Cell Biology Learning Objectives

Core objectives:

1. Students will understand the structures and purposes of basic components of prokaryotic and eukaryotic cells, especially macromolecules, membranes, and organelles
2. Students will understand how these cellular components are used to generate and utilize energy in cells
3. Students will understand the cellular components underlying mitotic cell division.
4. Students will apply their knowledge of cell biology to selected examples of changes orlosses in cell function. These can include responses to environmental or physiological changes, or alterations of cell function brought about by mutation.

Tier 1- All cell biology sections will cover the following topics

Understand the basic components of prokaryotic and eukaryotic cells

- The cell doctrine
- Chemistry of molecules:
  - Covalent and hydrogen bonds
  - Water and polarity: hydrophilic vs. hydrophobic
  - Organic molecules, functional groups
- Polymer macromolecules
  - Monomers and polymers
  - Monosaccharides and carbohydrates
  - Nucleotides and nucleic acids
    - Nucleotides, sugar-phosphate backbone
  - Amino acids and proteins
    - Peptide bonds
    - Side-chains
    - 1o-4o structure
  - Roles of different macromolecules:
    - Enzymes
    - Information storage: nucleic acids to protein
    - Energy storage
- Membranes
  - Lipids, bilayers
  - Chemical evolution: micelles into cells
  - Membrane proteins, fluid mosaic model
  - Pores and pumps: facilitated diffusion, active transport, co-transport
  - Organelles
  - Prokaryotes vs. eukaryotes
  - Nucleus
    - DNA
    - mRNA and cytoplasmic ribosomes
    - nuclear pores
  - Endomembrane system
    - Smooth and rough ER
    - Golgi
    - Transport and secretory vesicles
    - Endo and exocytosis
    - Other vesicles and vacuoles
  - Mitochondria and chloroplasts
    - Structure and roles
    - Endosymbiont theory
  - Cytoskeleton
    - Microtubules, microfilaments and intermediate filaments
    - Tubulin and actin
    - Motor proteins
    - Cilia, flagella and microtubules
    - Microfilaments and cell shape changes

Understand how energy is used and generated in cells

- ATP and its uses
- Respiration
  - Electron carriers
  - Roles of enzymes
  - Glycolysis
  - Krebs
  - Oxidative phosphorylation
    - Electron transport chain and proton pumps
    - ATP synthase
  - Fermentation
- Photosynthesis
  - Light reactions
    - Electron transport chain and proton pumps
    - ATP synthase and NADPH
    - Cyclic vs. non-cyclic
  - Calvin cycle

RUBISCO
Production of G3P

Understand how cells undergo mitosis

Prokaryotic fission
Circular chromosomes
Eukaryotic mitosis
Linear chromosomes
Production of sister chromatids
Phases of mitosis
Centrioles and the mitotic spindle
Cytokinesis
Cell cycle
Phases
Checkpoints

Tier 2

The cell biology section of Biology 151 may cover in addition one or more of the following topics:
Osmosis
Cell signaling and signal transduction
Organizing cells into tissues
Animal development
Chemical evolution
Cancer
Metabolic diseases

Genetics Learning Objectives

Last updated: 4/16/07

Core Objectives:

1. Students will learn the basic principles of inheritance at the molecular, cellular and organismal levels.
2. Students will understand causal relationships between molecule/cell level phenomena ("modern" genetics) and organism-level patterns of heredity ("classical" genetics)
3. Students will test and deepen their mastery of genetics by applying this knowledge in a variety of problem-solving situations.

TIER 1 – All genetics sections of Biology 151 will cover the following topics:

Cellular level: cell cycle and cell division

1. The key roles of mitosis and meiosis during the life cycle. Compare and contrast different life cycle strategies, focusing on the human life cycle.
2. Stages of mitosis and meiosis, highlighting similarities and differences. Describe stages of the cell cycle; focus on behavior of chromosomes.
3. Origins of genetic variation, including independent assortment and crossing over, which happen during meiosis, combined with random fertilization.

Rules of heredity at the level of an organism

1. Laws of segregation and independent assortment; their physical basis in specific events that take place during meiosis (gametogenesis) and fertilization
2. Practical methodology for applying Mendelian laws (heavily reliant on problem solving)
3. Extensions of Mendelian genetics, including different forms of allelic relationships
4. Inheritance of linked genes, including recombination mapping, and the physical basis of these rules (chromosomal behavior during meiosis)
5. Special case of linkage: sex-linked genes and their inheritance, including X-inactivation.
6. Applications of the above to human heredity (eg. hereditary disease)

Molecular level

1. DNA as the genetic material; basic mechanism of DNA replication
2. RNA and the basic mechanism of transcription
3. Protein and the basic mechanism of translation
4. Mutations as an additional source of genetic variation; a role for mutations in disease

