Biology 151 Lecture Learning Objectives

(sample, Spring 2024)

Species, Evolution, and Cells

1. Outline at least two different definitions of species, and the basics of the Linnean classification system.
2. Describe experiments that argue against the spontaneous creation of living animals and cells.

Cells, Water, and Chemicals

1. Describe how data from fossils and new environments argue for the evolution of new species from old species.
2. Outline the theory of natural selection.
3. Outline how electron sharing or electrical attraction differ between covalent bonds (non-polar and polar), ionic bonds, hydrogen bonds, and van der Waals interactions.
4. Draw a set of water molecules showing their polar nature, hydrogen bonds, and how these features lead to the properties of cohesion and adhesion.
5. Explain how water interacts with hydrophilic and hydrophobic compounds.
6. Describe the relative densities of liquid water and solid ice, and water's high specific heat.
7. Predict how water's pH value relates to the concentrations of H+ and OH- ions.

Organic molecules, chemistry, and energy

1. Recognize the difference between an inorganic and an organic molecule.
2. Understand different representations of an organic molecule.
3. Predict whether an organic molecule is hydrophilic, hydrophobic, or amphipathic.
4. Understand how conservation of mass and energy work in chemical reactions.

More energy, ATP, and Enzymes

1. Use your understanding of Gibb's free energy, endergonic reactions, and exergonic reactions to predict whether a chemical reaction occurs spontaneously or requires energy input.
2. Use rules of thumb about anabolic and catabolic reactions to predict whether a reaction is exergonic or endergonic
3. Predict how coupling an exergonic reaction to an endergonic reaction will affect the change in Gibb's free energy and the spontaneity of the coupled reaction.
4. Compare the potential energy in the bonds in ATP + H2O to the free energy in the bonds of ADP + Pi.
5. Relate the conversion between ATP and ADP to coupled catabolic and anabolic reactions in a cell.
6. Explain how the energy of activation slows some chemical reactions, and how this barrier can be overcome by an enzyme.

Polymer macromolecules: carbohydrates and proteins

1. Explain the roles of dehydration and hydrolysis reactions in the formation and breakdown of polymer macromolecules using monomers.
2. Analyze whether a macromolecule monomer is a monosaccharide, an amino acid, or a nucleotide.
3. Identify a glycosidic linkage, a peptide bond, and a phosphodiester bond.
4. Name some polysaccharides and their biological roles
5. Define the characteristics and bonds that give proteins their primary, secondary, tertiary, and quaternary structures.

Polymer macromolecules: more proteins, nucleic acids

1. Identify the bonds that can give proteins their secondary, tertiary, and quaternary structures, and

how this might be changed by changing the amino acids in a protein.
2. Predict how changes in temperature and pH might affect the shape and function of proteins
3. Define what competitive inhibition and allosteric regulation of an enzyme means
4. Draw a simple diagram of a metabolic pathway undergoing feedback regulation using an allosteric inhibitor.

Lipids, Membranes, and Transport
1. Identify the phosphate, monosaccharide and nitrogenous base portions of a nucleotide, and the phosphodiester bond in a nucleic acid polymer
2. Explain the role of hydrogen bonding between complementary nitrogenous bases in the formation of the DNA double helix and a folded RNA ribozyme.
3. Describe roles for nucleotides and nucleic acids in energy transfer and information storage in a cell
4. Explain the structural/chemical difference between a fatty acid, triglyceride, phospholipid, and steroid
5. Draw a diagram of a micelle and of a liposome phospholipid bilayer, showing how hydrophobic and hydrophilic interactions stabilize these structures.
6. Predict how the presence of saturated fatty acids, unsaturated fatty acids, and cholesterol influence membrane fluidity.

Transport continued and Eukaryotes
1. Explain what is meant by the terms semi-permeable and fluid mosaic when referring to a cell membrane.
2. Predict the direction of water's osmosis across a membrane when a cell is placed in hypertonic, isotonic, or hypotonic solutions, and how some cells use this to create turgor pressure.
3. Draw how channels, carriers, pumps, and energy sources move molecules across a membrane and explain which of these allow these molecules to move with or against their concentration gradient.
4. Explain how cotransport differs from primary active transport and know the difference between a symporter and an antiporter.

