A
- AC. AC1 create codes which require the use of advanced OO concepts such as inheritance, class hierarchy, and polymorphism.
  AC2 explain how inheritance is a form of code re-use that can be valuable in large systems.
  AC3 given a parent class and a specification for a subclass, implement the subclass, including method overriding, calls to the super class constructor and calls to the super class's version of the overwritten method.
  AC4 explain what happens when polymorphic assignment happens.
  AC5 explain what happens when a polymorphic method call is made.
  - assessed in F, L, (A)
- AD. Apply with more expert competence class design and usage through practice with programs implementing inheritance, class hierarchy and polymorphism. – assessed in F, L, (A)

Graphics

- AE. AE1 explain how graphics applications use inheritance and interfaces.
  AE2 create codes which require the use of basic graphical user interface APIs in Java.
- AF. Create codes which utilize an event-driven execution model.

CPSC 1111 Course level goals and topic level goals alignment

	1. Write and modify code ……..	2. Read and hand-execute..	3. Write code to solve moderately…	4.Recognize, create, and……..	5. Explain Java language….	6. Explain the major components…
Computing Systems (2)						A, B
Programming Language Basics (4)	C, D	C				E, (F?)
Classes and Objects (3)	G, H	G, H, I			I	
Conditionals (3)	J, K, L	J, K, L	(J?, K?), L			
Designing and Defining Classes (4/2)	M, N, O, (Q?)	(O?), R	N, Q	O, R	M, P	
Iteration (3)	S, U	T	S, U	T		
Arrays (3,1)	V, X		V, W, X			
Sorting (2)		Z		(Z?)		AA* (not done by everyone who teaches course)
Advanced Class Design (3)	AB1, AC1, AC3	AB4, AC4, AC5	AD		AB2, AB3, AC2, (AC4?), (AC5?)	
Graphics (2)	AE2, AF				AE1	

UBC – CPSC 121 (Models of Computation) - complete

Course level learning goals

After completing this course, students should be able to:

1. Apply the formal systems we discussed to model computational systems (like programs and circuits), including reasoning about them, proving relevant properties, and communicating about them clearly and precisely with fellow Computer Scientists. Learn and apply new formalisms, specifically be able to connect between features and conclusions in the formal and informal (English language, sketch-based, pseudo-code, etc.) representations.
2. Justify the behaviour and correctness of some algorithms (e.g. at the level of selection sort and recursive binary search or quicksort), but especially for algorithms with singly and doubly nested loops in order to prove them correct or bound their running time.

3. Translate easily among English language, simple formal representations (i.e., propositional and shallowly nested predicate logic statements), and closely related equivalent formal representations (in order to identify alternate methods to solve or simplify a variety of problems, such as writing conditionals, as you work with them). Write proofs for simple theorems by translating the theorem into first-order logic, decomposing the statement into its components, and then using the proof techniques discussed in class (direct proofs, indirect proofs by contrapositive, indirect proofs by contradiction, proofs by weak and strong mathematical induction).
4. Read a proof, and justify why each step of the proof is correct.
5. Create regular expressions and Deterministic Finite-State Automatons (DFAs) to solve problems that are important to them in programming.

<u>Topic level learning goals</u>

Students can……
Propositional Logic and Circuits

A. Express simple natural language statements using propositional logic. – assessed with B, should be assessed on a quiz, assignment
B. Distinguish between statements that express the same information about the world versus statements that don't, using logical equivalences. – assessed in midterm (sometimes on a quiz, but generally too long)
C. Translate back and forth between propositional logic statement and circuits that assesses the truth or falsehood of those statements. – assessed in Lab(1-2), quiz or midterm, sometimes assignment

Proofs

D. Express natural language statements which require the use of predicate logic to describe, for example, the result of algorithms that use loops. – assessed in F6a, midterm, assignments (with variety of domains), quiz
E. Make statements about the relationships between properties of various objects (e.g. every candidate got votes from at least three people in every province). – assessed in Assignment, sometimes quiz
F. Create simple direct and indirect proofs, to be able to prove the correctness of operations that can be performed in programs. As another example, supports the development of data type representations (e.g. rational numbers). – assessed in F5, F6b, F7b, F9, quizzes, assignments, midterm

G. Evaluate when a proof fails to satisfy as a communication between people – that is identify inaccuracies or missing steps in proofs. – Previously, not directly assessed (now somewhat on one quiz and one assignment), maybe occasionally on an assignment.

Arithmetic Circuits

H. Describe how the arithmetic operations of the computer break down into simpler logical operations as this is understanding one step of the layered structure of computers. – assessed in F1a, F1b, labs a lot, lightly on assignment
I. Recognize why the numerical systems that we work with on computers behave the way they do, especially in cases where they break down such as floating point representation being inaccurate, overflow, and limitations of integral numerical types (longs, ints, etc.).- assessed in F1b?, F3a, F3b, F3c, lab, breakdown not assessed otherwise

Sets and Functions

J. J1 apply previously developed formalism to proofs about sets and functions as applied in Java collection classes and in databases.

