Study Guide - Make sure to have a solid understanding of the concepts outlined below. Also, review the homework, lecture slides, your notes from lecture, and the pdf Ch. readings.

* You can reference a single 3x5 note card with notes on the front and back of the card.
* Bring a scantron for multiple-choice questions.
* Scientific method –
* Ch.10 DNA to RNA to Proteins
  1. DNA basics
     + Molecular biology?
       1. The study of heredity at the molecular level…
     + What is the most deadly virus in human history?
     + DNA is the molecule of heredity, not Protein (see Hershey-Chase Experiment in the PowerPoint
     + Nucleic acids are either DNA or RNA
     + What are nucleic acids (polynucleotides) made of?
       1. Nucleotide monomers
     + Components of a nucleotide - phosphate, sugar, base
     + Deoxyribonucleic acid -
     + Bases give the nucleotide its identity as – A, T, C, G
     + What are the differences between DNA and RNA?
     + What kind of bond holds nucleotides together?
       1. Covalent
     + What kind of bond holds the base pairs of strands together?
       1. Hydrogen
     + Base pairing rules – A to T, C to G, A to U in RNA
     + What did Watson, Crick and Franklin figure out about DNA?
       1. A double helix (spiral)
       2. with a uniform diameter
       3. made up of two polynucleotide strands.
       4. They used the X-ray image of DNA produced by Rosalind Franklin.
       5. The structure they proposed ‘immediately suggests a possible copying mechanism’
       6. DNA is like a twisted rope ladder
  2. DNA Replication
     + Produces a new double helix that has one old strand and one new strand
     + model of DNA suggests that each DNA strand serves as a mold, or template, to guide reproduction of the other strand.
     + What enzyme copies DNA?
       1. DNA polymerase
       2. fewer than one in a billion bases incorrectly paired bases
       3. human cell has 6 billion nucleotides
     + Where in the cell does DNA replication happen?
       1. Nucleus
     + Key Point – DNA replication ensures that the cells in a multicellular organism carry the same genetic information
  3. Relationship between genes, alleles, genotype and phenotype
     + Central Dogma of Molecular Biology - DNA dictates the production of a protein (DNA 🡪 RNA 🡪 protein)
     + *Genotype* - genetic makeup, the heritable information contained in the sequence of nucleotide bases
     + *phenotype*, the organism’s physical traits, arises from the actions of a wide variety of proteins.
     + When a segment of DNA is transcribed, the result is an RNA molecule. The process is called transcription because the nucleic acid language of DNA has simply been rewritten (**transcribed**) as a sequence of bases of RNA
     + **Translation** is the conversion of the nucleic acid language to the polypeptide language
     + Genetic Code – converts the language of nucleic acids (DNA/RNA) into polypeptides (then protein).
     + A polypeptide is a chain of amino acids
     + Three nucleotides code for a single amino acid (codon)
     + Example - An RNA molecule contains the nucleotide sequence CCAUUUACG. Using Figure 10.10 in the text, translate this sequence into the corresponding amino acid sequence.
     + Because all life on Earth shares a universal genetic code, your DNA could be used to genetically modify a monkey.
     + **Key Points** – the universality of the genetic code implies that all it arose very early in the history of life on the planet. All organism use the same genetic code…
  4. DNA to RNA (transcription)
     + Steps of transcription – initiation, elongation, termination
     + If eukaryotic, then happens in the nucleus
     + During elongation the enzyme RNA polymerase adds nucleotides to the growing RNA strand
     + In prokaryotes DNA is directly transcribed into RNA
     + In eukaryotes the transcribed RNA is modified.
       1. These additions, called the **[cap](https://etext.pearson.com/eps/pearson-reader/api/item/18a5ba13-4ac2-41dc-9126-86930d6a8ed3/1/file/SimonEB6-071415-MJ-LS/OPS/s9ml/glossary/filep7000496869000000000000000006ec8.xhtml" \l "P700049686900000000000000000708D" \t "_blank)** and **[tail](https://etext.pearson.com/eps/pearson-reader/api/item/18a5ba13-4ac2-41dc-9126-86930d6a8ed3/1/file/SimonEB6-071415-MJ-LS/OPS/s9ml/glossary/filep7000496869000000000000000006ec8.xhtml" \l "P7000496869000000000000000007A41" \t "_blank)**, protect the RNA from attack by cellular enzymes and help ribosomes recognize the RNA as mRNA.
       2. Introns are cut out (splicing)
       3. Exons are the regions that then get translated into polypeptides
       4. 21,000 genes to produce many thousands more polypeptides
       5. mRNA is the sequence of nucleotides that gets translated into a polypeptide
  5. mRNA to polypeptide (translation)
     + Side chains give amino acids their identity
     + Polypeptides are made of amino acids bonded covalently
     + Proteins are mad of amino acid chains
     + mRNA leaves the nucleus and goes into the cytoplasm to be translated into a polypeptide with the help of a ribosome.
     + The players (all nucleic mostly nucleic acids-
       1. mRNA – has the code for the polypeptide that it got from DNA (transcription).
       2. transfer RNA (t-RNA) – a shuttle that brings amino acids to the growing polypeptide chain – a nucleic acid that has an amino acid bonded to it. Have two important parts, the amino acid binding region and the anticodon that is complementary to the mRNA codon.
       3. ribosomes – cellular machine made out of RNA that translates the genetic code of RNA to amino acids
          1. complex RNA machine that translates mRNA to a polypeptide by adding amino acids in a particular sequence.
          2. Small subunit bind the mRNA molecule
