Chapter 11: Mendelian Patterns of Inheritance

a) Know genotypes and phenotypes of a monohybrid cross in the P, F1, and F2 generations. Be familiar with expected ratios in the F2 generation of a dihybrid cross.

b) When is a testcross performed? What are the phenotypes of the parents in a testcross?

c) If an organism expresses the recessive phenotype, what must its genotype be?

d) Understand how to apply the multiplication rule to ratios to calculate the probability of inheriting several different traits.

e) What are Mendel’s laws of segregation and independent assortment? What other ideas did Mendel come up with from his pea plant experiments?

f) Punnett squares give possible outcomes in the offspring. Are the resultant offspring always in the numbers predicted? If a 3:1 ratio was predicted for a trait and a child is born with the recessive trait, what is the probability that the next child will be born with the recessive trait?

g) Be able to use Punnett squares to predict expected genotypic and phenotypic ratios of offspring if given the blood types of the parents.

h) Know how blood type is inherited. Be able to determine possible blood types of offspring if given the blood types of the parents.

i) Be familiar with all forms of inheritance patterns (simple dominant/recessive, sex-linked, codominance, incomplete dominance, multiple alleles, polygenic, epistasis, pleiotropy, etc)

j) What sex chromosomes make up an individual female? Male?

k) What are the first 22 chromosomes called?

l) In what organism was X-linkage first discovered?

m) What does one map unit represent?

n) Know how to figure out where on a chromosome genes are located when given map units or percentages of gene linkage.

o) Understand the four types of chromosomal mutations and diseases that result from them (Williams, cri du chat, Alagille, etc)

p) How are karyotypes arranged? What can be told from a karyotype?

q) Understand the diseases (causes and effects) – Down syndrome, Huntington’s disease, hemophilia, cystic fibrosis, Tay-Sachs, Klinefelter, Turner’s syndrome, fragile-X, Jacob’s, sickle-cell anemia, color blindness, and muscular disease.

r) Be familiar with pedigrees and how to determine the type of inheritance of a trait.

s) What is nondisjunction and what does it result in?

t) What disorder was in the royal families of Europe?

Chapter 12: Molecular Biology of the Gene

1. What three characteristics does genetic material need to have? What reasons were given that DNA was not considered to be the most likely candidate for genetic material early on in the search?

2. Know and understand the three sets of experiments that point to DNA as the transforming factor (Griffith, Avery, and Hershey and Chase).

3. What are Chargoff’s rules? Know what they are and be able to apply them.

4. Who were ALL the researchers involved in figuring out the structure of DNA? Who took the X-ray crystallography pictures of DNA? What did that picture reveal about DNA’s structure?

5. What is the structure of DNA? (Know the requirements of your 3D model.) How is the 5’ and 3’ end determined? Which bases are pyrimidines and which are purines?

6. How is DNA replicated?

7. Understand the Meselson and Stahl experiment. Is DNA replication conservative, semiconservative, or dispersive? (What do these terms mean?)

8. What are the three enzymes that aid in replication and what jobs do they perform?
9. What is the rate of mistakes in DNA synthesis before and after DNA repair enzymes? (Go with # in text on page 233). What causes mutations?
10. What are nucleosomes?
11. With which organism did Beadle and Tatum experiment? What was their conclusion and the reasoning behind it?
12. What did Pauling and Itano find in their gel electrophoresis of hemoglobin?
13. Genes encode for what? (Be specific)
14. Understand the figure on pg. 241 that deals with number of nucleotides and amino acids specified.
15. How are DNA and RNA different?
16. What are mRNA, tRNA, and rRNA? What roles do they play in the manufacture of proteins?
17. Be able to transcribe a sequence of DNA. Be able to translate a sequence of mRNA into amino acids using the genetic code.
18. What changes need to be made to an RNA strand after transcription before it is ready to leave the nucleus? What are introns and exons?
19. Where does protein synthesis occur? Be able to describe the processes of transcription and translation (initiation, elongation, and termination). Understand the difference between codons and anticodons. To what does the term wobble refer?
20. What are ribozymes? How are they important to the “chicken or the egg” dilemma of DNA and proteins? Understand the diagrams on pages 246-247.

Chapters 11-12 Essays

2007 Form B Question 3
A molecule of messenger RNA (mRNA) has just been synthesized in the nucleus of a human cell.
   a) What types of modifications may occur to this RNA before it leaves the nucleus?
   b) Once in the cytoplasm, how is the mRNA translated to a protein?
   c) If the cell is a secretory cell, how is the protein from part (b) eventually targeted, packaged, and secreted to the exterior of the cell?