Organelles and Energy I: Respiration
1. Outline some unique ways in which membranes are used in eukaryotic cells.
2. Diagram the origins and fates of vesicle membranes and vesicle contents during exocytosis and endocytosis.
3. Provide evidence in favor the endosymbiont origin of mitochondria and chloroplasts.
4. Diagram the cellular locations of the different phases of respiration

Energy II: Respiration continued
1. Describe the inputs to and products of glycolysis, including the two different molecules used to capture energy.
2. Describe the inputs to and products of pyruvate oxidation and the Krebs (citric acid) cycle, including CO_2 and the different molecules used to capture energy,
3. Explain why the citric acid (Krebs) cycle a cycle.
4. Diagram the origins, flow and exit of electrons through the electron transport chain, the chain's location in the mitochondrion, and the chain's effects on H^+ ions.
5. Explain how chemiosmosis through ATP synthase converts a H^+ gradient across the inner membrane of the mitochondrion into the formation of ATP.

Energy III: Fermentation, Photosynthesis
1. Explain why ATP synthesis by the both Krebs cycle and the electron transport chain in the

mitochondrion is inhibited by anaerobic conditions and how ATP synthesis can be maintained by fermentation.
2. Explain the role of alternative final electron acceptors in anaerobic respiration.
3. Relate a cell's source of carbon and energy to its "troph" classification.
4. Draw the structure of the chloroplast noting where the electron transport and Calvin cycle reactions of photosynthesis occur.
5. Describe the inputs needed for the Calvin cycle.

Energy IV: Photosynthesis and alternatives (continued)

1. Explain the role of the photosystems and their pigments in the light reactions
2. Diagram the process of non-cyclic light reactions, including inputs and outputs, photosystems II and I, the proton pump, ATP synthase and $NADP^+$ reductase.
3. Contrast non-cyclic and cyclic light reactions.Diagram the Calvin cycle showing the carbon inputs and outputs, where energy is used and the fixation, reduction and regeneration stages.
4. Describe what happens during photorespiration and how it is affected by the relative levels of CO_2 and O_2.

Inheritance and DNA

1. Explain how CAM and C4 photosynthesis is used by some plants to suppress photorespiration.
2. Discuss ways in which cells might have generated energy on earth before the evolution of oxygenic photosynthesis.
3. Explain why misconceptions about the nature of life, such as the theories of spontaneous generation or preformation, slowed our understanding of heredity and genetics.
4. Explain why the behavior of chromosomes during meiosis suggested that chromosomes were the physical location of Mendelian genes.
5. Describe the experiments that indicated that genes are made of DNA instead of proteins.

DNA & Replication

1. Describe the structure of a nucleotide (sugar, phosphates, nitrogenous base) and how nucleotides are bound together to make a single DNA strand.
2. Understand how complementary nucleotides on opposite DNA strands match through hydrogen bonding between their nitrogenous bases
3. Use the antiparallel structure of the two DNA strands and the binding between complementary nitrogenous bases to predict the nucleotide sequence of one strand based on the sequence of the other strand.
4. Explain why DNA replication is considered semi-conservative.
5. Diagram how DNA polymerase adds dNTPs to a replicating DNA strand.

Replication & Transcription

1. Diagram replicating prokaryotic and eukaryotic chromosomes including the origins of replication, replication bubbles, replication forks, and the location of the template and newly synthesized strands.
2. Predict where the enzymes helicase, primase, DNA polymerase, and DNA ligase act in a replication fork.
3. Explain what topoisomerase does to alleviate supercoiling in a replicating chromosome.
4. Using information about the 5' and 3' ends of the parent DNA, predict the location of the leading strand and the lagging strands in a replication fork, and explain how this results from building both strands from 5’ to 3’.
5. Explain why it is difficult to fully replicate telomeres, and how telomerase overcomes this problem.