          3. Large subunit accepts transfer RNAs in the order dictated by the mRNA sequence following the genetic code.
  6. Why and how were researchers able to make glow in the dark pigs?
     + See pgs 179-180
  7. Mutations – Any change in the nucleotide sequence of a cell’s
     + Mutations can involve large regions of a chromosome or just a single nucleotide pair, as in sickle-cell disease.
     + DNA polymerase makes mistakes very rarely, 1 in 1 billion nucleotides (base pairs)
     + Mutations are the raw material of genetic change
     + Example – Sickle Cell Anemia – a single nucleotide change causes the hemoglobin protein to be unable to transfer oxygen through the body
     + Substitution (Point mutation) – a single nucleotide changes
     + Frameshift – a nucleotide is added or removed to create a non-functional protein.
     + When do mutations happen?
       1. During DNA replication or recombination
     + Mutagens – chemicals or radiation that cause the rate of nucleotide changes to increase.
     + Carcinogen – Mutagen that causes cancer rates to increase
     + Mutations and variation – allelic variation
  8. Viruses
     + is an infectious particle consisting of little more than “genes in a box”:
     + protein coat, nucleic acid as molecule of heredity, sometimes a membrane envelope
     + Are viruses alive?
       1. No
       2. A virus cannot reproduce on its own, and thus it can multiply only by infecting a living cell and directing the cell’s molecular machinery to make more viruses
       3. Viruses that attack bacteria are called **[bacteriophages](https://etext.pearson.com/eps/pearson-reader/api/item/18a5ba13-4ac2-41dc-9126-86930d6a8ed3/1/file/SimonEB6-071415-MJ-LS/OPS/s9ml/glossary/filep7000496869000000000000000006ec8.xhtml" \l "P7000496869000000000000000006FE0" \t "_blank)** (“bacteria-eaters”), or **[phages](https://etext.pearson.com/eps/pearson-reader/api/item/18a5ba13-4ac2-41dc-9126-86930d6a8ed3/1/file/SimonEB6-071415-MJ-LS/OPS/s9ml/glossary/filep7000496869000000000000000006ec8.xhtml" \l "P7000496869000000000000000007784" \t "_blank)** for
       4. **[lytic cycle](https://etext.pearson.com/eps/pearson-reader/api/item/18a5ba13-4ac2-41dc-9126-86930d6a8ed3/1/file/SimonEB6-071415-MJ-LS/OPS/s9ml/glossary/filep7000496869000000000000000006ec8.xhtml" \l "P70004968690000000000000000075BB" \t "_blank)** - The lytic cycle gets its name from the fact that after many copies of the phage are produced within the bacterial cell, the bacterium lyses (breaks open
       5. **[lysogenic cycle](https://etext.pearson.com/eps/pearson-reader/api/item/18a5ba13-4ac2-41dc-9126-86930d6a8ed3/1/file/SimonEB6-071415-MJ-LS/OPS/s9ml/glossary/filep7000496869000000000000000006ec8.xhtml" \l "P70004968690000000000000000075B5" \t "_blank)**. During a lysogenic cycle, viral DNA replication occurs without phage production or the death of the cell.
       6. Prophage - viral DNA is inserted into the chromosome of a bacterium. Once there, the phage DNA is referred to as a **[prophage](https://etext.pearson.com/eps/pearson-reader/api/item/18a5ba13-4ac2-41dc-9126-86930d6a8ed3/1/file/SimonEB6-071415-MJ-LS/OPS/s9ml/glossary/filep7000496869000000000000000006ec8.xhtml" \l "P7000496869000000000000000007860" \t "_blank)**.
       7. Plant viruses – cause disease in crop plants
          1. Tobacco mosaic virus – structure was determined by R. Franklin using x-ray crystallography.
          2. Most are RNA viruses
          3. No ‘cure’ prevent infection/cross contamination
          4. Engineer disease resistant plants.
       8. Animal Viruses –
          1. Usually have a membrane envelope
          2. Review the reproductive cycle of the mumps virus enveloped DNA viruses that reproduce in a host cell’s nucleus, and they get their envelopes from the cell’s nuclear membrane. Copies of the herpesvirus DNA usually remain behind in the nuclei of certain nerve cells.
          3. Key points – the immune system of your body fight viruses. There are no antibiotic equivalents for ‘killing’ viruses
       9. HIV/Aids –
          1. HIV is a retrovirus
          2. Has an enzyme called reverse transcriptase that makes a DNA copy of the virus RNA.
          3. Breaks the DNA to RNA rule….
          4. Provirus – Viral DNA is inserted into eukaryotic host chromosome
          5. AZT is similar to the nucleic acid thymine, so it messes up replication.
       10. What is a prion?
           1. A protein that causes other proteins to become non-functional.
* Ch. 11 Gene Regulation
  1. Introduction
     + Gene regulation - mechanisms that turn on certain genes while other genes remain turned off.
       1. Allows for cells to become specialized
       2. Gene expression – overall process where genetic information flows from DNA to RNA to proteins
       3. Review figure. 11.1
  2. Gene Regulation in Bacteria – Review the *lac* operon – we covered this thoroughly in class, so make sure you review it.
  3. Gene Regulation in Eukaryotes –
     + What is a Eukaryote? –
     + Usually multicellular organism that has cells membrane bound organelles and DNA within a nucleus
     + Your book uses a ‘pipeline’ analogy - 11.3 The gene expression “pipeline” in a eukaryotic cell.
       1. What do the valves in the pipeline represent
       2. What is the most important type of regulation in Eukaryotes
          1. Transcription
     + Steps in the ‘pipeline’
       1. DNA packing – DNA stays condensed and wrapped around chromosomes, so it is not available for transcription
          1. Example – X - chromosome inactivation in female mammal
          2. Tortoiseshell female cat example
       2. initiation of transcription - whether transcription starts or not
          1. similar to what happens in bacteria, but with different players