2012 Question 3
Information flow in cells can be regulated by various mechanisms.
   a) Describe the role of THREE of the following in the regulation of protein synthesis:
      • RNA splicing
      • Repressor proteins
      • Methylation
      • siRNA
   b) Information flow can be altered by mutation. Describe THREE different types of mutations and their effect on protein synthesis.
   c) Identify TWO environmental factors that increase the mutation rate in an organism, and discuss their effect on the genome of the organism.
   d) Epigenetics is the study of heritable changes in the phenotype caused by mechanisms other than changes in the DNA sequence. Describe ONE example of epigenetic inheritance.
2013 Question 5
The table below shows the amino acid sequence of the carboxyl-terminal segment of a conserved polypeptide from four different, but related, species. Each amino acid is represented by a three-letter abbreviation, and the amino acid residues in the polypeptide chains are numbered from the amino end to the carboxyl end. Empty cells indicate no amino acid is present.

<table>
<thead>
<tr>
<th>Species</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>VAL</td>
<td>HIS</td>
<td>LEU</td>
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<td>GLU</td>
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<td>II</td>
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<td>III</td>
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<td>IV</td>
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<td>HIS</td>
<td>LEU</td>
<td>VAL</td>
<td>ARG</td>
<td>TRP</td>
<td>ALA</td>
<td>CYS</td>
<td>MET</td>
<td>ASP</td>
</tr>
</tbody>
</table>

a) Assuming that species I is the ancestral species of the group, explain the most likely genetic change that produced the polypeptide in species II and the most likely genetic change that produced the polypeptide in species III.
b) Predict the effects of the mutation on the structure and function of the resulting protein in species IV. Justify your prediction.

2013 Question 1
In an investigation of fruit-fly behavior, a covered choice chamber is used to test whether the spatial distribution of flies is affected by the presence of a substance placed at one end of the chamber. To test the flies’ preference for glucose, 60 flies are introduced into the middle of the choice chamber at the insertion point indicated by the arrow in the figure above. A cotton ball soaked with a 10% glucose solution is placed at one end of the chamber, and a dry cotton ball with no solution is placed at the other end. The positions of flies are observed and recorded every minute for 10 minutes.

a) Predict the distribution of flies in the chamber after 10 minutes and justify your prediction.
b) Propose ONE specific improvement to each of the following parts of the experimental design and explain how the modification will affect the experiment.
   a) Experimental control
   b) Environmental factors
c) The experiment described above is repeated with ripe bananas at one end and unripe bananas at the other end. Once again the positions of the flies are observed and recorded every minute for 10 minutes. The positions of flies after 1 minute and after 10 minutes are shown in the table below.
<table>
<thead>
<tr>
<th>Time (minutes)</th>
<th>Position in Chamber</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>21</td>
</tr>
<tr>
<td>10</td>
<td>45</td>
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<tr>
<td></td>
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<td>18</td>
<td>21</td>
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<tr>
<td>3</td>
<td>12</td>
</tr>
</tbody>
</table>

**Perform** a chi-square test on the data for the 10-minute time point in the banana experiment. **Specify** the null hypothesis that you are testing and **enter** the values from your calculations in the table below.

d) **Explain** whether your hypothesis is supported by the chi-square test and **justify** your explanation.

e) Briefly **propose** a model that describes how environmental cues affect the behavior of the flies in the choice chamber.

**2014 Question 8**
A research team has genetically engineered a strain of fruit flies to eliminate errors during DNA replication. The team claims that this will eliminate genetic variation in the engineered flies. A second research team claims that eliminating errors during DNA replication will not entirely eliminate genetic variation in the engineered flies.

a. Provide ONE piece of evidence that would indicate new genetic variation has occurred in the engineered flies

b. Describe ONE mechanism that could lead to genetic variation in the engineered strain of flies

c. Describe how genetic variation in a population contributes to the process of evolution in the population.

**2016 Question 4**

The figure represents the process of expression of gene X in a eukaryotic cell.

a. The primary transcript in the figure is 15 kilobases (kb) long, but the mature mRNA is 7 kb in length. **Describe** the modification that most likely resulted in the 9 kb difference in length of the mature mRNA molecule. **Identify** in your response the location in the cell where the change occurs.

b. **Predict** the length of the mature gene X mRNA if the full-length gene is introduced and expressed in prokaryotic cells. **Justify** your prediction.
2017 Question 3

Gibberellin is the primary plant hormone that promotes stem elongation. GA 3-beta-hydroxylase (GA3H) is the enzyme that catalyzes the reaction that converts a precursor of gibberellin to the active form of gibberellin. A mutation in the GA3H gene results in a short plant phenotype. When a pure-breeding tall plant is crossed with a pure-breeding short plant, all offspring in the F1 generation are tall. When the F1 plants are crossed with each other, 75 percent of the plants in the F2 generation are tall and 25 percent of the plants are short.

A. The wild-type allele encodes a GA3H enzyme with alanine (ALA), a nonpolar amino acid, at position 229. The mutant allele encodes a GA3H enzyme with threonine (THR), a polar amino acid, at position 229. Describe the effect of the mutation on the enzyme and provide reasoning to support how this mutation results in a short plant phenotype in homozygous recessive plants.

B. Using the codon chart provided, predict the change in the codon sequence that resulted in the substitution of alanine for threonine at amino acid position 229.

C. Describe how individuals with one (heterozygous) or two (homozygous) copies of the wild-type GA3H allele can have the same phenotype.