Transcription & Translation

1. Explain the role of RNA transcription in protein production, and outline the advantages of having messenger RNA as an intermediate step.
2. Describe the mechanisms through which promoter and terminator DNA define a transcription unit.
3. List the differences between DNA replication and RNA translation.
4. Diagram how the primary transcript in eukaryotes is modified to make a mature mRNA and describe how each modification affects mRNA function.
5. Describe how snRNA helps the spliceosome process introns and exons

Translation

1. Explain why the genetic code requires triplet codons.
2. Diagram the binding relationship between mRNA codons and tRNA anticodons.
3. Diagram how the ribosome A, P, and E slots are used during each step of mRNA translation.
4. Explain how specific tRNAs are loaded with the correct amino acids.
5. Relate start and stop codons, initiator tRNAs, and release factors, to explain how they define the open reading frame and the untranslated regions for a given mRNA.

Mutations, Gene expression

1. List possible causes of DNA mutations.
2. Predict whether a change, addition, or deletion of a DNA nucleotide leads to a specific class of point and frameshift mutation.
3. Describe how mutations relate to species differences in genes and genome sizes.
4. Describe different ways mutations in non-protein coding regions of DNA could still affect cells.
5. Predict and explain why changes in the levels of Lactose change gene expression of the lac operon in bacteria.

Eukaryotes: More gene expression. Endomembrane system & trafficking

1. Predict and explain why changes in the levels of glucose change gene expression of the lac operon in bacteria.
2. Explain how enhancer and silencer DNA regulates the expression of nearby eukaryotic transcription units, and how transcription factors can act as master switches.
3. Predict and explain how acetylation of histones, methylation of DNA, and microRNA changes eukaryotic gene expression.
4. Describe several ways in which mutations could alter the activity of transcription factors.

Eukaryotes: the Cytoskeleton

1. Diagram how different protein signal sequences direct them through the nuclear pore into the nucleus, or through pores in the endoplasmic reticulum.
2. Diagram the trafficking of a secreted or transmembrane protein from its synthesis to its secretion from the cell or its placement in the plasma membrane.
3. Contrast the functions of the smooth and rough endoplasmic reticulum, the Golgi apparatus, transport and secretory vesicles, and the lysosome.
4. Describe how the placement of intermediate filaments provides structural support for membranes
5. Describe how microtubules and microfilaments assemble, and how changes in assembly and their associated motor proteins can create cellular movement.
6. Diagram how microtubule sliding changes the shape of cilia and flagella.

7. Provide examples of how microfilaments and their associated myosin motor proteins can create cellular movement.

Mitosis, the cell cycle

1. Explain different mechanisms by which prokaryotic cells trade DNA information
2.. Draw and label the structure of a single eukaryotic chromosome before and after DNA replication
3. Draw the stages of mitosis, including the structure and location of chromosomes, centrosomes, the mitotic spindle, and the nuclear envelope.
4. Explain how the kinetochore and microtubules move chromosomes to the poles of the cell.
5. Diagram how DNA content of a cell changes during the phases of the cell cycle.

Meiosis and sexual reproduction

1. Describe how the interaction between cyclin and cyclin-dependent kinase (CDK) can control whether a cell can enter the M phase of mitosis.
2. Contrast how prokaryotes and eukaryotes pass genetic information between unrelated cells.
3.. Distinguish between gene and allele, sister chromatids, and homologous chromosomes
4. Relate changes in homologous chromosomes and sister chromatids to the alternation between diploid and haploid cells during the life cycle of most animals.

Mendelian Genetics I

1. Contrast chromosome behavior between mitosis and the two divisions of meiosis.
2. Identify steps during sexual reproduction that increase genetic diversity in a population.
3. Identify steps during meiosis that account for Mendel's Law of Segregation and Independent Assortment.
4. Predict the possible genotypes of haploid gametes that can be produced from a diploid germ line cell of a given genotype.

Mendelian Genetics II

1. Design genetic crosses to determine an organism's genotype: whether it is homozygous or heterozygous for alleles of a gene, and which alleles are dominant and which recessive.
2. Calculate the probabilities of offspring with specific phenotypes using Punnett squares or other means.
3. Interpret pedigree trees to identify dominant and recessive modes of inheritance and to predict possible genotypes of individuals in the tree.

Sex chromosomes & dosage

1. Explain the different effects of alleles that show incomplete dominance versus those that show co-dominance.
2. Predict the outcomes of crosses regulating human ABO blood types.
3. Explain some ways in which pleiotropic mutations might affect multiple traits.
4. Outline different ways in which sex chromosomes can influence whether individuals produce sperm or eggs and the role of the Y-linked SRY gene in mammals.
5. Predict how hemizygosity for X-linked or Y-linked genes affects phenotypes in XY individuals,
6. Diagram how X and Y chromosomes behave during meiosis I and segregate during the production of gametes.