Transcription Factors – proteins that modify transcription speed

Activators increase transcription

Repressors decrease transcription

DNA regions that bind transcription factors – Enhancers (bind activators) and Silencers (bind repressors)

* + - 1. RNA Processing
         1. Cap/tail – bind to ribosome and protect transcript from degradation
         2. 5’ non-transcribed region – bind proteins that block translation
         3. 3’ non-transcribed region – determine how long mRNA stays in the cytoplasm before being broken down.
         4. Alternative splicing – introns are cut out, allows for protein variation.
         5. MicroRNA (miRNA) – regulates translation and break down of mRNA
         6. What is the difference between mRNA and RNA transcript?
      2. Protein Regulation
         1. Proteins are process
         2. Example insulin – gets translated in on long polypeptide and is cut to become the active hormone (protein).
  1. Cell Signaling
     + What is cell signaling
     + What is signal transduction pathway – chemical relay race
       1. Example insulin-
          1. pancreas produces insulin and tells all cells of the body to take up
          2. insulin interacts with membrane proteins that initiate a transduction pathway
          3. proteins are synthesized that cause glucose to move from the blood stream into the cell.
  2. Homeotic Genes – master control genes
     + A gene that controls many other genes
     + Example – legs where antennae should be
     + homeotic genes arose very early in the history of life and that the genes have remained remarkably unchanged over eons of animal evolution.
  3. DNA Microarrays
     + A **[DNA microarray](https://etext.pearson.com/eps/pearson-reader/api/item/18a5ba13-4ac2-41dc-9126-86930d6a8ed3/1/file/SimonEB6-071415-MJ-LS/OPS/s9ml/glossary/filep7000496869000000000000000006ec8.xhtml" \l "P7000496869000000000000000007240" \t "_blank)** is a slide with thousands of different kinds of single-stranded DNA fragments attached in a tightly spaced array (grid).
     + Reverse transcriptase makes a DNA strand that is complementary (cDNA) to each mRNA sequence.
     + Tells researchers which genes are turned on in a given cell
  4. Cloning Plants and Animals
     + Key Point - One of the most important take-home lessons from this chapter is that all body cells contain a complete complement of genes, even if they are not expressing all of them
     + **Cloning** is the process of producing genetically identical individuals of an organism either naturally or artificially.
     + In nature, many organisms produce **clones** through asexual reproduction.
     + Regeneration - the regrowth of lost body parts. When a salamander loses a tail, for example, certain cells in the tail stump **reverse their differentiated** state, divide, and then differentiate again to give rise to a new tail
     + Reproductive cloning in mammals– nuclear transplantation – diploid nucleus from a somatic cell is put into an egg cell. Then after some 100’s of cell divisions the cloned organism is implanted into a surrogate uterus
       1. Practical application – conservation, cloning extinct mammals, production of important materials.
          1. Spider silk in goats milk
          2. pig clones that lack a gene for a protein that can cause immune system rejection in humans.
       2. Could Jurassic park happen?
       3. Cloned animals might age more quickly…
     + Therapeutic cloning **-** The purpose of this procedure is not to produce a living organism but rather to produce embryonic stem cells (ESC).
       1. ESC - removing cells from an early embryo and growing them in laboratory culture.
          1. Differentiation of embryonic stem cells through gene expression
       2. Umbilical cord cells - a treatment for leukemia
       3. Adult stem cells – example bone marrow … not as universal as embryonic stem cells
* Text Covered –
  + - pdf Ch10,
    - pdf Ch.11, through cloning