J2 give examples of function that have certain properties and vice versa (e.g. injective, surjective, bijective). – assessed in F2a (simpler), F2b, F7a, F7b, not really the application to Java or DB (issue with 211), assignments, quiz,

K. More precisely explain the meaning of quantified statements. (elaboration of D/E) –Continue to do questions like D/E and they understand better. Assignments, quizzes

Finite Automata

L. Model and solve real world problems such as control circuits (traffic lights), matching problems, validating input, and (in the abstract) modeling the capabilities of a computer using real circuits/DFAs. – assessed in F11a, lab (adding a new one), assignment

M. Students can create regular expressions which produce DFAs to solve problems that are important to them in programming. – assessed in F11b, assignment, quiz, lab

N. REMOVED

Induction

O. Prove things about programs that the use loops and recursion. – assessed in F8(not prog), F10b but easier, too hard to assess, not convinced that we have a simple enough problem that they can do. Save for 221., assignment (a lot), quiz

P. Justify the correctness of a reasonably complex recursive algorithm (like quicksort or mergesort). An example of O.- assessed in F8(not prog)

Q. Be able to list out the exhaustive steps from a proof that should prove that -- given a property that they want to prove and given any specific value to prove that property at. – assessed in F8(not prog), F10a, talk a lot about in class, but not on assignment, the application can just be done mechanically (NOT ASSESSED BEFORE FINAL- needs attention)

Relations

R. Prove that a relation is symmetric, transitive or reflexive. – (Sometimes we get to it and sometimes we don't.

<u>Course level goals and topic level goals alignment</u>

	1. Apply the formal system….	2. Justify the behavior…..	3. Translate easily among..	4. Read a proof and ….	5. Create regular expression….
Propositional Logic and Circuits (3)	C		A, B		
Proofs (4)	(G)?	(F)?	D, **E,** F	G	
Arithmetic Circuits (2)	H, I				
Sets and functions (2)	J		K		
Finite Automata (3)	L, M, N				L, M
Induction (3)		O, P	O	Q	
Relations (1)	R		R		

UBC – STAT 200 (Elementary Stat for Applications) - complete

Attitudinal aims

In addition to specific learning outcomes, the course aims to shape the attitudes of learners regarding the field of Statistics. Specifically, the course aims to

1. Motivate in students an intrinsic interest in statistical thinking.
2. Instill the belief that Statistics is important for scientific research.
3. Provide a foundation and motivation for exposure to statistical ideas subsequent to the course.

Learning outcomes

Each numbered item states a learning aim for the course, and the items that follow indicate the learning outcomes (or objectives) through which that aim could be deemed to have been satisfied.

1. Demonstrate the ability to apply fundamental concepts in exploratory data analysis.
    a) Distinguish between different types of data.
    b) Interpret examples of methods for summarizing data sets, including common graphical tools (such as boxplots, histograms and stemplots) and summary statistics (such as mean, median, mode, variance and IQR).
    c) Assess which methods for summarizing a data set are most appropriate to highlight interesting features of the data.
    d) Identify the features that describe a data distribution.
    e) Use an appropriate software tool for data summary and exploratory data analysis.

2. Design studies for obtaining data whilst avoiding common design flaws that incur bias, inefficiency and confounding.
    a) Recognize observational studies and experiments.
    b) Identify features common in experiments, including the experimental units, treatments, factors, control groups, randomization and blocking.
    c) Recognize some common types of sampling design, such as simple random sampling, stratified sampling and multistage designs.
    d) Identify possible sources of bias and confounding in experiments and surveys.
    e) Identify possible hidden variables in a study.

3. Demonstrate an understanding of the basic concepts of probability and random variables.
    a) Recall rudimentary mathematical properties of probability.
    b) Describe the sample space for certain random experiments.
    c) Explain probability in terms of long-term relative frequencies in repetitions of experiments.
    d) Recall what are meant by the terms independent, disjoint and complementary events.
    e) Apply the definition of independence to attempt to determine whether an assumption of independence is justifiable in a given situation.
    f) Find probabilities of single events, complementary events and the unions and intersections of collections of events.
    g) Describe the main properties of probability distributions and random variables.
    h) Identify the random variable(s) of interest in a given scenario.
    i) Contrast discrete and continuous random variables.
    j) Find probabilities for distributions over finite discrete sets and for those continuous distributions for which probabilities can be found without the use of calculus.
    k) Calculate the mean and variance of a discrete random variable.

l) Apply general properties of the expectation and variance operators.
m) Interpret the mean of a random variable in terms of the Law of Large Numbers.
n) Recall the key properties of the Normal distribution, including the preservation of Normality under linear transformation.
o) Find the following for a Normal distribution: (i) the probability over a set of values, (ii) a percentile, (iii) the mean or variance given the other and either a percentile or a probability over a set and (iv) the mean and variance given probabilities over two sets.
p) Recognize cases where the Binomial distribution could be an appropriate model.
q) Recall characteristics of the Binomial distribution, such as the mean and variance.
r) Compute probabilities for a Binomial distribution.
s) Approximate Binomial probabilities using a Normal distribution, incorporating a continuity correction as appropriate.

