Answers to text questions:

Chapter 2
http://fire.biol.wwu.edu/trent/trent/IGA_10e_SM_Chapter_02.pdf

Chapter 3
http://fire.biol.wwu.edu/trent/trent/IGA_10e_SM_Chapter_03.pdf

Answers to Edition 9 text questions:
http://fire.biol.wwu.edu/trent/trent/answers2.9.pdf

Answers to Questions from old quizzes and exams

Problem 1A
(i). a (ii) c (iii) a (iv) d

Problem 1B
a. aabb X AB → AaBb females showing dominant phenotypes and ab males showing recessive phenotypes
b. AABB X ab → AaBb females and AB males – all showing dominant phenotypes
c. AaBb X AB → ¼ females AABB ¼ AaBB ¼ AaBb ¼ AABb
All females show dominant phenotypes and genotypes as above
Males: ¼ AB ¼ Ab ¼ aB ¼ ab (phenotypes directly correspond to genotypes)
Problem 2

The allele notation in a is correct since the a single-eye spot is the wild-type phenotype. Note that this allele designation conveys no information about dominance.

The allele notation in e is correct as well since the cross shows a sex-linked inheritance pattern and the table (page 1) tells you that butterflies have Z and W chromosomes rather than X and Y.

The allele notation in c is also correct since the outcome of the cross tells you that the wild-type allele is dominant to the mutant allele:

Note ZZ male parent must be homozygous because only one phenotypic class of ZW female progeny were produced.

double male $Z^eZ^e$ X single female $Z^EW$

$\downarrow$

$Z^eW$ double females

$Z^EZ^e$ single males

Problem 3

- Red and jagged are dominant over green and smooth.
- If XY system, the wing trait would be autosomal - indicated by the fact that the phenotypes of the F1 males and females are the same for this trait in both crosses. The eye trait would be X-linked and in experiment #1 F1 males should have been green and jagged and F1 females red jagged. In experiment #2, F1 males and females should have been red and jagged. So XY system isn’t consistent with the data.
- The data fit with the ZW (female) ZZ (male) system.
- Wing trait is autosomal and eye trait is Z-linked.

Designation of allele symbols:

$Z^R$ → Red eyes allele, Z linked dominant

$Z^r$ → Green eye allele, Z linked recessive

$J$ → Jagged wing allele, autosomal dominant

$j$ → Smooth wing allele, autosomal recessive

answer continues on the next page
**Experiment 1**

Parental: green, jagged female (Z’W, JJ) X red, smooth male (Z^RZ^R, jj)

F1: All progeny are red, jagged
   - All female F1 progeny have the genotype (Z^RW, Jj)
   - All male F1 progeny have the genotype (Z^RZ’, Jj)

F2:
Females:
3/8 red, jagged (Z^RW, J--)
3/8 green, jagged (Z’W, J--)
1/8 red, smooth (Z^RW, jj)
1/8 green smooth (Z’W, jj)

Males:
3/4 red, jagged (Z^R --, J--)
1/4 red, smooth (Z^R --, jj)

Males have 1/2 probability of being Z^RZ^R and 1/2 probability of being Z^RZ’.
Also, both male and female individuals in this generation displaying the dominant phenotype (J—) have 1/3 probability of being JJ and 2/3 probability of being Jj.

**Experiment 2:**

Parental: red, smooth female (Z^RW, jj) X green, jagged male (Z’Z’, JJ)

F1: all green, jagged females (Z’W, Jj)
    all red, jagged males (Z^RZ’, Jj)

F2:
Females:
3/8 red, jagged (Z^RW, J--)
3/8 green, jagged (Z’W, J--)
1/8 red, smooth (Z^RW, jj)
1/8 green, smooth (Z’W, jj)

Males:
3/8 red, jagged (Z^RZ’, J--)
3/8 green, jagged (Z’Z’, J-)
1/8 red, smooth (Z^RZ’, jj)
1/8 green, smooth (Z’Z’, jj)

