Format:

Section I   21 multiple choice questions
Section II   1 essay question and 3 short free response questions

Reading: Hillis chapters 9, 10, and 11

Concepts to Review:

- DNA and Replication
  - Be able to describe the structure of DNA.
  - Know the DNA base pair rules.
  - Be able to describe the process of DNA *replication* and the roles of the enzymes *primase*, *DNA polymerase*, *DNA ligase*, and *telomerase*.
  - Be able to explain why the leading strand and lagging strand must be synthesized in different ways.
  - Be able to explain how the *Polymerase Chain Reaction* (*PCR*) method is used to copy DNA in a lab.
  - Be able to describe the following types of mutations: *chromosomal*, *substitution* (*point*), *insertion* (*addition*), *deletion*, *inversion*, and know what a *frame-shift mutation* is.
  - Be able to explain the differences between *silent*, *loss-of-function*, *gain-of-function*, and *conditional* mutations.
  - Be able to explain how DNA can be transferred from one bacterium to another by *transformation*, *transduction*, and *conjugation*.
  - Be able to describe how DNA is organized into chromosomes/chromatin in eukaryotes.
  - Be able to explain why organisms that are very different can have such similar DNA (e.g., humans and bananas sharing approximately half their DNA).
  - Be able to describe the experimental evidence showing: DNA as the genetic material, DNA as a helix, DNA as double-stranded, base pair rules, and semiconservative replication.

- Protein Synthesis
  - Understand how DNA controls all cell activities, as well as an organism's characteristics.
  - Know the RNA base pair rules.
  - Be able to explain the processes of *transcription* and *translation*, including the roles of the enzymes *RNA polymerase* and *tRNA synthetase*.
  - Be able to describe how mRNA is processed after transcription, including the roles of *introns*, *exons*, *spliceosomes* (*snRNPs*), *GTP caps*, and *poly-A tails*.
  - Be able to use the *genetic code table* to translate a string of mRNA codons into a sequence of amino acids.
  - Be able to explain what a *virus* is and how it reproduces.
  - Be able to explain what a *retrovirus* is, how it takes over a cell, and the role of *reverse transcriptase*.
  - Be able to explain how changes in DNA affect the resulting protein.
  - Be able to describe the experimental evidence showing that mRNA is read in triplet codons.
  - Be able to describe how and why polypeptides may be processed after being synthesized.

- Gene Regulation
  - Be able to compare how prokaryotes and eukaryotes regulate gene expression.
  - Understand the differences between *inducible* vs. *repressible genes*, *positive* vs. *negative regulation*, and genes that are *constitutively* expressed.
  - Be able to describe the structure of a prokaryotic gene and the structure of a eukaryotic gene, including the *promoter*, *operator*, *enhancer*, *repressor*, *TATA box*, *coding region*, and *noncoding region*.
  - Understand how an *operon* works (specifically, the *lac* operon and the *trp* operon).
  - Understand how *transcription factors* work.
  - Understand the term *epigenetics*, and be able to explain the roles of *methylation* and *acetylation* (*histone modification*) in gene expression.
  - Be able to explain how *alternative splicing* regulates gene expression after transcription.
  - Be able to explain how *ubiquitin* regulates gene expression after translation.

Suggestion: Answer all of these questions in writing, then compare answers with a classmate. I promise that taking the time to do so will be well worth it and much more useful then memorizing facts and definitions.

1. What is the difference between a nucleotide, a codon, an allele, a gene, a chromosome, and a genome? What does a gene code for? What does a codon code for?
2. How do conjugation, transformation, and transduction contribute to variation in prokaryotes?
3. Why must DNA be replicated before cell division?
4. How do continuous replication on the leading strand and Okazaki fragments on the lagging strand address the directional (5′ to 3′) nature of DNA polymerase?
5. Why do chromosomes get shorter when telomerase is not present?
6. Why do loss-of-function mutations tend to be recessive alleles and gain-of-function alleles tend to be dominant alleles?
7. What is the relationship between nucleotides and polypeptides? What does a gene code for? What does a codon code for?
8. What does it mean for a gene to be expressed? What steps are necessary for gene expression to occur? How can gene expression be prevented at each of these steps?
9. How are the steps required for a gene to be expressed different in prokaryotes and eukaryotes? How is the regulation of those steps different in prokaryotes and eukaryotes?
10. What does a gene look like? That is, what are the parts of a gene? How is coding DNA different from noncoding DNA? Why is noncoding DNA so important if it is not expressed?
11. How do mechanisms for regulating the expression of a gene provide organisms with an evolutionary advantage?
12. How does the splicing of introns provide eukaryotes with an evolutionary advantage?
13. Why is it that bacteria can synthesize human insulin when transformed with DNA that contains human insulin genes even though bacteria and humans are so different? How is it that all humans share over 99 percent of our DNA even though we are all so different?

Calculator Policy:

A four-function calculator (with square root) is required for all remaining exams in this course. No other types of calculators, including scientific or graphing calculators, are permitted on exams.

Four-function calculators have a one-line display and a simple layout of numeric keys (e.g, 0–9), arithmetic operation keys (e.g., +, −, ×, and ÷), and a limited number of special-use keys (e.g., %, +/–, C, and AC). Simple memory buttons like MC, M+, M–, and MR may also be included on a four-function calculator. In contrast to scientific calculators, four-function calculators do NOT include trigonometric and logarithmic functions (e.g., SIN, COS, TAN, TRIG, LOG, or LN), statistical capabilities, or graphing capabilities.

Practice Exam Questions:

Visit the course website and click on the "Multiple Choice Practice" link. Complete all practice questions for the relevant chapters and check your work against the answer key. Note: these items are password protected.

A Note About Molecular Genetics:

The ability to comprehend any concept in modern genetics requires a deep understanding of how proteins are synthesized. Be sure that you can describe step-by-step how the information coded in DNA is used to synthesize proteins.