4. Understand the concept of the sampling distribution of a statistic, and in particular describe the behaviour of the sample mean.
   a) Distinguish between a population and a sample, and between parameters and statistics.
   b) Recall the sampling distribution of the mean of a sample from a Normal distribution.
   c) Describe properties of the sampling distribution of the sample mean in general situations, using the Central Limit Theorem where appropriate.
   d) For statistics other than the sample mean, identify features that will influence the sampling distribution of the statistic.
   e) Apply the Central Limit Theorem to problems involving sums and averages of variables from arbitrary distributions.

5. Understand the foundations for classical inference involving confidence intervals and hypothesis testing.
   a) Describe the property of unbiasedness.
   b) Interpret a confidence interval and confidence level.
   c) Identify features that determine the width of a confidence interval.
   d) Identify the components of a classical hypothesis test, including the parameter of interest, the null and alternative hypotheses and the test statistic.
   e) Compute, or approximate, the P-value of a test statistic.
   f) Explain the two types of errors possible and define the associated probabilities.

6. Apply inferential methods relating to the means of Normal distributions.
   a) Recall the definition of a t statistic in terms of statistics of a sample from a Normal distribution.
   b) State and apply the definitions of the t, F and $\chi 2$ distributions in terms of the standard Normal.
   c) Conduct inference for the mean of a Normal distribution where the underlying variance is either known or unknown, including the construction of confidence intervals and one and two—sided hypothesis tests.
   d) Recognize when inference should be based on matched pairs.
   e) Perform inference when data are in matched pairs.
   f) Identify where a two—sample inference is required.
   g) Conduct inference about the difference in the means of two Normal distributions, including cases where the underlying variances are known or unknown.
   h) Be aware of robustness issues in the context of one and two—sample t tests.

7. Apply and interpret basic summary and modelling techniques for bivariate data and use inferential methods in the context of simple linear models with Normally distributed errors.
   a) Identify a possible relationship in bivariate data from a scatterplot.

b) Recall the properties of a sample correlation.
c) Interpret a sample correlation.
d) Recognize the limitations of correlation as a summary of bivariate data.
e) Define the concept of least squares estimation in linear regression.
f) Fit a linear model to a bivariate data set via software.
g) Interpret the parameter estimates in a fitted linear model.
h) Identify which variable is most naturally the response variable in a regression analysis.
i) In the context of an example, explain why correlation need not necessarily imply causation.
j) Evaluate the fit of a linear model by consideration of the residuals.
k) Conduct inference for the slope and intercept parameters, including construction of confidence intervals and hypothesis tests.
l) Calculate interval estimates for the mean and predicted responses at a given value of the explanatory variable.
m) Estimate the underlying variance about the line.
n) Explain the output from a software package for a regression analysis.

8. Demonstrate an appreciation of one-way analysis of variance (ANOVA).
   a) Identify situations where one-way ANOVA is and is not appropriate.
   b) State the modeling assumptions underlying ANOVA.
   c) State the null and alternative hypotheses for the ANOVA test.
   d) Explain the partitioning of the total sum of squares into the "within" and "between" group components.
   e) Identify the degrees of freedom associated with each sum of squares.
   f) Interpret an ANOVA table.
   g) Perform the F test in ANOVA, evaluating or approximating the P-value of the test statistic.
   h) Use the data to estimate the underlying within-group variance.
   i) Explain the output from a software package for an ANOVA study.

9. Interpret and analyze data that may be displayed in a two-way table.
   a) Recognize when a two-way table is an appropriate way to summarize a data set.
   b) Compute and interpret marginal and conditional distributions from two-way tables.
   c) Describe the possible relationships between two categorical variables in a two-way table.
   d) Perform the Chi-squared test for association for a two-way table, computing the test statistic if necessary.