Genome level

1. Genomic diversity: general features of viruses, bacteria, and eukaryotes
2. Regulation of gene expression: bacteria vs eukaryotes
3. Eukaryotic genomes: "junk" DNA, coding vs non-coding genes

DNA technology

1. Recombinant DNA methods and their basis in bacterial genetics
2. Applications of DNA technology: pharmaceuticals, agriculture

TIER 2 – Each genetics section of Biology 151 will cover at least 2 of the following topics:

Gene expression regulation during embryogenesis
Gene expression misregulation in carcinogenesis
Viral and bacterial genetics and infectious disease
Genomics (eg. microarray technology for gene expression studies)
Stem cell genetics

Links to other parts of the course:
• Cell biology
• Evolution

Evolution Learning Objectives

Core objectives:

Students will:

1. understand the evidence that living species share descent from common ancestry and how this fact explains the traits of living species
2. understand that evolution entails changes in the genetic composition of populations
3. understand the source of genetic variation and how it is shaped in the absence of selection (Hardy-Weinberg; genetic drift)
4. understand the concept of fitness and how heritable differences in fitness result in natural selection
5. understand the process of allopatric speciation

Learning objectives for evolution
Common ancestry

- Understand that a phylogenetic tree depicts lines of evolutionary descent
- Understand that no living species is ancestral to another
- Understand that the relatedness of two species is determined by how recently they share a common ancestor.
- Understand that the traits of living species are those that accumulated during their evolution.
- Understand the role of genetic isolation in generating a tree-like phylogeny
- Understand the principles that allow phylogenies to be estimated from trait data
- Understand the connection between taxonomy and evolutionary history and relatedness

Mechanisms of Evolution

- Understand that evolution involves genetic change in the composition of populations
- Understand Darwinian (individual-level) natural selection.
- Understand the concept of relative fitness.
- Understand the role of mutation in Darwinian evolution
- Understand the role of the environment in Darwinian Evolution
- Understand the difference between directional and balancing selection
- Understand the role of genetic drift
- Understand the assumption of basic population genetics and the Hardy-Weinberg equilibrium
- Understand that allopatric speciation involves evolution (by “normal” selection and drift) in geographically isolated population.

Evolutionary history

- Appreciate the time-frame of evolution on life on earth
- Know current views on the origin of eukaryotes
- Know the overall structure of the tree of life
- Understand the concepts of preadaptation and exaptation and their role in major evolutionary transitions.
- Understand the concepts of homology and convergent evolution.
- Understand the nature of fossils.
- Understand the evidence for evolution.

Tier 2

- Understand the principle of parsimony as applied to character mapping on phylogenies.

- Understand the distinction between a natural hierarchy as arises due to phylogeny and an artificial hierarchical structure that can be imposed on any set of objects
- Understand the distinction between the tree and ladder-of-life narrative
- Understand that once an allele is lost from a population it cannot be regained (except by reoccurrence of an identical allele)
- Understand how mutation, selection, and drift explain the frequency of deleterious alleles in a population – specifically human genetic diseases.
- Understand the concept of sexual selection
- Understand the concept of genic selection
- Understand the concept of group selection
- Appreciate the issues involved in explaining the origin of life and how they might be resolved
- Understand the concept of extinction
- Know key events in the history of evolutionary thought

Plant Physiology Learning Objectives

Core Objectives: Students will be able to explain how terrestrial vascular plants acquire and use the energy and material resources needed to complete their life cycle, highlighting relationships between structure and function, and coordination of development, resource acquisition and environmental responses within and across cells, tissues and organs.

Tier 1 Objectives - Students in all sections of 152 should be able to accomplish the following:

1. Plant structure vis-à-vis function

- Identify the organs and tissue systems of plants, and explain their respective functions.
- Describe the principal cell types comprising each tissue system.
- Identify location and function of apical meristems, and describe their general structure.
- Distinguish secondary from primary tissues in woody stem and root growth.

2. Plant growth & development

- Contrast the life cycles of annual, biennial and perennial plants.
- Summarize the three fundamental processes underlying plant development.
- Using an example such as flowering, explain the fundamental role of gene expression in plant development.

3. Acquisition and use of mineral nutrients by plants

- Identify the essential elements, rank their relative abundance in plant tissues, and describe their general roles in plant function.
- Identify the ionic forms in which essential macro-elements are typically available in the soil.
- Explain the mechanisms by which inorganic ions are absorbed by the root and transported throughout the plant.
- Describe the two major symbioses occurring between plant roots and other organisms, and the benefit of each for plant nutrition.

