Biology 181: Study Guide

Purpose
This study guide provides a checklist of terms, concepts and topics covered in Bio 181. Although arranged by chapters from your text, topics may be presented at various times in lecture, lab, or both. This guide is not exhaustive. It should be used with your lecture and laboratory notes, and your text.

College-Level Science Courses
Many students take BIO181 as their first college-level science course. Introductory Biology for Majors is a gateway for students who intend to become active biologists, as well as for students working to be Medical Doctors (etc.). Historically, many people fail these courses! Over the last 40 years, these courses have not become easier. In fact, the science of biology has been incredibly successful, which means there is even more knowledge for you to acquire. You are expected to learn (memorize) and process a large amount of detailed material. Moreover, you need to understand how the facts you memorize are used to support (or reject) hypotheses and theories. Thus, you need to be able to both analyze and synthesize the material you memorize. Your success in this course (and others) depends in large part on two major factors: 1) the time you devote to the course (study), and 2) effective study methods.

Time – Be sure you budget enough time on a daily and weekly basis to read, process, and learn the large amount of material presented. The GCC Student Handbook provides a sample time budget on pages 22 & 23. It would be well worth your time to develop a time budget you can live with that will also accommodate your other weekly activities. Besides attending each lecture and lab, plan to study at least eight hours per week. You cannot succeed (earn an A) without this time! Remember, biology keeps expanding which means more for us to learn!

Effective Study – Okay, you have set aside eight hours of study per week. Now, what do you do with this time? First, use your time to read the assigned chapter before the lectures on that topic. Biologists use many specialized terms. By reading these terms first, you can understand them and the rest of the lecture. Second, be sure to attend every lecture, be awake, pay attention, and write lots of notes. If you thoroughly read the text before the lecture and write lots of notes during the lecture, by the end of each lecture you should understand the material! Once you understand the material – both facts and hypotheses – then you can effectively memorize the facts and analyze the ideas based on these facts. Importantly, if you do not understand the material after reading and coming to lecture, you need to get clarification. If you do not understand a concept - return to the text and your notes, or stop by my office, call or e-mail with your question.

Once you understand the material, you need to ‘make it your own’ – memorize facts in the context of hypotheses and related biological functions. Many common methods have proven successful. These include making your own flashcards (which can be used on your own or with a partner), ‘teaching’ your fellow students in a small group, etc. I found it most useful to rewrite a detailed outline of each lecture, initially from notes, but ultimately on a blank sheet(s) of paper from memory. The GCC Student Handbook has many other ideas and lists on-campus resources that can help you develop good study habits.

For additional review answer the questions at the end of each chapter, use the CD & web site that accompanies your text and take the appropriate online self tests.
PART I. INTRODUCTION AND THE CHEMISTRY OF LIFE: Chapters 1-5


Chapter 1. Introduction: Themes in the study of life.

Biology is the scientific study of life and living things. Your text (and this course) introduced ten themes in biology which provide a framework for your studies.

1. Each level of biological organization has emergent properties.
2. Cells are an organism’s basic units of structure and function.
3. The continuity of life is based on heritable information in the form of DNA.
4. Structure and function are correlated at all levels of biological organization.
5. Organisms are open systems that interact continuously with their environments.
6. Regulatory mechanisms ensure a dynamic balance in living systems.
7. Diversity and unity are the dual faces of life on Earth.
8. Evolution is the core theme of biology.
9. Science is a process of inquiry that includes repeatable observations and testable hypotheses.
10. Science and technology are functions of society.

We will return to these themes throughout the semester (and beyond, e.g. Bio182). You should be able to explain each of these themes and illustrate with an example.

In addition, be able to answer the following questions.

What criteria define living things? What is the fundamental unit of life?

In what way is biology the most complex of the sciences?

Be able to describe the relationship between structure and function in biology, and illustrate with examples.

Explain why individual evolutionary events may be considered a fact, but the process of evolution by natural selection is considered to be a theory. What is the difference between a hypothesis and theory?

Be familiar with three general approaches to science: reductionistic, holistic and integrative.

You should be able to describe the classic Hypothetico-Deductive method that includes: observation, question, hypothesis, prediction experiment, and analysis.

You should also be able to write a hypothesis based on an observation, describe an experiment you design to test that hypothesis, the possible outcomes of your experiment and the conclusions you could draw from each of these different outcomes (results). Include in your experimental design the following:
Independent Variable
Dependent Variable
Controlled Variable(s)
Control Group(s)
Treatment (Experimental) Group(s)

Chapter 2. The Chemical Context of Life.