UBC-PHYS 100 (Introductory Physics)

Course Goals

1. Apply conservation of energy and thermal physics principles to real-world thermal systems, such as home heating and climate change.
2. Apply knowledge of work and Newton's laws to calculate basic dynamics and energy consumption of common transportation systems (cars, bicycles etc.)
3. Qualitatively explain how electricity is generated in various types of power plants and the "life cycle" of electricity from production through transmission to consumption, and calculate power consumption for various common circuits.
4. Use algebra to solve simple equations.
5. Appreciate that while physics often gives approximate answers, it is very relevant to the real world and is a useful tool for solving problems at the global as well as the personal level.
6. Develop the inclination and ability to apply problem solving techniques to simplify "real world" problems in terms of simple physics concepts and to compute or estimate solutions.

7. Recognize that scientific conclusions - whether from an outside source or from your own calculations - may be incorrect, and develop the ability to check these conclusions with simple calculations, 3rd party information, and/or common sense.

Content

- Conservation of energy, dynamic equilibrium
- Heat, home heating, radiation
- Physics of climate
- Kinematics, forces, Newton's laws
- Work, potential energy
- Electric current, resistance
- Applications of DC and AC circuits
- Electricity generation and transmission
- Impacts and costs of energy production

Lecture Scale Goals (week by week)

NB: goals that we do not plan to explicitly test are listed in *italics.*

Week 1. Introduction, Course Outline, discussion of techniques, Measurement, Units, Data Analysis, Experimental Error

Students *Should* Be Able to:

- *appreciate why active engagement techniques are being used in this class*
- *access the course website to find more information*
- *summarize the expectations for course content and student workload*
- apply their knowledge of measurement error to determine what an appropriate number of sig. figures is for a particular measurement device
- describe in simple terms the general nature of a scientific theory and its relationship to the experimental data
- explain the nature of a scientific model
- use and convert between various units

Week 2. Intro to Conservation Laws, Conservation of Energy, Dynamic Equilibrium

Students Will Be Able to:

- identify correct system boundaries needed to apply conservation laws
- explain how energy can remain at a constant level even when there is a flux of energy into or out of the system
- give examples of a physical system in dynamic equilibrium
- calculate kinetic and potential energies in mechanical systems
- recognize assumptions needed to apply conservation of mechanical energy
- explain the effect of friction and air drag on the energy of a mechanical system

Week 3. Thermal Physics

Students Will Be Able to:

- recognize different forms of energy
- explain the connection between the energy of motion and thermal energy
- define and use common units of energy and power including Joules, Watts, BTUs and kilowatt-hours and convert between them
- list the approximate (within factor of 3) energy consumption for a household appliance, for an entire house, for a country
- recognize and describe the mechanisms of the three major heat transfer mechanisms
- use energy diagrams to describe conversions between different types of energies

Week 4. Home Heating, Radiation

Students Will Be Able to:

- explain the energy flows and energy transformations in the simple home heating model
- calculate heat flows in a one-dimensional thermal model
- use a simple home heating model to calculate heat flow and associated heating bill
- give reasons why such a model is a reasonable place to start, and state limitations of such a model
- appreciate that visible light is one part of a spectrum of electromagnetic energy characterized by its wavelength
- describe the relationship between temperature of an object and the wavelength and power of its emitted radiation

Week 5. Climate Change

Students Will Be Able to:

- use the σT^4 formula (Stefan's law) to calculate the radiant flux of any body, such as the Earth
- construct a thermal model of the Earth and explain the source of each input and output flux
- describe the strength of this model (that it definitively gives the temperature of the upper atmosphere) and several weaknesses of this model (that it ignores the interior dynamics of the climate system.
- see that a very simple model gives reasonably accurate results

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Week 6. Climate Change cont.

Students Will Be Able to:

- explain several major feedback mechanisms that have strong effects on the climate temperature, (water vapor, ice cover) and how they can make the temperature response quite sensitive to small changes
- explain why small changes in a minor constituent of the atmosphere are thought to have a large impact on the global temperature
- identify data that supports current climate models
- recognize and assess key criteria for evaluating scientific arguments (Strong data to support strong conclusions, knowledgeable and ethical source, no simpler explanation possible, etc.)
- qualitatively describe the physics behind the major projected effects of climate change (rising sea levels, increased droughts etc.)
- discuss the relationship between climate models and historical shifts in the Earth's climate
- list the top five greenhouse gas producers worldwide, and the top five greenhouse gas producers per capita worldwide
- list the main industrial sources of greenhouse gas production worldwide

MIDTERM (cons. of energy, thermal physics, basic physics of climate change)

Week 7. Kinematics, Motion under Constant Acceleration

Students Will Be Able to:

- define the terms position, velocity and acceleration and explain how each of these quantities can be measured in the real world
- use algebraic and graphical methods to calculate velocity and acceleration of a moving object
- relate a description of an object's motion to qualitative statements of its position, velocity, and acceleration