Gene linkage & recombination

1. Interpret crosses and pedigrees to identify sex-linked modes of inheritance and predict possible genotypes of individuals.
2. Explain how the formation of Barr bodies aids dosage compensation and affects the phenotypes of individual cells.
3. Diagram ways that non-disjunction leads to monosomy and trisomy.
4. Explain how the formation of Barr bodies aids dosage compensation is XXY and XXX trisomic cells
5. Explain why linking two genes on the same chromosome affects the independent assortment of alleles of those genes during meiosis.
6. Diagram how, in cells heterozygotes for two genes, crossing over between homologous chromosomes can alter parental links between alleles and produce recombinant, non-parental chromatids.

More complications, non-Mendelian inheritance

1. Use test crosses and the frequency of offspring phenotypes to predict whether two genes are linked, which alleles were linked in the parental, non-recombinant chromosomes, and the distance between the genes in centimorgans.
2. Understand the relationship between polygenic traits and quantitative phenotypes.
3. Explain how, in a polygenic pathway, an allele of one gene could be epistatic to an allele of another gene in the pathway
4. Analyze data from studies of fraternal and identical twins to determine whether a trait is inheritable.

Junctions and signaling between cells

1. Diagram how mitochondrial mutations would be inherited in a pedigree.
2. Propose a possible mechanism for epigenetic inheritance of gene expression.
3. Explain how the ability of a signaling molecule to move through cell membranes would influence the location of the receptor for that signal.
4. Diagram the step that comes after activation of a G protein-coupled receptor, a protein kinase, and an adenylyl cyclase.
5. Predict whether different members of signal transduction pathways would or would not amplify signaling.

Multicellularity, homeostasis, structure & function

1. Describe the advantages & disadvantages of multicellularity.
2. Understand that each disadvantage is a challenge that must be met by specialized tissues, organs, and organ systems.
3. Know the four types of tissue in the human body and the general function of each.
4. Explain why diffusion limits the size of unicellular organisms and how multicellular organisms overcome this limitation.
5. Understand the concept of homeostasis and how negative feedback helps multicellular organisms remain in homeostasis.
6. Apply the concept of how form and function to predict the function of an organ/tissue/system by looking at its form/shape (and vice versa).

Nervous system I

1. Describe how a neuron’s structure relates to its overall function.
2. Understand how charge differences between the inside and the outside of a neuron are due to differences in charged ions that dictate its membrane potential.
3. Understand how the membrane potential is maintained at rest, how it changes during an action

potential, why, and what proteins and ions are responsible.
4. Illustrate how an action potential travels down an axon in one direction and how it resets shortly thereafter.
5. Describe what happens at a neuronal synapse during synaptic transmission of neurotransmitters.
6. Know the role of glial cells and why they are necessary for proper neuron function and maintenance.

Nervous system II

1. Predict whether an ion will initiate an EPSP or IPSP with respect to the change in membrane potential of the postsynaptic cell.
2. Know that the CNS and PNS work together to sense and respond to the environment, coordinate movement, and regulate internal functions of the body.
3. Compare and contrast the Sympathetic and Parasympathetic control over bodily functions.
4. Describe how the nervous system helps regulate body temperature via negative feedback.
5. Understand how simple reflex circuits make fast responses possible and underpin a mouse's ability (or inability) to escape from a cat.

Sensory Systems I

1. Differentiate between chemo- mechano- and photoreception in general including the specialized proteins responsible for receiving the different environmental signals.
2. Know the process of sensory transduction in general, from detection to signal transmission to the brain.
3. Understand how action potentials convey intensity, location, and duration information, and enhance edge and border detection.
4. Know which of our senses rely on GPCRs for signal transduction and why.
5. Describe sensory transduction for olfaction (smell) from stimuli detection to neuronal transmission to the brain.
6. Compare and contrast sensory transduction for the five basic flavors humans can detect, differentiating between which directly depolarize sensory cells and how vs. the flavors that rely on GPCRs.