From a periodic table, be able to determine:

- Atomic number
- Mass number
- Atomic weight
- Number of protons
- Number of electrons
- Number of neutrons

Compare and contrast:

- Element, atom, molecule and compound
- Electron shell and valence shell
- Inert and reactive elements
- Stable and radioactive isotopes
- Neutral atoms and ions
- Covalent and ionic bonds
- Polar and nonpolar covalent bonds
- Form and function of biological structures

What is the ‘Valence Shell’? What is the ‘Rule of the Octet’?
Describe how these concepts can explain patterns of covalent bonds and provide examples. In what way does it explain the reactivity of Hydrogen?

Be able to identify by name and chemical symbol these six important elements of living things.

- H – Hydrogen
- O – Oxygen
- C – Carbon
- N – Nitrogen
- P – Phosphorus
- S – Sulfur

What are hydrogen bonds? What type of compounds make hydrogen bonds?


Be able to explain five ways in which the polar nature of water molecules creates an environment suitable for life. Included in your explanation be sure to refer to:

- cohesion & adhesion
- high Specific Heat
- high Heat of Vaporization
- high Heat of Melting
ice as a protective blanket
water as the solvent of life

Be able to define: solution, solvent and solute.

Describe how salts are dissolved in water.

What is evaporative cooling? How does it moderate global temperature? Your temperature?

Be able to define and use:
- pH
- acid
- base
- buffer
- hydrophilic
- hydrophobic
- surface tension
- mole / molar solution

**Chapters 4 & 5. Organic Chemistry.**

What is ‘tetravalence’? What role does Carbon’s tetravalence have in this element’s importance to biochemistry?

Compare and contrast inorganic and organic chemistry.

Be able to describe the four ways in which organic molecules vary, and provide illustrations of each:

- length of carbon chain
- arrangement of double bonds between carbons
- variation in side chains (branching pattern)
- ring structures

What is a hydrolytic reaction? What is a condensation (dehydration) reaction? Be able to write chemical equations for both types of reactions.

Define: monomer, dimer, oligomer and polymer.

Be able to describe the three classes of macromolecules that consist of polymers, each type of monomer, the bonds between monomers, and provide examples of each type of macromolecule that illustrate the link between form and function.

Describe the difference between alpha and beta glycosidic linkages and their biological significance. For example: What is the relationship between amylose and amylase? How effective is amylase at hydrolyzing cellulose? Why?

What characteristic defines the lipids? Name 3 types of lipids, their structures & functions.

Know the following functional groups, where they are found and how they function:
Be able to refer to the above groups as amino acid R-groups and their possible affects on tertiary structure.

Describe the four levels of structure found in proteins, which types of proteins are associated with these levels, and explain the critical importance of the primary structure.

What happens when proteins are heated? or placed in acid? How does this affect the function of these proteins?

What happens to carbohydrates, lipids and proteins when placed in water? Why?

Be able to define and use the following terms:

- isomer
- structural formula
- molecular formula
- enantiomer
- organic
- monosaccharide
- disaccharide
- polysaccharide
- triglyceride
- amino acid
- dipeptide
- glycerol
- fatty acid
- nucleic acid
- phospholipid bilayer

What are the functions of the nucleic acids?

Be able to write out the words for DNA and RNA.

Describe the monomers of the nucleic acids and how they are arranged as a polymer.

What is the ‘Central Dogma’ of biology? Why is this term not favored by current scientists?

DNA is the heritable material passed from one generation to the next. How do scientists use this information to determine relationships between close relatives? Between large groups of living organisms?

Note: several pages in handout not included here, periodic table and diagrams of molecules.

**PART II. CELLS & MEMBRANES**

Computer Self Tests for this section: **Cell Structure**

**Chapter 6. A Tour of the Cell**

This chapter focuses on the Eukaryotic cell: its parts and functions. Much of this material must simply be memorized. You should be able to identify each organelle, its major components (structure) and their function.
Golgi Apparatus   Lysosome   (rough & smooth)
Vesicle   Vacuole   Tonoplast
Peroxisome   Mitochondrion   Chloroplast

Define:

Prokaryote   Eukaryote   Plasma membrane
Cytoplasm   Cytosol   Organelle   Cytoskeleton

Be able to list the three parts to the ‘Cell Theory’ of biology.

1. All living things are made of cells.
2. Cells come from other cells and give rise to new cells.
3. Metabolism (living processes) occurs inside cells.

How are viruses the exception to this theory? How do they support this theory?

Cells live in an ‘open system’ that tends to entropy (disorganization). What role does the plasma membrane play to protect the cell? (i.e. fence and gate). How does the interaction between membrane surface area and cell volume limit the size of cells?