- relate a description of an object's motion to graphs of its position, velocity, and acceleration vs. time
- apply the equations of kinematics to solve one-dimensional quantitative kinematics problems for constant acceleration
- describe the velocity and acceleration at every point for an object under constant acceleration (e.g. a ball tossed in the air)
- interpret kinematic problems involving multiple representations of information (kinematic graphs, motion diagrams, algebraic calculations)

Week 8. Forces & Newton's Laws

Students Will Be Able to:

- explain what a force is and how it can be measured by simple mechanisms or by the human body
- calculate the magnitude of the gravity, normal force, and friction acting on a body at rest or moving in one dimension
- correctly interpret the direction of the normal force and friction in different circumstances
- construct a free body diagram suitable for solving dynamics problems
- use Newton's second law to predict a body's response to the forces on it
- apply newton's laws to perform one dimensional dynamics calculations

Week 9. Work, Energy Transformations in Motion

Students Will Be Able to:

- calculate the magnitude and direction of work done on a body in motion
- illustrate the connection between work and kinetic energy with specific examples from real life
- describe the energy transformations occurring in common transportation systems in steady and accelerating states(bike, car, skytrain)
- apply conservation of energy to calculate the energy or fuel requirements of various passenger vehicles
- identify and explain metrics for evaluating the efficiency of different transportation options (mpg, passenger-miles per gallon, l / 100 km)

Week 10. Review & Discussion of Transportation Technologies

Students Will Be Able to:

- illustrate the connection between work and kinetic energy with specific examples from real life
- describe the energy transformations occurring in common transportation systems in steady and accelerating states (e.g. bike, car, skytrain, airplane)
- apply conservation of energy to calculate the energy or fuel requirements of various passenger vehicles
- identify and explain metrics for evaluating the efficiency of different transportation options (mpg, passenger-miles per gallon, l / 100 km)

Week 11. What is Electricity? Parallel and Series Circuits

Students Will Be Able to:

- calculate how the dissipated power depends on various parameters in a simple circuit (e.g. current, voltage, resistance)
- draw a circuit diagram corresponding to a real collection of conductors and resistors (e.g. a light bulb, a toaster)
- calculate current and voltage for a variety of series and parallel resistance circuits

- discuss how an open circuit or short circuit affects the voltage, current, and power dissipated in a circuit

Week 12. AC Circuits, Home Electricity

Students Will Be Able to:

- discuss qualitatively the similarities and differences between AC electricity and DC electricity
- use the power consumption of typical household appliances as a reference to assess other electrical systems
- explain why parallel wiring is used in homes, and draw an example circuit diagram for wiring a room.
- explain why we use circuit breakers and fuses

Week 13. Electricity Generation and Distribution, and Environmental Impacts

Students Will Be Able to:

- compare the cost of electricity and GHG production for various forms of power generation systems (hydro, wind, coal, nuclear, solar)
- discuss the advantages and disadvantages of these power generation systems
- calculate power losses in electricity transmission lines and explain why we use high voltage transmission lines
- Estimate the energy available in wind, hydro and fossil fuels.
- Discus the energy transformations for various forms of power generation systems (hydro, wind, coal, solar)

UBC-PHYS 200 (Relativity and Quanta) - complete

Broad Goals:

After taking this course, students should be able to:

- list the basic postulates of relativity, and be able to describe some of the basic implications of these that go against our usual intuition (and explain how experimental evidence supports these)
- analyze simple dynamical processes using relativistic dynamics. This will include:
    - knowing how to relate physical quantities measured by observers moving at some relative velocity and know which quantities observers at relative velocities will agree upon.
    - knowing the limits of applicability of elementary formulae from mechanics and know the more general formulae that replace these in situations where velocities are not a negligible fraction of the speed of light

- describe and predict basic behavior of light and electrons in terms of both classical mechanics and quantum mechanics descriptions, and be able to specify differences
- argue how the assertions of quantum mechanics are inferred from the experimental evidence
- calculate the characteristics of quantum states and probabilities for outcomes of measurements for a few very mathematically simple quantum systems, including ones that student has not seen before. This requires understanding the basic mathematical framework well enough to apply it to such novel systems.