Sensory Systems II

1. Know which of our senses rely on mechanotransduction, chemotransduction, and phototransduction.
2. Understand how hair cells convey information about gravity, movement, and sound by physically opening ion channels when activated.
3. Describe the role of the outer, middle, and inner ear and what forces are being generated in each portion.
4. Recognize how sound perceived by an ear conveys information about pitch by stimulating different portions of the cochlea and volume by stimulating the hair cells w/in the cochlea more or less intensely.
5. Recall how light activates retinal which changes opsin's confirmation and initiates the phototransduction cascade.
6. Describe the phototransduction cascade in general, starting with rods/cones and finishing with action potentials sent to the visual cortex.
7. Know the cellular organization of the retina and each cell's role in phototransduction (sensory transduction for vision).

Sensory systems III: Brains

1. Know how the brain processes and integrates information from multiple sensory systems to different cortices in the brain responsible for each.
2. Understand the two cortices responsible for sensing and coordinating a physical response via our skeletal muscles.
3. Understand how your brain rewards pleasurable experiences via a complex pathway that reinforces that pathway.
4. Know that cognition is the brain's ability to process and integrate complex information, remember and interpret past events, solve problems, reason, and form ideas.
5. Apply your understanding of learning to understand positive feedback.
6. Understand how sleep and learning are inexorably linked.

Muscles

1. Know the basic structure of muscles and how they are organized from the sarcomere through the muscle.
2. Understand how actin and myosin interact via the cross-bridge cycle to generate force and produce movement.
3. Know how smooth and striated (cardiac & skeletal) muscle types differ and are controlled by different branches of the nervous system.
4. Understand how muscle contraction starts via motor neurons depolarizing muscle cells, resulting in calcium release and initiating sarcomere contraction.
5. Know that the force generated by a muscle depends on its size, the degree of actin-myosin overlap, the shortening velocity, and the stimulation rate.

Endocrine Systems

1. Understand how the endocrine system (ES) works in tandem with the nervous system (NS) to better respond to environmental stressors.
2. Understand the difference between hydrophilic and hydrophobic hormones based on where their receptors are on the cell and the type of response invoked.
3. Know the difference between tropic and direct hormones.
4. Understand the difference between negative and positive feedback and be familiar with examples of each.
5. Describe how your body maintains blood sugar levels (homeostasis of blood sugar) when they get too high or too low.
6. Know how the sympathetic NS interacts with the ES, amplifying the signal and fully engaging an animal’s fight or flight response.
7. Give three examples of pheromones and their roles in other animals, but also explain why humans don’t make any.

Respiration

1. Understand anatomically, where multicellular organisms utilize diffusion over short distances and bulk flow over long distances.
2. Know where in the body gas exchange occurs, how SA is maximized, and how concentration gradients are maintained to facilitate diffusion.
3. Intuit where in the body partial pressures of O_2 and CO_2 are high & low, and why.
4. Know the structure of Hemoglobin and how it facilitates the loading/unloading of O_2 via cooperative binding.
5. Understand how Oxygen disassociation curves help illustrate how oxygen is loaded or unloaded and shifts in different environments.

Circulation & the heart

1. Explain how vessels of different sizes facilitate bulk flow and diffusion.
2. Understand how the differences in the structure of veins and arteries underlie their different functions.
3. Recognize how pressures facilitate things leaving and returning into capillary beds.
4. Explain the path of blood from the body, through the heart to the lungs, back to the heart, and out to the body again.
5. Examine the connectivity of the specialized cardiac muscle cells and how they generate action potentials to pump blood through the chambers synchronously.
6. Understand how the nervous and endocrine systems control heart rate as needed and how blood flow to different organs will change under different circumstances.

Digestion & Absorption

1. Know the roles of the foregut, midgut, and hindgut in digesting an animal's diet.
2. Know where and how the three macromolecules break down in the foregut and midgut and how they are absorbed into the body.
3. Understand the necessity of a strongly acidic stomach and how protein digestion occurs within the stomach. Describe how the stomach creates and maintains an acidic stomach.
4. Describe how the small Intestine works with the pancreas and liver to finish digestion and complete absorption.
5. Know that the large intestine retains digesta long enough to absorb water and nutrients before expulsion.

