Chapter 16 – Outline

The Molecular Basis of Inheritance

Level 1 Items

AP Biology students should be able to:

1. Recognize scientists and the experiments that lead to the understanding of the molecular basis of inheritance.
2. Identify the double helix composition and structure of DNA.
3. Identify the process and steps of DNA replication.
4. Recognize the problems in replicating the ends of the DNA molecules
5. Give an example of DNA proofreading and repair.
6. Gain familiarity with the packing of DNA into a Eukaryotic chromosome

Outline

AP Biology students should understand:

A. Historical Development and Experiments
- 1. Griffith - 1928
  - a. Experiment
  - b. Results
  - c. Importance
- 2. Avery, McCarty and MacLeod - 1944
- 3. Hershey and Chase - 1952
  - a. Experiment
  - b. Results
  - c. Importance
- 4. Chargoff and Chargoff's Rule
- 5. Watson and Crick - 1953

B. DNA Composition and Structure
- 1. Backbone
  - a. Sugar
  - b. Phosphate
- 2. Nitrogen Bases
  - a. Purines
  - b. Pyrimidines
- 3. Double Helix
  - a. General Structure
  - b. Dimensions

C. DNA Replication - Basic Concepts
- 1. Models for Replication
  - a. Conservative
  - b. Semiconservative
  - c. Dispersive
- 2. Meselson-Stahl Experiment
  - a. Experiment
  - b. Results
  - c. Importance

D. DNA Replication - Specific Concepts
- 1. Origins of Replication
  - a. Prokaryotic
  - b. Eukaryotic
- 2. Elongating a DNA Strand
  - a. DNA Polymerases
  - b. Nucleoside Triphosphates
- 3. Problem of Antiparallel DNA Strands
  - a. Problem
  - b. Leading Strand
  - c. Lagging Strand
    - 1. Mechanism
    - 2. Okazaki Fragments
    - 3. DNA Ligase
- 4. Priming DNA Replication
- 5. Other Proteins
  - a. Helicase
  - b. Single-Strand Binding Proteins

E. Proofreading and Repair
- 1. DNA Polymerase proofreading
- 2. T-T dimmers and excision repair

F. Replicating the ends of the DNA molecule
- 1. Problems with replicating the end of the DNA molecules
- 2. Telomeres
- 3. Telomerase

G. DNA packing into Eukaryotic Chromosomes
- 1. Introduction to Histones
- 2. Nucleosomes or beads on a string
- 3. Fibers and looped domains
- 4. Metaphase Chromosomes

Chapter 16 – Homework

The Molecular Basis of Inheritance

1. A number of historically important scientists and experiments are presented in this chapter. Test questions have been found pertaining to these scientists on the AP Biology National exam. **For each scientist or team of scientists give the following information:**
   a) A short, but complete description of their historical experiment or discovery.
   b) An explanation on **how** their work contributed to our understanding of the molecular basis of inheritance.

Scientists:

Griffith; Avery, McCarty and MacLeod; Hershey and Chase; Chargaff; Watson and Crick; Franklin; Meselson and Stahl

2. **Imagine** that the bacteria in the experiment of Meselson and Stahl were grown originally on ^{15}N media and switched to heavier ^{16}N media. What should the results of the density bands look like after the 1st generation of DNA replication? After two generations of replication?

3. **Explain** why DNA replication is described as "semi-conservative".

4. **Discuss** the key points of the DNA molecular structure as worked out by Watson and Crick.

5. **Create** a review table that **identifies** the key enzymes and proteins that are involved with DNA replication and **describes** each molecule's function or purpose.

6. **Contrast** and **compare** DNA replication in regard to the leading and lagging strands.

7. **Describe** a chromosome telomere and its possible function(s).

8. A scientist submits a proposal for a cancer research project that targets the enzyme telomerase. As a reviewer of grant proposals, **discuss** if this proposal has any merit. Can telomerase be a potential target for cancer therapy?

9. Imagine that a hypothetical human DNA repair mechanism known as No. 12 has mutated and no longer works. **Speculate** on the effect this might have on human cells.

BONUS: **Locate** and **write out** the original science journal citation for Watson and Crick's paper for their proposed structure of DNA.

(Warning – don't use a web site citation here. The web didn't exist in 1953. Give the citation such as you would for a research paper including the journal, title, issue and page numbers)

Chapter 17 – Homework

From Gene to Protein

1. **Describe** how the genotype of an organism is turned into the phenotype.