- give qualitative predictions and explanations of the behavior of simple quantum systems, such as the distribution of electrons in atoms and the spectrum of light emitted and absorbed by atoms

- argue that physics goes beyond a collection of empirical laws, and involves a deeper conceptual framework that is inferred from experiment but is not at all obvious from our everyday experience
- better understand popular science articles on current research in physics and answer questions about modern physics from curious friends and relatives
- see value in achieving a deeper understanding of quantum mechanics and learning more about modern physics

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<u>Topic Specific Goals</u>:

After taking the course, students should be able to:

RELATIVITY

Newton's Laws and Relativity

- explain what is meant by "relativity"
- explain what is meant by a "frame of reference" and an "inertial frame"
- give examples of how relativity manifests itself in ordinary situations
- show that Newton's Laws obey the principle of relativity
- argue why the equivalence of physical laws in different frames implies that it is impossible to set up an experiment to measure an absolute velocity

Puzzles from Electromagnetism

- show how the speed of light follows directly from Maxwell's equations
- give simple examples from electricity and magnetism to show that either the principle of relativity or some basic notions of distance, time, and velocity must be abandoned

Einstein's Resolution

- argue how the experimental evidence implies that the velocity of light is always independent of the of the motion of the source or of the observer
- state Einstein's postulates of special relativity
- explain how an given observer can set up a coordinate system for making measurements of time and position
- be able to show how Einstein's postulates imply that observers at large relative velocities will not agree on distances, time intervals or whether two events are simultaneous
- describe qualitatively the meaning of length contraction and time dilation
- correctly calculate the lengths and times differences that an observer will measure, properly accounting for length contraction and/or time dilation.
- use Lorentz transformation formulae to relate the measurements of observers moving at relative velocities
- use the velocity transformation formula to calculate the observed velocity of an object in a new frame given the velocity in the old frame and the relative velocity of the two frames
- calculate the Doppler shift of light frequencies for an observer moving relative to the source and discuss the importance of the Doppler effect in astrophysics

Relativistic Invariants

- describe the meaning of spacelike separation, timelike separation, proper length, and proper time
- know how to calculate the proper length/time between two events and the time elapsed on the clock of an observer on some general trajectory
- represent graphically simple scenarios on a spacetime diagram
- use spacetime diagrams to analyze simple processes involving relativistic velocities and resolve apparent paradoxes (e.g. ladder passing through barn)

Relativistic Energy and Momentum

- argue why classical formulae for momentum and energy must be modified
- know the relativistic formulae for energy and momentum
- analyze high-energy particle decay processes and scattering processes using energy and momentum conservation
- give evidence for and explain the most basic implications of the equivalence between energy and mass

QUANTUM MECHANICS

- explain how classical physics picture of light and electrons is in conflict with observations, using examples such as model of atom as electrons orbiting nucleus and spectra of light emitted by atoms

Light as a Particle

- qualitatively describe what is measured in the photoelectric effect experiment and explain how this implies a quantum picture of light, including explaining what results the classical interpretation of light would predict for this experiment
- quantitatively analyze photoelectric data to deduce the relationship between energy of photons and frequency of light

Properties of Quanta of Light ("Photons")

- argue why results of sending light through a polarizer combined with quantum interpretation from photoelectric effect must require a probabilistic (i.e. non-deterministic) behavior of photons
- define what is meant by an "eigenstate" for a given measurement in the context of photons passing through polarizers
- recognize that complex superposition is intimately related to classical superposition with relative amplitude and phase
- compare and contrast classical superposition and quantum superposition
- relate any classical polarization to a complex superposition of photon eigenstates
- describe what is meant by incompatible observables in the context of the quantum description of light passing through a polarizer
- predict the probability that a given photon will pass through a polarizer of given orientation
- calculate how the initial quantum state of a photon is changed by passing through a polarizer

Wave Properties of Electrons

- describe the Davisson-Germer experiment and argue why its results demonstrate wave properties of electrons

- state de Broglie's relationship between wavelength and momentum of a particle
- describe the double-slit experiment for light and electrons and explain why the interference pattern is different depending on whether or not a measurement is made as to which slit the photon/electron passes through
- explain why the results of the double slit experiment imply that the initial electrons do not have well defined positions
- explain what is meant by position and momentum eigenstates of electron
- write down the mathematical description of the wavefunctions for position and momentum eigenstates
- explain how a wavefunction can be used to describe a general complex superposition of all position eigenstates
- for a one-dimensional case, calculate the probability for finding a particle in a given region of space from its wavefunction.
- qualitatively relate the shape of the wavefunction to the relative probability of finding the particle at different positions in space
- qualitatively relate the shape of the wavefunction to the relative probability of finding the particle in a given momentum range
- know the definition of an expectation value
- calculate the expectation value of position (or simple functions of position) from a wavefunction
- state that an arbitrary function can be described as a superposition of sinusoidal functions, and argue why this is plausible
- calculate the expectation value for momentum of a particle given its position space wavefunction
- know the definition of uncertainty (i.e. standard deviation) and be able to calculate the uncertainty in position given a position space wavefunction
- qualitatively describe the implications of the Heisenberg Uncertainty principle in terms of measurements of the position and momentum of a particle