Osmoregulation

1. Describe osmoregulation, why it is necessary, why we excrete N-waste, and what forms N-waste take in different animals.
2. Understand the role of the Glomerulus, how it filters, and what comes through to form the filtrate.
3. Explain the role of the convoluted tubules and what comes out of and stays in the filtrate.
4. Analyze the loop of Henle in the nephron and understand how water & NaCl are retained via the countercurrent structure.
5. Explain why urea recycling is necessary and what it does within the nephron.
6. Know when/how antidiuretic hormone and aquaporins are employed to save water and create concentrated urine.

Biology 152 Lecture Learning Objectives

Evolution:

- Diverse living species show common ancestry
- Evolution is a population-level phenomenon
- Natural selection explains adaptation
- The history of common ancestry is depicted in phylogenetic tree diagrams
- Relatedness is equivalent to recency of common ancestry
- Evolution is a branching process that is not goal directed or able to plan ahead
- The traits of organisms are a summation of changes along their ancestral lineage
- Biological taxonomy is based on phylogenetic relatedness
- Phylogenetic trees provide information about evolutionary history, including trait homology

- Evolution is change in the frequency of genetic variation in a population
- Evolution entails a change in allele frequency
- Allele frequency and genotype frequency can be related by the Hardy-Weinberg law
- Fitness is the expected reproductive output of a genotype relative to other genotypes
- Directional selection tends to increase the frequency of high-fitness alleles until they become fixed
- Mutation is the ultimate source of all genetic variation
- Changes in allele frequency occur even without selection
- Genetic drift can reduce the efficacy of natural selection
- The frequency of genetic disorders is based on a balance between the rate of mutation and the strength of negative selection
- Genetic disorders vary in frequency among populations, especially small, inbred populations
- Over-dominant selection tends to maintain polymorphisms in a population
- Heritability describes the extent to which variation in a continuous trait has a genetic basis
- Eugenics has scientific and ethical flaws
- Selection can act not only on the mean but on the variance of a continuous trait
- Sexual selection can favor traits that lower survivorship but increase reproductive success
- The nature of species is controversial
- Species may contain discrete races/varieties often called subspecies
- The splitting of an ancestral lineage into independently evolving descendant lineages can occur without prior geographic isolation
- Changes in trait function contributed to the evolution of some complex phenotypes
- There are three domains of life, united by common ancestry
- Eukaryotes arose as a merger of a bacterial (mitochondria) and TACK archaeal lineage
- There are two models for the origin of the nucleus and endomembrane system

Plant Biology:

- List some of the ways plants are important to humans
- Identify the characteristics that indicate green algae are closely related to plants and the preadaptations of Charophytes that would have allowed their ancestor to move onto land
- Draw the zygotic meiosis life cycle
- Understand ways that land plants changed the planet
- Explain the function of the three traits shared by all land plants and why those traits are needed on land
- Compare the land plant life cycle to zygotic meiosis
- Identify general characteristics shared by the “bryophytes”
- Compare the gametophyte and sporophyte stage of bryophytes, ferns, gymnosperms, and angiosperms. Which is dominant? Which provides the nutrients to the other (or are they independent)?
- Identify which groups share the traits we discussed on the land plant phylogenetic tree.
- Compare seeds in gymnosperms and angiosperms. Identify evolutionary advantages of seeds over spores.
- Draw the female and male parts of the flower.
- Draw the formation of female and male gametophytes and double fertilization in angiosperms.

