Topic Review Guide 10: Molecular Genetics

To Think About: How is heritable information passed to the next generation in eukaryotes, and how do changes in genotype result in changes in phenotype of an organism? What multiple processes increase genetic variation in biological systems, and how do environmental factors influence the expression of the genotype in an organism? How is DNA, and in some cases RNA, the primary source of heritable information? How does gene regulation result in differential gene expression, leading to cell specialization? In what ways do a variety of intercellular and intracellular signal transmissions mediate gene expression? How does viral replication result in genetic variation, and how can viral infection introduce genetic variation into the hosts? How do interactions between external stimuli and regulated gene expression result in specialization of cells, tissues, and organs?

Watch:
First: Mr. Andersen's "DNA and RNA, part 1" video
Then: Mr. Andersen's "DNA and RNA, part 2" video
Next: Mr. Andersen's "Transcription and Translation" video
Then: Mr. Andersen's "Genotype and Phenotype" video
Then: Mr. Andersen's "Gene Regulation" video
Last: Mr. Andersen's "Molecular Biology" video

Read: Chapter 9, Hillis et al. Principles of Life, 1st edition (2012), pages
Next: Chapter 10, Hillis et al. Principles of Life, 1st edition (2012), pages
Then: Chapter 11, Hillis et al. Principles of Life, 1st edition (2012), pages

Supplementary Resources: Click the links below for more information to help you learn more about this lesson.

- Crash Course Biology: DNA Structure and Replication
- Crash Course Biology: DNA Transcription and Translation
- DNA From the Beginning: Molecules of Genetics
- University of Utah Genetic Science Learning Center: DNA to Protein
- University of Utah Genetic Science Learning Center: Epigenetics
- BioCoach: DNA Structure and Replication
- BioCoach: Transcription and Translation
- Hillis: Animated lac operon
- Hillis: Animated trp operon
- Hillis: Eukaryotic Gene Expression Control Points Activity

Listen and Look: Here is a list of key terms and concepts you will hear about and see during these podcasts and chapter readings. Get to know them! Be able to connect them to one another using a concept map.

KEY TERMS

DNA replication	Nucleotide	Chromosome	Central dogma
Transcription	Translation	Phenotype	Genetic engineering
DNA polymerase	RNA polymerase	Deoxyribonucleic acid (DNA)	Ribonucleic acid (RNA)
Messenger RNA	Transfer RNA	Semiconservative replication	Operon
Lac operon	Trp operon	Positive control (inducible)	Negative control (repressible)
Regulatory gene	Regulatory protein	Repressor	Operator
Promoter	Inducer	Retrovirus	Reverse transcriptase
Plasmid	Restriction enzyme	Polymerase chain reaction	Gel Electrophoresis

Recall and Review: Use the lecture in the video and your textbook reading to help you answer these questions.

1. **Explain** how the experiments that each of the following people/groups of people performed provided evidence that DNA is the genetic material.
    a. Frederick Griffith
    b. Oswald Avery, Maclyn McCarty, and Colin MacLeod
    c. Alfred Hershey and Martha Chase
    d. Erwin Chargaff
2. **Explain** why the peanut plant in Mr. Andersen's DNA and RNA video is able to express a gene from *B. thuringiensis* (Bt).
3. **Describe** the structure of a eukaryotic chromosome. How does it compare to a prokaryotic chromosome?
4. **Describe** the characteristics of the DNA molecule that make it a good information-bearing molecule.
5. **Explain** why DNA replication is considered to be semiconservative. Why is the leading strand replicated continuously, while the lagging strand is replicated discontinuously?
6. Francis Crick coined the term "central dogma" with regard to the relationship between DNA and RNA. **Explain** what Crick meant by this.
7. **Explain** the relationship between protein synthesis and an organism's phenotype.
8. **Explain** how the "one-gene-one protein" hypothesis was derived by Beadle and Tatum. Why has this hypothesis been refined to "one gene-one polypeptide," and now "one gene-one (protein) domain?"
9. **Create** a graphic organizer that illustrates the differences between the processes of transcription and translation, including how they operate in prokaryotes vs. eukaryotes.
10. **Create** a diagram illustrating the following mutations:
    a. Silent mutation
    b. Missense mutation
    c. Nonsense mutation
    d. Frameshift mutation
11. **Explain** what would happen to the process of gene expression if the gene for RNA polymerase was mutated.
12. Each amino acid has a tRNA synthetase enzyme that is responsible for attaching it to a tRNA molecule. **Explain** what would happen if there was a mutation in the gene encoding one of these enzymes.
13. **Describe** how proteins can be altered once they have been synthesized at the ribosome and what organelles are involved.
14. **Explain** how retroviruses modify the central dogma.
15. **Describe** how viruses are able to cause tumors and cancer in human cells, such as HPV that causes cervical cancer.
16. Define **operon. Explain** how bacterial cells use operons to control gene expression.
17. **Explain** how repressible operons differ from inducible operons. Use the trp and lac operons as examples.
18. **Describe** how the following tools are used to study or modify organismal genomes:
    a. Restriction enzymes
    b. Plasmids
    c. Gel electrophoresis
    d. Polymerase Chain Reaction (PCR)
19. **Create** a t-chart that lists the benefits and drawbacks to genetic modification of organisms.

Learn More: For more information about DNA, RNA, their processes and their history, follow the links below:

- Nobelprize.org: DNA – The Double Helix Game
- Nobelprize.org: The Nobel Prize in Physiology or Medicine 1962—Watson, Crick and Wilkins
- Nobelprize.org: The Nobel Prize in Physiology or Medicine 1965—Jacob, Lwoff and Monod (operons)
- Nobelprize.org: The Nobel Prize in Physiology or Medicine 1968—Holley, Khorana and Nirenberg (genetic code)
- Nobelprize.org: The Nobel Prize in Physiology or Medicine 1978—Arber, Nathans and Smith (restriction enzymes)
- Nobelprize.org: The Nobel Prize in Physiology or Medicine 2006—Fire and Mello (RNAi)
- Nobelprize.org: The Nobel Prize in Chemistry 1993—Mullis and Smith (development of PCR)
- Nobelprize.org: The Nobel Prize in Chemistry 1980—Berg, Gilbert and Sanger (DNA sequencing and rDNA)