2. When genetic material was first being isolated and studied, there was a controversy about it being protein or DNA (as discussed in Chapter 16). Those that backed protein as the genetic material almost got it right. **Discuss** what the connection was between the two molecules that was not understood.

3. **Discuss** THREE ways that mRNA used in protein synthesis differs from the original RNA transcript. What is the apparent function of each of the alterations or modifications?

4. The enantiomer form of a candidate drug from the Eli Lilly Co. was found to cause deletions of two base pairs at various intervals in the DNA of test animals. **Explain** to the stockholders why the drug should or should not be put into commercial production (details at the molecular level are important in your answer).

5. A new candidate drug produced by Eli Lilly damages a transcription factor molecule. **Describe** the probable outcome of this damage and speculate on what results it might have on the organism.

6. Another Eli Lilly candidate drug impairs the function of the large unit of the prokaryotic ribosome. **Discuss** if this drug would have any potential use in controlling bacterial diseases and if it would be expected to be dangerous to humans.

7. **Describe** a mechanism used to route or guide the production of a protein for exportation out of a cell.

8. Assume that one backbone of a DNA molecule has the sequence given below.

   A-T-G-G-G-G-G-C-G-A-T-A-T-T-T-T-A-T-C-C-G-A-C-G

   For this sequence:
   a) give the expected sequence of the other DNA backbone.
   b) give the RNA sequence transcribed from the original DNA backbone.
   c) give the Amino Acid sequence of the protein built from the original DNA backbone.

9. **Contrast and compare** the following mutations in terms of the genetic code:
   a) Nonsense mutation
   b) Sense mutation
   c) Missense mutation

10. Imagine that an accident has exposed you to a mutagen. However, the medical report indicates that only your germ cells (not your somatic cells) have been affected by the exposure. **Speculate** on how this might or might not change your future.

11. **Discuss** TWO mechanisms or process that ensure the correct amino acid is added to the growing polypeptide chain.

12. Suppose that a burst of X-rays have caused a sequence change in the TATA box of a particular gene. Speculate on what affect this might this on the transcription and translation of the gene?

Chapter 18 – Homework

Bacterial Genetics

1. **Discuss** two types of operons that express negative gene regulation and **explain** how they work. **Contrast and compare** the similarities and differences between the two types.

2. **Contrast and compare** positive gene regulation with negative regulation and give an **example** of positive gene regulation.

3. Expression of Green Fluorescent Protein in the bacteria transformation lab is triggered by the presence of Arabanose. **Describe** how this system worked. (hint – take a look at the last handout from that lab)

4. **Discuss** if histone tail deacetylation increases or decreases the transcription of a gene located in that nucleosome.

5. Describe RNAi and explain why it is important.

6. **Imagine** that a bicoid mutation gives a gradient of the protein at both the anterior and posterior ends of a fruit fly egg. What would you expect the embryo to look like?

7. **Explain w**hy identical twins become less "identical" as they age.

8. Imagine that a check of your DNA reveals that the chromosome area for the protein p53 has somehow been duplicated on one of your chromosomes, giving you 4 copies of the gene. **Speculate** on what this mutation might mean in terms of your risk for cancer.

9. Cancer cannot be inherited directly from your parents, but a predisposition can be inherited allowing cancer to "run in families". Imagine that this topic comes up during a family reunion. **Explain** to aunt Sally how this works as she is certain that she has inherited the family "curse" of cancer and will die before her time.

10. DNA sequences can act as "tape measures of evolution". Scientists analyzing the human genome sequence were surprised to find that some regions of the human genome that are most highly conserved (similar to comparable regions in other species) don't code for proteins at all. Given what you've learned about "genes" s**peculate** on reasons why this might be so.