Be able to describe how a bit of membrane may be constructed in the Endoplasmic Reticulum, sent off as a vesicle to the Golgi Apparatus, and end up in the Plasma Membrane. What other cell products might accompany the membrane on its journey?

Most of the DNA of Eukaryotic cells rests in the nucleus. What other two organelles contain their own DNA?

Describe the three parts of the Cytoskeleton. What are these parts made of? Where are they found? What type of movements originate with these structures?

Compare and contrast the Cell Wall of plants to the Extracellular Matrix of animal cells. Given these protective coverings, how can neighboring cells of an organism communicate?

What is a motor molecule? Where are they found in relation to the cytoskeleton?

Compare and contrast cilia and flagella. Which has the ‘9+2’ arrangement? Give an example of each.

On the next page is a study sheet that may aid in your organisation of material related to organelles. A second page is included for you to copy and use.

**PART II. CELLS & MEMBRANES**

**Chapter 7. Membrane Structure and Function**
Describe the changing scientific view of the cell membrane over the last century, and the evidence for each model. What is the current model? (name and concept)

In the **Fluid Mosaic** model which part is ‘fluid’ and which ‘mosaic’? How can variations in these parts affect the membrane? What third type of molecule is in the membrane?

Be able to define and use the following terms:

- diffusion
- osmosis
- concentration gradient
- hypotonic
- isotonic
- hypertonic
- plasmolysis
- osmoregulation
- selective permeability
- transport protein
- facilitated diffusion
- active transport
- membrane potential
- proton pump
- sodium-potassium pump
- exocytosis
- endocytosis
- electrochemical gradient
- phagocytosis
- pinocytosis
- receptor-mediated endocytosis

Explain the movement of different molecules across the plasma membrane. Through what part of the membrane does each type of molecule pass?

- small, neutral molecules (e.g. O2, CO2, H2O)
- small ions (e.g. H+, Cl-)
- disaccharides (sucrose)

What is the function of membrane sugars? How do they affect human blood groups?

List six functions of membrane associated proteins.

Compare and contrast: facilitated diffusion, active transport, co-transport

How does a cell wall help plant cells deal with hypotonic and hypertonic environments?

How can protists respond to hypotonic solutions?

Describe the movement of a peripheral protein from its origin on the endoplasmic reticulum to its placement on the plasma membrane. Would it be carried on the inside or outside of a transport vesicle? What organelles might be visited en route? What modifications might take place?
STUDY SHEET FOR ORGANELLES

Organelle:

Purpose/Function:

Parts/Structure:

Where is this organelle formed?

Where does it exist in the cell?

What are its specific functions?

Any special cells associated with this organelle?
PART III. Metabolism, Respiration & Photosynthesis

Chapters: 8 - 10

Self-Tests:

Energy & Enzymes, Aerobic Respiration, Photosynthesis

Chapter 8. An Introduction to Metabolism

A review of topics:

1. The chemistry of life is organized into metabolic pathways
2. Organisms transform energy
3. Energy transformations of life are subject to the Laws of Thermodynamics
4. Organisms live at the expense of free energy
5. ATP powers cellular work: it couples exergonic to endergonic reactions
6. Enzymes are protein catalysts: they speed up metabolic processes
   a. lower energy barriers
   b. substrate specific
   c. active site
7. The chemical and physical environment affect enzyme activity
   a. temperature and ph
   b. cofactors
   c. inhibitors
   d. allosteric regulation
   e. cooperativity
8. Metabolic order emerges from the cell’s regulatory systems and structural organization
9. Emergent properties

What is energy? Be able to define ‘energy’ and discuss the ways in which energy can be transferred or transformed, and what happens to energy in each of these transformations.

Why are there no perpetual motion machines?

Be able to define / describe and use the following terms:

<table>
<thead>
<tr>
<th>First Law of Thermodynamics</th>
<th>Second Law of Thermodynamics</th>
</tr>
</thead>
<tbody>
<tr>
<td>free energy</td>
<td>entropy</td>
</tr>
<tr>
<td>exergonic</td>
<td>catalyst</td>
</tr>
<tr>
<td>potential energy</td>
<td>enzyme</td>
</tr>
<tr>
<td>catalytic</td>
<td>inhibitor</td>
</tr>
<tr>
<td>kinetic energy</td>
<td>inactivation</td>
</tr>
<tr>
<td>chemical</td>
<td>active site</td>
</tr>
<tr>
<td>potential energy</td>
<td>allosteric site</td>
</tr>
<tr>
<td>allosteric inhibition</td>
<td>feedback</td>
</tr>
<tr>
<td>allosteric inhibitor</td>
<td>allosteric site</td>
</tr>
<tr>
<td>induced fit</td>
<td>anabolism</td>
</tr>
<tr>
<td>allosteric inhibitor</td>
<td>catalabolism</td>
</tr>
</tbody>
</table>

Explain the first two laws of thermodynamics and how they affect living things.
Where does most energy used by living things originate? What form of energy is it transformed into by plants? What form do animals use? If animals keep degrading their energy (increasing entropy) how can they survive?