- Contrast double fertilization with pollination.
- Explain the function of apical and axillary buds.
- Draw an apical bud growing. Label and understand the processes occurring in the zones of cell division, elongation, and differentiation. Where are these zones as the bud elongates?
- Compare the three tissue types.
- Draw and label the tissues in leaves and primary roots and shoots.
- Compare primary and secondary growth.
- Understand the difference between positive and negative tropisms and the kinds of tropisms we identified in class.
- Identify the steps in signal transduction.
- Explain the experiments that identified where light is sensed in phototropism.
- Draw the changes in auxin movement down a stem when light comes from one side.
- Describe the steps in the Acid Growth Hypothesis and how that results in growth in a shoot when light is from above and from one side (i.e., are all cells in a cross section expanding equally?).
- Describe the steps in leaf abscission.
- Predict how bright fall leaf colors will be based on weather conditions and the color of the leaves the previous year. [this requires knowing which colors change based on weather and how weather affects the color that does change].
- Compare and contrast spongy mesophyll and palisade mesophyll cells.
- Explain three functions of the spongy mesophyll that increase whole-leaf photosynthesis.
- Predict which colors will drive photosynthesis when white light hits a leaf of a hypothetical color.
- Explain the results of the radish seed experiment. Why did the “light” treatment gain mass and the “dark” treatment lose mass?
- Draw the cycle of photosynthesis in a chloroplast.
- Compare the inputs and outputs of the Calvin Cycle and photorespiration.
- Predict if plants in a habitat will exhibit C3, C4, or CAM photosynthesis (e.g., what photosynthetic pathway are you likely to find in plants living in a desert?).
- Compare C3, C4, and CAM photosynthesis.
- Explain how water’s various physical properties (e.g., high surface tension) are the result of its ability to form hydrogen bonds and how those properties are important in plant biology.
- Compare the three forms of water movement in plants (what drives the movement? How do you determine the direction of flow? Is a membrane necessary?).
- Mathematically define water potential from its two components.
- Describe water potential and its two components (e.g., what causes each component to increase or decrease, are they positive or negative?).
- Solve equations involving the components of water potential.
- Predict the direction of flow and any resulting change in the solute potential based on given water potential parameters.
- Understand the uses of water in plants.
- Predict changes in vapor pressure difference (VPD) based on changes in relative humidity or temperature.
- Compare the controls on water loss through stomata (VPD, temperature, and stomatal
- conductance).

- Explain the steps of stomatal opening.
- Predict how stomata will respond to changes in internal CO_2 concentration, VPD, temperature, soil moisture content, and light.
- Explain why the water potential equation for xylem water can be simplified to only include the pressure potential.
- Describe the xylem cells through which water moves.
- Explain why plants need xylem transport.
- Explain why the water potential equation for xylem water can be simplified to only include the pressure potential.
- Describe the xylem cells through which water moves.
- Describe how the negative pressure is created in the water in the leaf and why that causes flow in the xylem.
- Predict the water potential along the path from the soil through the plant to the air (i.e., it becomes more negative).
- Explain what is transported in the phloem, and, for the sugars, the reasons they are good for transport.
- Compare phloem sources and sinks. Can an organ that is a sink ever become a source?
- Describe the phloem cells through which photosynthates move. Explain how sieve tubes can survive without a nucleus.
- Draw a mesophyll cell, bundle sheath cell, companion cell, and sieve tube and diagram how symplastic and apoplastic loading work.
- Compare symplastic and apoplastic loading.
- Explain how loading sugars into the xylem leads to flow in the phloem and sugar unloading at the sink leads to water being recycled into the xylem.
- Compare the functions of root hairs, fine roots, and thicker roots.

Ecology:

- Match ecological questions to the major levels of study in ecology (e.g., individual, population, community, landscape, ecosystem, global).
- Distinguish between ecology and conservation biology, and recognize their shared history and interactions.
- Explain how abiotic factors, biotic factors, dispersal, behavior, and environmental variation can affect species distribution patterns.
- Notice the natural environment around you and practice separating your observations from interpretations.
- Define what “climate” means and how it differs from “weather”.
- Explain the causes of the seasons.
- Describe how climate varies with latitude and how these differences are related to variation in sunlight that strikes the earth and the major atmospheric circulation cells.
- Compare and contrast major terrestrial biomes (climate, dominant life forms, location).
- Compare and contrast major aquatic biomes (physical factors, dominant life forms, location). Be able to use the terms below for the different aquatic zones when appropriate to describe aquatic biomes.