The Schrödinger Equation

- qualitatively describe what a wavepacket is and explain the difference between phase and group velocities
- show that requiring the group velocity for wavepackets to agree with the electron velocity requires the frequency for momentum eigenstate wavefunctions to be proportional to electron kinetic energy
- write down the time-dependent wavefunction for a momentum eigenstate and demonstrate that it satisfies the Schrödinger equation
- know the interpretation of the various terms in the one-dimensional Schrödinger equation
- write down the potential for simple physical setups

Bound states and atomic spectra

- describe what is meant by an energy eigenstate
- know what is meant by the statement that energy eigenstates are "stationary"
- describe what the time-independent Schrödinger equation is used for
- describe a simple physical setup that can be approximately described by an infinite square well potential
- solve the Schrödinger equation for an infinite square well to calculate the allowed values of energy and the corresponding wavefunctions
- state the possible energies that might be obtained in a measurement performed on a simple superposition of energy eigenstates

- predict probabilities for measurements of energy or position give for simple superpositions of the energy eigenstates
- know that general bound systems have discrete energy spectra and use this to explain the discrete nature of atomic spectra

Tunneling (covered if time?)

- describe the behavior of the wavefunction in regions where the particle is classically forbidden
- describe the qualitative evolution of a wavefunction initially localized in one half of a double well
- explain properties of radioactive alpha decay

Special Topics

- be aware of various fascinating topics in modern physics and realize that most of them are built upon the material presented in this course
- feel inspired to learn more about statistical mechanics and condensed matter physics, nuclear and particle physics, general relativity and cosmology

UBC- BIOL 361 (Introduction to Physiology) - complete

Course theme:
How do animals sense and respond to their environment? More specifically, how do they sense their environment, how is this information communicated and integrated within the body (signaling – both the nervous system and the endocrine system), and how do they generate a response (muscular system)?

Major topics and time spent on each topic:
In the fall term of 2007, there were 36 lecture times (50 minutes) for Biology 361. One class was used for the midterm, one for a guest lecture, one for the course introduction, and one for final exam review. Four classes were used for going over problem sets. The remaining 28 lecture times were used to cover the following topics:

1. Cell Membranes and Cell Signaling – 4 lectures (plus 1 problem set spanning 2 class times)
2. Systems for signaling in multicellular organisms – 1 lecture
3. Sensory – 7 lectures
4. Neurons – 5 lectures (plus 1 problem set)
5. Brain and Nervous System – 2 lectures
6. Skeletal muscle – 3 lectures (plus 1 problem set)
7. Cardiac muscle – 1.5 lectures
8. Smooth muscle – 2.5 lectures
9. Endocrinology and the vertebrate stress response – 2 lectures

Assessment:
5% – In-class exercises (problem solving, approximately every third lecture period)
40% – Midterm (50 minutes)
55% – Final Exam

Exams are mainly composed of short answer questions involving explanations and problem solving, as well as short essay questions. Exams are closed book.

Expected Learning Outcomes:

1. Mechanisms and regulation of cell signaling

Students will be able to:

- Describe how chemical and electrical gradients are used to transport molecules across a cell membrane
- Calculate the membrane potential of a cell using the Nernst and Goldman equations
- Explain, using examples, how signal transduction pathways in cells allow for amplification of signals
- Describe how signaling pathways are stopped once they have been activated
- Describe in detail the mechanisms of G-protein signaling
- Predict how experimental modification of regulatory mechanisms (such as phosphorylation or dephosphorylation of receptors) of signaling pathways will affect the cell signal and the expression of target genes

2. How animals use sensory receptors to sense their environment

Students will be able to:

- Interpret written or graphical information on stimulus intensity and action potential frequency to determine how a sensory receptor encodes stimulus intensity
- Explain the difference between tonic and phasic receptors
- Compare transduction of stimuli to action potentials for chemoreceptors, mechanoreceptors, and photoreceptors
- Describe the structure and function of the vertebrate ear
- Describe the structure and function of photoreceptors, focusing on the rods and cones of the vertebrate eye

3. How neurons process and communicate information

Students will be able to:

- Recognize the major structural components of neurons
- Describe the three phases of a neural action potential
- Explain how temporal or spatial summation of graded potentials can cause a neuron to reach the threshold required to produce an action potential
- Predict how changes in the structure, density, and diversity of ion channels will affect action potential shape
- Predict how changes in myelination and axon diameter will affect the conduction speed of action potentials
- Predict whether a neuron will fire an action potential, given experimental data
- Describe the mechanisms of synaptic transmission, using acetylcholine receptors as an example

4. Structure and function of the different regions and functional units of the nervous system in vertebrates

Students will be able to:

- Compare the structure and function of the major regions (hindbrain, midbrain, and forebrain) of the vertebrate brain
- Contrast the structural organization of cells within the brain, spinal cord, and nerves (in mammals)
- Contrast how the structure and function of the forebrain relates to intelligence in mammals versus birds
- Compare the structure and function of the sympathetic and parasympathetic nervous systems