Be able to provide other examples of energy, energy transformations, and examples of entropy.

What is an open system?

Be able to identify the reactants and products of a chemical reaction, the activation energy for a normal exergonic reaction, and the relative activation energy of the same reaction catalyzed by an enzyme.

Describe the structure and function of enzymes: normal reactions (discuss induced fit and microhabitat effects), two types of inhibitors (competitive and noncompetitive), environmental effects (temperature and pH), allosteric regulation and feedback.

What are anabolic pathways? catabolic pathways? Which of these is endergonic? which is exergonic?

What environmental changes affect enzyme activity? How are enzymes affected?
Be able to explain in terms of the different structures of proteins and the bonds involved at these different levels.

Describe three generalized forms of work done by a cell. What is the source of energy for these reactions? Be able to describe ATP and the energy contained in its bonds.
Chapter 9 Cellular Respiration: Harvesting Chemical Energy

This chapter draws on earlier topics of chemistry, the terms and concepts of metabolism, and two molecules: glucose and ATP. Cellular respiration is the aerobic oxidation of glucose to water and carbon dioxide, with the transfer of free energy to ATP. You should be able to describe and relate the terms given for metabolism (chapter 6) to the process of respiration. In addition, be able to define and discuss:

- reduction and oxidation
- substrate-level phosphorylation
- glycolysis
- Electron Transport Chain
- NAD+
- chemiosmosis
- cytochromes

- phosphorylated intermediate
- oxidative phosphorylation
- Krebs Cycle
- anaerobic respiration
- alcohol & lactic acid fermentation
- proton motive force

Most important for this section is to be able to:

1) describe the overall process of aerobic respiration, the major steps and where they occur
2) for each step track the organic molecules and energy carriers (reactants and products)
3) compare the efficiency of aerobic respiration to anaerobic fermentation (in terms of ΔG)
4) write out the equations for the catabolism of glucose, ATP & NADH (include ΔG)

Other questions you should be able to answer:

Why do cells constantly recycle ATP instead of storing enough for a day’s needs?

How does energy released from the catabolism of ATP become coupled to cellular work?

If glucose provides the ultimate source of energy for cells, why do they transfer that energy to other molecules like ADP -> ATP? or NAD+ -> NADH?

Compare substrate-level phosphorylation to oxidative phosphorylation. Which require enzymes? what are the oxidizing agents? where do these processes occur?

What is meant by the phrase:

In respiration, electrons fall ‘downhill’ from organic molecules to oxygen.

What is chemiosmosis? How does it relate to osmosis? What diffuses? Where? How is chemiosmosis related to the Proton-motive force?

What other macromolecules can be catabolized as energy sources? How do they compare to glucose in terms of ATP produced and waste products? Where does this catabolism occur?
Describe how ATP and ADP act as allosteric regulators of respiration.

Which process is older, fermentation or respiration? What is the evidence?

BE SURE YOU CAN ANSWER QUESTIONS FROM YOUR TEXT BOOK.

What is the Pasteur affect? Explain.
Cellular Respiration: Worksheet

For each step below: 1. fill in the number of steps and enzymes; 2. identify the number of organic molecules, ATP, NADH and FADH2 that enter and exit each step (use one glucose as a reference), and 3) state where these processes occur.

Overview:

\[
\text{enzymes} \\
\text{Glucose + oxygen} \rightarrow \text{carbon dioxide + water + Energy} \\
(\Delta G = -686 \text{ kcal / mol})
\]

Glycolysis:

Splits Glucose --------> 2 Pyruvate

Occurs in cytosol

Performed by all cells

Does not require oxygen

Transition (Bridge) reaction:

Pyruvate crosses into Mitochondrion, rearranges & binds to CoA

Krebs Cycle:

Finishes the oxidation of carbon compounds from glucose

Occurs in Mitochondrial matrix

Eukaryotes (similar process in Prokaryotes)

Requires oxygen

Electron Transport Chain:

Reduction - oxidation reactions pass electrons to oxygen
Occurs on Mitochondrial inner membrane

Eukaryotes (similar process in Prokaryotes)

Requires oxygen
Glycolysis: Overview

Energy score: ATP  NADH  FADH2

Organic Input:
Organic Output:
Number of steps and enzymes:
Where?