- Know the general kinds of locations where the major aquatic and terrestrial biomes would be found on earth.
- Recognize abiotic and biotic factors that may prevent a species from occupying its full fundamental niche.
- Describe the two major vegetation zones of Wisconsin and the community types in each of these zones. Which major biomes include these two zones?
- History shows that species have responded individualistically to past climate changes; some current plant communities such as hemlock-hardwood forests of northern Wisconsin are of recent origin.
- List some ways that species can respond to changes in abiotic conditions.
- What factors affect the number of species on a habitat island, when arrivals and extinctions are at equilibrium?
- How can the number of species on a habitat island be relatively constant despite constant changes in species identity?
- Understand how sampling methods may interact with dispersion or behavior of organisms to affect the accuracy of population estimates from population subsamples.
- Be able to apply the mark-recapture method to estimate population size.
- Fully understand and be able to use and interpret the exponential model of population growth.
- Interpret the values of r so that you know when a population's size is increasing, decreasing, or not changing.
- Understand how the feedback term in the logistic model changes with population size and how that affects population growth rate.
- Explain why a population that fits the logistic growth model increases more rapidly at intermediate sizes than at relatively small or large sizes.
- How does the population size at which maximum growth rate occurs relate to the population size that is the carrying capacity, K?
- Be able to draw and interpret a graph of population size (N) vs. rate of population change (dN/dt) for both exponential and logistic growth models
- Distinguish between the traits that typify r-selected and K-selected species.
- Know how to determine source vs. sink patches in a metapopulation, and why these are important for overall population size
- Understand the general pattern of human population growth globally over time
- Describe the stages of the demographic transition, how birth and death rates change, and how the factors that contribute to these changes
- Interpret age pyramids for relative rates of population growth
- Know the factors that contribute to faster vs. slower human population growth rates, including both biophysical and cultural factors
- Describe the costs and benefits of foraging for a prey item. What does an optimal foraging model optimize?
- Be able to recognize when an organism is foraging optimally from an example.
- Be able to recognize costs of searching and handling time and estimate net profit in an example.
- Use data on prey selection to predict costs of searching + handling time compared with energy content of different prey items.

- Why would optimal foraging theory predict that a predator should select only the most profitable prey type in an environment? Why would individuals sample other prey items despite the predictions of optimal foraging theory?
- Recognize the selective pressures created by different mating systems and the differences in characteristics of males and females in each.
- Be able to calculate whether a behavior that has a cost to the donor is outweighed by the benefits to closely related recipients, in terms of fitness.
- Understand the difference between kin selection and reciprocal altruism, and identify when each might be the mechanism by which a behavior persists in a population.
- Explain why predator and prey populations cycle and what is happening to predators and prey in each of the four phases of the cycle
- Describe what resource partitioning is and how it allows species to coexist
- Explain how species with similar resource needs can coexist.
- Explain how population interactions differ in their effects
- Know the vocabulary used to describe population interactions and be able to categorize a given interaction correctly
- Be able to reason from examples about the type of interaction that is occurring
- Describe what dominant species, keystone species, and ecosystem engineers are and how they influence community structure.
- Be able to compare species richness and evenness in example communities.
- If given a community dataset, be able to compare communities using species richness and relative abundance/evenness.
- Understand why very high rates of disturbance reduce landscape patch biodiversity.
- Explain how space-for-time substitution studies allow inference of long-term ecological changes.
- Differentiate between primary and secondary succession
- Explain the general pattern of successional stages that might develop following a disturbance
- Describe the differences in life history traits between early- and late-successional species
- How do the size and frequency of disturbance interact with the lifespan of dominant species and rates of secondary succession to generate landscape patch type diversity?
- Explain the difference between gross primary productivity (GPP) and net primary productivity (NPP)
- For a given terrestrial or aquatic biome, understand how both its global area and rate of primary production affect its contribution to total global primary production
- Describe the effects of top-down vs. bottom-up control on trophic structure
- Know which of the biologically significant elements have global cycles and which are more variable at a local scale.
- Know the biological significance, biologically available forms, major reservoirs, and important processes in the cycles of carbon, nitrogen, and phosphorus.
- Understand why the global concentration of CO_2 in the atmosphere increases during northern hemisphere winter.
- Be able to interpret the results of experiments testing whether particular nutrients limit plant growth rates or net primary production.
- Know the major threats to biodiversity
- Understand the difference between habitat loss and fragmentation

- Know the relative importance of edge effects in landscapes where patch area and geometry vary
- Understand how edges increase transmission of zoonotic diseases
- Know how to describe species in terms of their evolutionary origins (native, non-native) and impact (invasive, not).
- Describe the rationale behind using managed relocation as a conservation strategy and what some of the risks and benefits of this approach are.