5. Molecular and mechanical processes involved in muscle function, and the regulation of these processes

Students will be able to:

- Explain how actin and myosin interact to produce muscle contraction (the sliding filament model)
- Calculate changes in muscle band length during muscle contraction
- Graph how changes in sarcomere length affect force of contraction in both skeletal and cardiac muscle
- Explain how the timing of stimuli can cause summation and tetanus
- Contrast the structure and function of fast-twitch and slow-twitch fibres in skeletal muscle and the metabolic pathways used by these fibres (the phosphagen, glycolysis, and oxidative systems)
- Compare the molecular and electrical properties of action potentials of cardiomyocytes and neurons
- Describe how an action potential from the pacemaker travels through the heart to cause contraction
- Contrast how heart rate (the rate of pacemaker potentials) is modulated by the parasympathetic nervous system versus the sympathetic nervous system
- Compare the structure and function of skeletal, smooth, and cardiac muscle
- Compare, in detail, excitation contraction coupling in skeletal, smooth, and cardiac muscle
- Propose reasons for improved or reduced performance at the whole animal level by integrating information on cellular and molecular mechanisms of nerve and muscle structure and function

6. How the endocrine system is used for communication

Students will be able to:

- Predict the most likely communication system (nervous, endocrine, or paracrine) to be used by an animal for a given physiological task, based on the velocity and distance of the communication required
- Contrast peptide, steroid, and amine hormones with regards to their release and transport throughout the body and their action on their target tissue
- Describe the pathways and regulation of the hormonal part of the vertebrate stress response

APPENDIX to Learning Goals Examples

A Preliminary Summary of the Study of the Use and Value of Lecture Level Learning Goals in a Computing Course for Non-majors -Beth Simon

In Term 1 (Fall 2007) we studied students use and value of lecture level learning goals provided and discussed at the beginning of each lecture. This course is a first computing course for non-majors and lecture level learning goals were developed as part of a process of making it clear for the instructor what the expected outcomes and competencies were for students for each lecture or unit component. The lecture level goals were developed in summer by the instructor teaching the class in fall. The STLF, Beth Simon, reviewed the lecture level goals developed for the course, attended 4 class sessions and observed the manner in which these goals were introduced and referred to in the actual classroom setting. Then she interviewed 10 students after the midterm (one group of 3, one group of 2, and 5 individually) following a protocol to determine A) if students would self-identify that they used the learning goals to study for the midterm and B) to elicit students' views on the value of the learning goals. The interview finished with students completing 5 copies of the sentence "For me, learning goals are…". In the last week of class, students were asked to complete an in-class survey which asked some specific course evaluation questions and also asked them to complete 5 copies of the sentence "For me, learning goals are….".

Interviews:
In interviews, there were 21 separate and specific statements where students referred to or described using learning goals to study for the class. All but one subject brought up (before being prompted) learning goals as one of the ways in which they studied (usually it was the first thing mentioned). When asked about how learning goals are valuable, 17 statements were made which spanned uses which included: learning goals give direction, describe expectation, are findable, and "simplify" the textbook (which rambles). Students were also asked to identify when learning goals were confusing or not helpful. The 6 statements on this include when students don't understand the material, when learning goals are long, or when they are not reflected on the exam. Several students made reference to the use of learning goals in this course in comparison to other courses they have. These statements all indicated that learning goals as used at the lecture level in this class were "superior". Below we share two quotes about the comparison to other UBC courses:

- Generally if the teacher gives you an outline, but broken up -- you get it while you are learning it (after class, by yourself). Better to get it while you are going (in class) -- allows you to figure out what he's teaching what's important and what's not.
- If you give me the LGs right before the midterm it's overwhelming -- if you go bits and pieces and you can absorb a bit every day and it's easier.

Surveys:
A preliminary analysis of the student responses on the survey to "For me, learning goals are…" (N responses = 213) show that 80% of responses were "positive" in valuation, 13% were negative and 7% where neutral or could not be determined. General categories of positive valuation include:

- Helpful in choosing or identifying important material, a reminder of what to focus on, pinpoints learning
- Helpful in breaking down complex topics
- Helpful because reinforced in lecture and lab, focuses attention in lecture
- Improves study or review habits, staying "on track", makes studying easier
- Good way to measure progress in course, helps student develop questions to ask
- Fun, interesting, useful, helpful, clear, concise, different, comprehensive, cool, filled with learning

Negative responses were generally of the form of providing suggestions for making learning goals "better" including making sure they link to materials on exams, keeping wording succinct and breaking up compound sentences, avoiding jargon, making sure they are not repetitious, making sure they are clearly worded. A few students felt learning goals were "useless" since they didn't understand lecture content.