Energy-Investment Phase

Organic Input:
Organic Output:
Number of steps and enzymes:
Where?

Energy-Yielding Phase of Glycolysis

Organic Input:
Organic Output:
Number of steps and enzymes:
Where?

Total: Glycolysis

Glucose ----> 2 Pyruvate

Energy Summary:

Transport of NADH from cytosol:

Transition (Bridge) reaction:

Organic Input:
Organic Output:
Number of steps and enzymes:

Where?

Energy Summary:
Krebs Cycle: Energy score: ATP NADH FADH2

Organic Input:

Organic Output:

Number of steps and enzymes:

Where?

Energy Summary:

Electron Transport Chain:

Input:

Output:

Number of steps and enzymes:

Where?

Energy Summary: ATP NADH FADH2

Glycolysis

Transport of NADH from cytosol:

Transition (Bridge) reaction:

Krebs Cycle:

Electron Transport Chain:

Total:

Review Free Energy & Efficiency of Energy Transfer:

What percent of the energy from glucose catabolism is trapped in ATP?
PART III. Metabolism, Respiration & Photosynthesis (continued)

Chapter 10. Photosynthesis

Photosynthesis traps solar energy (PHOTO -) and uses that energy in the synthesis of sugar (SYNTHESES). In Eukaryotic plants, this two-step process occurs in the chloroplast. The first step, known as the **Light Reactions**, occurs on Thylakoid membranes within the chloroplast. Here, chlorophyll a and accessory pigments absorb photons of light which ‘excite’ an electron into a higher energy orbital. This initial capture of light energy fuels the synthesis of ATP (through chemiosmosis) and powers the reduction of NADP+ --> NADPH. ATP and NADPH power the synthesis of sugar in the Stroma of the chloroplast. This process, the **Calvin Cycle**, occurs in three main steps:

1. The Fixation of Carbon (from CO2, powered by ATP); 2. Reduction of the 3-carbon intermediate into a 3-carbon sugar (powered by NADPH), and 3. Regeneration (powered by ATP).

Solar energy trapped by photosynthesis is the primary source of Free Energy for life on Earth. The sugars produced fuel Respiration. In many ways, Photosynthesis echoes the process of respiration, but in reverse.

**PHOTOSYNTHESIS:** Solar Energy (light) + 6 CO2 + 6 H2O --> C6H12O6 + 6 O2

**RESPIRATION:** C6H12O6 + 6 O2 --> 6 CO2 + 6 H2O + Chemical Energy (ATP)

Be able to define, use, or describe the list of terms below:

- autotroph
- heterotroph
- chlorophyll
- Light Reactions
- Calvin Cycle
- photosystem
- accessory pigments
- reaction center
- absorbance spectrum
- action spectrum
- visible light
- photons
- Rubisco
- NADPH
- C4 plants

Be able to summarize the main steps of photosynthesis, the reactants and products, movement of electrons, and where these steps occur.

**What is the difference between Photosystem I and II?**

**How do they work together in Noncyclic Photophosphorylation?**

**How is this different from Cyclic Photophosphorylation?**

**Which of these splits water? What is the final electron acceptor in each process?**

**What do they produce?**
Which products from the Light Reactions are used in the Calvin Cycle? Why is the Calvin Cycle also referred to as the Dark Reaction? How many ‘cycles’ are needed to make a 3-carbon sugar (how much ATP & NADPH)?

Review all study questions from your text.

**Study Guide. Part IV.**

**Molecular Basis of Inheritance, Mitosis, Meiosis, Mendel & Genes**

**Chapters: 16(a), 12, 13 & 14.** Answer all questions at the end of each chapter.

**Self-Tests:**  **Cell Division**  **Genetics** (partial, available for credit in next section)

**Chapter 16. The Molecular Basis of Inheritance**

This chapter focuses on two related topics:

1) The research that led to the discovery of DNA as the heritable material.

2) Our current understanding of DNA replication. [We will save the details of DNA replication for the last section of the course]

You should be able to describe the basic experiments, results and conclusions of the early research (a & b) and other information that suggested DNA was the hereditary material.

a) The transformation experiments of Griffith and subsequent work of Avery

b) Hershey and Chase’s work with virus replication

c) Replication of DNA prior to mitosis and segregation of DNA during mitosis (and similar evidence from meiosis)

d) Chargaff’s work that found similarities in the proportions of bases among members of the same species, but differences between species.

You should be able to describe the basic methods used by Watson and Crick to determine the double-helix model of DNA (e.g. the x-ray crystallography of R. Franklin, use of models). In particular, how did they determine the base-pairing rule? How did this compare to Chargaff’s rule?