4. Transport of water and solutes through plants

- Explain the inextricable link between energy gain and water loss in land plants.
- Describe the pathway, driving force and resistances involved in water movement, from soil to atmosphere, through plants.
- Explain the mechanisms that plant cells use to compete with their surroundings for water.
- Outline the mechanism by which sugars and other metabolites/solutes are translocated throughout the plant.

5. Plant responses to environment

- Outline the general model (reception-transduction-response) used to explain plant responses to environmental stimuli.
- Define hormone and explain its general role as a signal transducer.
- List the well-documented roles of each of the major hormone groups in plant development and responses to environment.
- Explain the importance of phytochrome in plant responses to light environment.

Animal Physiology Learning Objectives

Last updated: 4/3/07

Core Objectives:

1. Using one or more model systems, students will be able to explain the molecular and cellular basis of physiological functions in animals.
2. Using one or more model systems, students will be able to integrate the regulation of organ system functions in a whole animal using a conceptual model of feedback to explain homeostasis.
3. Using one or more model systems, students will be able to explain structure-function relationships; how form follows function in animals.

TIER 1 – All sections of Biology 152 will cover these topics.

Nervous System

1. Students will be able to explain the three stages of information processing in the nervous system and relate them to the major anatomical divisions of the vertebrate nervous system.
2. Students will be able to describe how neural reflexes control physiological variables and mediate simple behaviors.
3. Students will be able to explain the ionic basis of the resting membrane potential, action potentials, synaptic and receptor potentials, and describe how the three types of gated ion channels produce these signals.
4. Students will know the structure of the neuron and be able to describe how electrical signals are generated and propagated in it.
5. Students will understand the role that myelination plays in nervous system function.

Hormones & Endocrine System

1. Students will be able to compare and contrast endocrine and nervous control systems.
2. Students will be able to name the key events involved in signaling by hormones.

Circulation

1. Students will know the anatomical components of circulatory systems.
2. Students will understand how the heart and blood vessels function to maintain adequate perfusion of tissues.

Osmoregulation & Excretion

1. Students will understand how molecules are transported across sheets of tissue via transepithelial transport.
2. Students will know how the excretion of nitrogenous wastes is linked to the regulation of water and salt balance in animals.
3. Students will know the anatomy of the kidney and be able to explain how its structure is related to its functions.

TIER 2 – Each section of Biology 152 will cover 2 or more of these topics.

Nutrition & Digestion
Gas Exchange
Motor Systems
Immune System
Links to other parts of the course:

- Intracellular signaling
- Evolution (structure-function)

Ecology Learning Objectives

Core Objectives:

1. Describe the structure and function of ecological systems and explain how ecological systems work at different spatial and temporal scales
2. List abiotic and biotic factors that affect, the distribution, dispersal, and behavior of organisms
3. Identify factors that affect biological diversity and the functioning of ecological systems in Wisconsin
4. Use an ecological vocabulary in arguments and explanations of ecological phenomena
5. Apply concepts and theories from biology to ecological examples
6. Analyze and interpret ecological information, research and data

Tier 1 – All sections of Biology 152 will cover these topics

The Importance of Scale in Ecology

1. Describe how interactions between organisms and between organisms and their environment are influenced by multiple factors that act at multiple spatial and temporal scales.
2. Describe how abiotic and biotic factors influence distribution, relative abundance, and species diversity.

Population Ecology

1. Describe and distinguish patterns of dispersion of individuals in a population.
2. Predict changes in populations.
3. Explain why factors such as changes in climate, spread of infectious disease, and access to resources influence populations.

Community Ecology

1. For a given community, under a set of specific conditions, determine the relative importance of competition, predation, herbivory, symbiosis, and infectious disease in driving changes in the community.
2. Predict how species composition, relative abundance, and diversity would change with changes in abiotic and biotic factors.
3. Describe how energy is transferred from producers to consumers.

Ecosystems

1. Describe the energy transformations that occur as part of the metabolism of ecological systems.
2. Illustrate the movement of carbon, nitrogen, phosphorus, and water in ecosystems.
3. Explain how temperature and evapotranspiration play a primary role in productivity.
4. Describe how and why a particular ecosystem may shift between alternative states.

Conservation

1. Identify factors that have influenced species extinctions.
2. For a particular species, under a given set of conditions, determine factors that might drive species extinction locally and globally.
3. Construct a conservation plan for particular species that considers landscape management and that addresses a variety of human impacts on biological diversity.

Tier 2 – Each section of Biology 152 will cover 2 or more of these topics.

1. Ecological systems and human health
2. Environmental issues and environmental policy
3. Ecology and environmentalism
4. Behavioral ecology
5. Disturbance and succession

Links to other parts of the course

- Surface area to volume constraints
- Evolutionary ecology