Chapter 20 – Homework
Biotechnology

1. The modification of the DNA of an organism to produce new genes with new traits is most widely called:
   a) Bioengineering
   b) *in vitro* gene technology
   c) biotechnology
   d) recombinant DNA technology
   e) genetic engineering

2. Splicing together DNA from 2 different organisms is called:
   a) Bioengineering
   b) *in vitro* gene technology
   c) biotechnology
   d) recombinant DNA technology
   e) genetic engineering

3. DNA ligase links two _____DNA fragments by _____bonds
   a) complementary; hydrogen
   b) circular; covalent
   c) linear; covalent
   d) palindromic; covalent
   e) linear; hydrogen

4. "Sticky ends" are:
   a) the double-stranded ends of a DNA segment created by some restriction enzymes
   b) a problem in recombinant DNA technology because they form loops of single-stranded DNA
   c) the single-stranded ends of a DNA segment created by some restriction enzymes
   d) sites of the origin of replication in prokaryotes
   e) sugar molecules that are bound to the ends of a DNA fragment

5. One feature of "engineered" plasmids that is helpful in the isolation and analysis of cloned DNA is:
   a) they can only handle DNA fragments of up to 120 kb
   b) that they are an integral part of all eukaryotic cells
   c) they contain no genetic material of their own so that the cloned fragment is truly isolated
   d) the presence of genes that allow transformed cells to survive on different media such as antibiotics.
   e) All of the above

6. In producing a genomic library for splicing DNA, the human DNA and plasmid DNA must first be treated with:
   a) Different restriction enzymes
   b) The same restriction enzyme
   c) The same DNA ligase
   d) Different DNA ligases
   e) None of the above

7. To avoid the introduction of introns into the prokaryotic vector, a _____ copy of mature mRNA is made using the enzyme _____.
   a) sDNA; RNA polymerase
   b) cDNA; DNA ligase
   c) sDNA; reverse transcriptase
   d) cDNA reverse transcriptase
   e) cDNA; DNA polymerase

8. In polymerase chain reaction technology, the two strands of DNA are separated by:
   a) gel electrophoresis
   b) treating them with restriction enzymes
   c) centrifugation
   d) exposing them to high pH
   e) heating them until they "melt"

9. _____ is a technique that can be used to separate DNA molecules on the basis of their size.
   a) Separation gradient
   b) Gel Electrophoresis
   c) Selective sorting
   d) Cloning
   e) PCR

10. PCR:
   a) Can only be carried out if DNA polymerase is heat-resistant
   b) Is used to amplify tiny quantities of DNA *in vitro*
   c) Only replicates target sequences
   d) Has applications for archaeology and crime scene analysis
   e) All of the above

11. Dideoxynucleotides are used in:
   a) DNA ligation
   b) DNA replication within a bacteria cell
   c) PCR
   d) Gel electrophoresis
   e) DNA sequencing

12. How is reverse transcriptase used to clone genes?
   a) Reverse transcriptase is used to make a cDNA copy of an mRNA strand
   b) Reverse transcriptase is used to make a cloned DNA copy of a plasmid DNA molecule
   c) Reverse transcriptase is necessary to read the information contained on the cDNA molecule
   d) Reverse transcriptase transcribes RNA from cDNA in reverse order
   e) Reverse transcriptase transcribes cDNA into RNA without transcription of introns

13. The presence of detectable variation in the genomes of different individuals of a population is termed:
   a) DNA sequencing
   b) DNA electrophoresis
   c) DNA tandem repeats
   d) Polymorphism
   e) DNA profiling

14. Examples of genetically modified crops include:
   a) Tobacco that produces high amounts of vitamin B_{12}
   b) Corn strains that produce high amounts of antibodies
   c) Rice strains that produce high quantities of β-carotene that is converted to vitamin A
   d) Apple varieties that produce high amounts of vitamin K
   e) All of the above

15. A _____ is required to transfer genes from one organism to another
    a) Vector
    b) Reverse transcriptase
    c) Genetic probe
    d) Transport molecule
    e) PCR device

Short Answer Questions

1. **Define** the term restriction enzyme and give two examples of ways in which these enzymes are used in recombinant DNA technology.

2. Imagine that the plasmid pGLO has ampicillin resistance and GFP traits. Imagine a plasmid pBLUE has streptomycin resistance and Blue Fluorescent Protein (BFP). Both GFP and BFP are in an arabanose operon**.** **Describe** a procedure that would allow you to produce cyan glowing bacteria (both GFP and BFP together) .

3. Food from GMOs (genetically modified organism) has recently been approved by the FDA for human consumption. **Discuss** if you think labels should be added to foods to list if they contain material from a GMO.

4. **Discuss** what danger, if any, a Genetically Modified Organism (GMO) might represent if someone released them into the wild.

5. **Describe** why stem cells are thought to be important in the future of medicine.