What is the Semiconservative model of DNA replication? How does this model differ from the Conservative and Dispersive models? What evidence led to the acceptance of the semi-conservative model?

What are the rules of complementary base pairing?
Be able to define and discuss:

- transformation
- bacteriophage (phage)
- E. coli
- Chargaff’s rule
- pyrimidine
- purine

Chapter 12. The Reproduction of Cells

A review of topics:

1. Cell division functions in Growth, Replacement & Repair, and Asexual Reproduction

2. Prokaryotes divide by Binary Fission

3. The Genome of Eukaryotes is organized into multiple Chromosomes

4. The Cell Cycle: Mitosis alternates with Interphase

5. The Mitotic Spindle distributes chromosomes to daughter cells

6. Cytokinesis divides the Cytoplasm

7. Mitosis (eukaryotes) may have evolved from binary fission (prokaryotes)

8. A molecular control system drives the cell cycle

9. External and Internal cues help regulate cell division

10. Cancer cells ‘escape’ controls on cell division

Be able to define / describe and use the following terms:

- genome
- binary fission
- somatic cell
- gamete
- chromatin
- sister chromatid
- autosome
- sex chromosome
- centromere
- mitosis
- karyokinesis
- cytokinesis
- kinetochore
- spindle
- aster
- cleavage furrow
- cell plate
- restriction point
- protein kinase
- density-dependent inhibition

The main focus of this section is to understand the five stages of Mitosis (karyokinesis) and the associated cytokinesis. Be able to describe each phase of mitosis, and the other phases of the cell cycle. In particular, be able to describe at each stage: 1) the state of the DNA (condensed or diffuse? replicated?), 2) centrioles, 3) spindle, and 4) nuclear envelope.
Know the functions of cell division. Be able to list differences in the mechanics of mitosis between plants and animals, and where mitosis occurs.

Does mitosis produce identical daughter cells? how many? identical to the mother cell?

What is the $G_0$ phase? From what phase in the cell cycle would a cell enter $G_0$? How does this relate to the Restriction point and factors that regulate cell division?

Be able to describe cancer cells in relation to the cell cycle.

What is tamoxifen? How is it used in cancer treatment?
Note: the effect of tamoxifen is another example of structure and function.

**Chapter 13. Meiosis and Sexual Life Cycles**

A review of topics:

1. Offspring acquire genes from parents by inheriting chromosomes
2. Like begets like, more or less: Sexual vs. Asexual Reproduction
3. Fertilization and Meiosis alternate in Sexual Life Cycles
4. Meiosis reduces chromosome number from Diploid to Haploid
5. Sexual Reproduction produces Genetic Variation among offspring
6. Evolutionary Adaptation depends on a Populations Genetic Variation

This chapter focuses on three aspects of meiosis:

1) the important role of meiosis in sexual life cycles
2) the mechanics of meiosis, particularly in comparison to mitosis
3) how meiosis generates genetic variability, and the consequences

In addition, this chapter introduces many important terms and concepts critical to any discussion of inheritance.

Be able to define / describe and use the following terms:

<table>
<thead>
<tr>
<th>gene</th>
<th>locus</th>
<th>sexual reproduction</th>
<th>somatic cell</th>
</tr>
</thead>
<tbody>
<tr>
<td>karyotype</td>
<td>autosome</td>
<td>sex chromosome</td>
<td>homologous chromosome</td>
</tr>
<tr>
<td>diploid</td>
<td>haploid</td>
<td>gamete</td>
<td>fertilization</td>
</tr>
</tbody>
</table>
Be able to describe all phases of meiosis. In particular, know when homologous chromosomes pair and divide, and when the sister chromatids divide. How does each stage of meiosis compare to the stages of mitosis?

Describe three ways in which the sexual life cycle generates genetic variability.

Be able to identify three possible sexual life cycles relative to the acts of meiosis, mitosis and syngamy, e.g. how are multicellular fungi haploid, and multicellular animals diploid? How do plants compare?

How can one ‘inherit’ their parents ‘eyes’, yet their parents still have their own eyes?

Why is genetic variability necessary for evolution?

Chapters: 14. Mendel & the Gene Idea

A review of topics:

1. Mendel used an Experimental and Quantitative Approach to Genetics

2. The Law of Segregation: Two alleles for a character are packaged into separate gametes

3. The Law of Independent Assortment: Each pair of alleles assort independently


5. Recap: Mendel discovered Particulate nature of Genes

6. Relationship between Genotype and Phenotype rarely simple as Mendel’s examples

7. Pedigree analysis: Mendelian patterns in human inheritance

8. Human disorders and Mendelian patterns of human inheritance

9. Technology for Genetic Testing

This chapter describes genes and inheritance, primarily at the organismal level. It begins with a full description of classical Mendelian genetics. Although modern scientists know many exceptions and many more molecular details, the basic laws of Mendel accurately describe the fundamentals of Segregation and Independent Assortment of alleles. The rest of the chapter
describes the exceptions, begins to explain the underlying molecular basis of inherited traits, and provides many examples of human inheritance.

Be able to define / describe and use the following terms:

- character
- trait
- true-breeding
- hybridization
- allele
- P, F1, F2
- monohybrid cross
- dihybrid cross
- dominant allele
- recessive allele
- law of segregation
- heterozygous
- homozygous
- genotype
- phenotype
- test cross
- probability
- punnett square
- law of independent assortment
- dominance
- complete dominance
- incomplete dominance
- pleiotropy
- norm of reaction
- polygenic inheritance
- quantitative characters
- epistasis
- pedigree
- sickle-cell anemia
- Tay-Sachs disease
- amniocentesis

Be able to define and use all terms from Mendelian genetics, and work problems using both a Punnett square and probabilities.

One of the best study aids for this section is to simply write out Punnett squares for all the crosses conducted by Mendel (Table 3.1 pg. 241). Begin with monohybrid crosses (e.g. Purple flower x White flower), and move up to dihybrid and even trihybrid crosses. If you can work through a trihybrid cross, you should do well on this section. How about working out the expected offspring using probability?

Be able to describe the findings and conclusions of Mendel (e.g. the Laws that describe the particulate nature of genes).

Be able to translate Mendel’s terminology into modern equivalents (e.g. trait vs. allele).

Know the rules of probability (multiplication and addition) and be able to apply them.

Be able to describe and EXPLAIN aspects of inheritance that do not fit Mendel’s examples: Incomplete dominance, pleiotropy, dominance at the organismal vs. biochemical level, epistasis, multiple alleles, and polygenic inheritance.


Be familiar with the human pedigrees and hereditary diseases (e.g. sickle-cell anemia and Tay-Sachs disease) presented in class.

Be able to describe tests for human hereditary diseases. How can these tests be used to counsel parents?
PART V. Chapters (14), 15, 16(b) & 17.

Self-Tests: Genetics (also used in last section), DNA/Protein Synthesis

Chapters: 14. Mendel & the Gene Idea (Review)

You will need to be able to perform monohybrid and dihybrid (Mendelian) crosses for part 5 as well as part 4 of this course. In addition, read over the following sections in your text:

- Human disorders and Mendelian patterns of human inheritance
- Technology for Genetic Testing

Chapter 15. The Chromosomal Basis of Inheritance

This chapter begins with a review of Mendel’s work from the perspective of chromosomes as the carriers of genes. Much of the chapter focuses on the work of Morgan and his students, with examples of sex-linked genes, linked genes, and linkage maps of chromosomes. Modern examples introduce the following topics: the chromosomal basis of sex determination and sex-linked disorders in humans, X-inactivation in females, and human disorders that result from alterations in chromosome structure and number. Finally, a variety of non-mendelian forms of inheritance are discussed: genomic imprinting, fragile X and triplet repeats, and maternal inheritance (e.g. mitochondria).

You should be able to identify and diagram Mendelian crosses in terms of the chromosomes that carry the genes of interest (as covered in your text, lecture and lab).

Be able to identify patterns of inheritance that are sex-linked vs. linked genes on autosomes.

Be able to construct a linkage map based on patterns of inheritance (i.e. crossing over). How does this map compare to a cytological map?

Be able to trace probabilities of inheritance of the human sex-linked disorder hemophilia.

Be able to define and identify types of chromosomal alterations:

- nondisjunction
- aneuploidy
- trisomic
- monosomic
- deletion
- duplication
- inversion
- reciprocal translocation

Other terms to know. Be able to define and use these terms:

- mutant phenotype
- sex-linked genes
- centimorgan
- Barr body
- triplet repeats
- wild type
- linked genes
- linkage map
- Down syndrome
- extranuclear inheritance
- Drosophila melanogaster
- parental types
- cytological map
- genomic imprinting
- fragile X syndrome
- hemizygous
- recombinants
- cytological map
- hemizygous
- fragile X syndrome

Bio181 Study Guide 24
Review the questions at the end of the chapter.

**Chapter 16**

We previously learned about the studies that led to the discovery that DNA carries the heritable material. This section focuses on the latter parts of chapter 16 (pages 292-302) beginning with the semi-conservative model of DNA replication. Be able to describe the basic steps of DNA replication and the associated enzymes presented in class and the text.

What are the 5’ and 3’ ends of DNA? Be able to relate this to the anti-parallel arrangement of the double helix.

How are errors in DNA replication prevented? How are they corrected? What other types of DNA repair occur in cells?

Be able to define and discuss:

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chargaff’s rule</td>
<td>Description of Chargaff’s rule.</td>
</tr>
<tr>
<td>replication fork</td>
<td>Description of replication fork.</td>
</tr>
<tr>
<td>DNA ligase</td>
<td>Description of DNA ligase.</td>
</tr>
<tr>
<td>excision repair</td>
<td>Description of excision repair.</td>
</tr>
<tr>
<td>pyrimidine</td>
<td>Description of pyrimidine.</td>
</tr>
<tr>
<td>purine</td>
<td>Description of purine.</td>
</tr>
<tr>
<td>origins of replication</td>
<td>Description of origins of replication.</td>
</tr>
<tr>
<td>DNA polymerase</td>
<td>Description of DNA polymerase.</td>
</tr>
<tr>
<td>leading strand</td>
<td>Description of leading strand.</td>
</tr>
<tr>
<td>lagging strand</td>
<td>Description of lagging strand.</td>
</tr>
<tr>
<td>Okazaki fragment</td>
<td>Description of Okazaki fragment.</td>
</tr>
<tr>
<td>helicase</td>
<td>Description of helicase.</td>
</tr>
<tr>
<td>mismatch repair</td>
<td>Description of mismatch repair.</td>
</tr>
<tr>
<td>single-strand binding proteins</td>
<td>Description of single-strand binding proteins</td>
</tr>
</tbody>
</table>

**Chapter 17. From Gene to Protein**

This chapter describes how the hereditary material (DNA) ‘blueprint’ becomes transcribed and translated into proteins that run the metabolism of the cell (and other functions, review chapter 5 on proteins). This process occurs in two main steps:

1. **Transcription**: messenger RNA (mRNA) is ‘transcribed’ by complementary base pairing with a strand of DNA (the template). The term ‘transcription’ refers to the similarity of the nucleotides that make up RNA and DNA; they code information in the same ‘language’.

2. **Translation**: information carried on mRNA (the specific sequence of nucleotides) becomes translated into a polypeptide chain (the specific sequence of amino acids). The term ‘translation’ refers to this change in ‘language’.

This sequence: DNA -> RNA -> Proteins, gave rise to the term **Central Dogma**, because it describes the flow of genetic information (in the form of DNA) to the form of its functional units (proteins). A related concept is the **one gene-one polypeptide hypothesis**, which posits that a 'gene' is a sequence of DNA nucleotides, each of which codes for a single strand of amino acids (polypeptide). These ideas are generally accurate and useful in your understanding, although your book notes several exceptions to both.
Your primary goal for this chapter is to be able to describe the one gene-one polypeptide hypothesis, the basic steps of transcription and translation, and some of the molecules involved in these processes.

Be able to define and use the following terms:

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>triplet code</td>
<td>codon</td>
</tr>
<tr>
<td>stop codon</td>
<td>promoters</td>
</tr>
<tr>
<td>mRNA</td>
<td>tRNA</td>
</tr>
<tr>
<td>polyribosomes</td>
<td>introns</td>
</tr>
<tr>
<td>poly A tail</td>
<td>hnRNA</td>
</tr>
<tr>
<td>ribozyme</td>
<td>mutagen</td>
</tr>
<tr>
<td>reading frame</td>
<td>transcription factors</td>
</tr>
<tr>
<td>transcription unit</td>
<td>RNA polymerase</td>
</tr>
<tr>
<td>transcription factors</td>
<td>rRNA</td>
</tr>
<tr>
<td>RNA polymerase</td>
<td>signal sequence</td>
</tr>
<tr>
<td>anticodon</td>
<td>exons</td>
</tr>
<tr>
<td>hnRNA</td>
<td>snRNA</td>
</tr>
<tr>
<td>spliceosome</td>
<td>signal sequence</td>
</tr>
</tbody>
</table>

Why is the DNA code considered redundant but not ambiguous?

How universal is the genetic code? What practical and theoretical uses are made from these similarities?

What are three differences between DNA and RNA?

Be able to describe the three steps of protein synthesis: initiation, elongation, termination.

How does protein synthesis differ between prokaryotes and eukaryotes?

In what ways do eukaryotes modify and process their mRNA? their proteins?

Be able to describe these types of mutations and their potential effects:

- base-pair substitution (missense and nonsense mutations)
- insertions and deletions (frameshift mutations).

Review the questions at the end of the chapter.