All progeny in this F2 generation displaying dominant wing phenotype (J--) have 1/3 probability of being JJ and 2/3 probability of being Jj.
Problem 4  Note the red flag in this problem: you don’t know anything about the ancestry of these flies, so you cannot assume that they are true-breeding. Also, you must inspect both crosses to determine dominance for the wing trait and whether the traits are autosomal or sex-linked.

a. Round is dominant (from F1). Wingless is dominant: The 1:1 ratio in the F1 doesn’t tell you anything about dominance for the wing gene. But it does reveal that one parent must have been heterozygous for this trait. This means that the F1’s carrying the dominant allele must be het for the wing trait. Since the winged F1’s breed true, they must be homozygous and the wingless F1s heterozygous.

b. Wing gene is autosomal since there is no difference in the segregation pattern in males and females in either cross.

c. The eye gene is X linked because in the F2 progeny the phenotypic outcome for this trait is different for males and females.

d. I’ll set up the parental genotypes and you can crunch through the F1 and F2 yourself.

Parental  \( w^+w^+; e^+e^+ \times w^+w; eY \)

e. \( w^+w; e^+e \text{ F1 female} \times w^+w^+; eY \text{ F2 male} \)

females:  
1/4 winged and round  \( w^+w^+; e^+e \)
1/4 wingless and round  \( w^+w; e^+e \)
1/4 wingless and oval  \( w^+w; ee \)
1/4 winged and oval  \( w^+w^+; ee \)

males:  
1/4 winged and round  \( w^+w^+; e^+Y \)
1/4 wingless and round  \( w^+w; e^+Y \)
1/4 wingless and oval  \( w^+w; eY \)
1/4 winged and oval  \( w^+w^+; eY \)
**Problem 5**

a. Green is dominant (from cross 1).  

b. The reciprocal crosses are consistent with XX/XY inheritance patterns (see below), but not ZZ,ZW inheritance patterns. Therefore, in Coolits, males carry the heteromorphic (XY) chromosome pair.

c. ii (Mendel style) and v are correct. You could also use the Drosophila style of allele designation where the gene is named after the mutant phenotype and the wild-type allele is designated by the + superscript. So this is the green gene:  

\[ g^+ = \text{the wildtype yellow allele} \]
\[ g = \text{mutant green allele} \]

Cross 1  
\[ X^g X^g \text{ green female crossed with a yellow X}^{g+} Y \]

\[ \downarrow \]

all green progeny \[ X^{g+} X^g \text{ and } X^g Y \]

I’ll let you crunch through the genotypes for the second cross

**Problem 6**

a.  \[ 1/3 \times 1/3 = 1/9 \]

b. Two ways to work this problem:

**Strategy 1: Directly calculate** chance that the one gene is het and the other homozygous dominant. **Either** AABb or AaBB meets the condition of the question, so you will sum the individual probabilities \[ = (1/3)(2/3) + (2/3)(1/3) = 4/9 \]

**Strategy 2:** Figure out probability of both homozygous (AABB) or both heterozygous (AaBb) and subtract from 1:

Probability that one gene is het and the other homozygous dominant equals the probability that the plant is neither homozygous (AABB) nor heterozygous for both genes (AaBb) \[ = 1.0 - [1/9 + 4/9] = 4/9 \]
Problem 7  You discover a new species of moth in Whatcom County. The local wild-type population of this moth has exhibits a naturally occurring variation in wing size which we will designate as large-winged versus small winged.

Being an admirer of Mendel you do capture moths and set up a breeding program to generate truebreeding strains. Here is your first cross:

**Parental large-winged females X small-winged males**

\[
\begin{align*}
Z^L & \quad W \\
Z^L & \quad Z^L
\end{align*}
\]

\[\downarrow\]

**F1 small-winged females and large-winged males**

\[
\begin{align*}
Z^L & \quad W \\
Z^L & \quad Z^L
\end{align*}
\]

a. Which trait is dominant?  Note: if you don’t immediately see the answer, use a trial and error approach.  **NOTE crisscross inheritance**

LARGE WINGED IS DOMINANT. THE TABLE INDICATES THAT MOTHS HAVE A ZW, ZZ SEX DETERMINATION SYSTEM. IF SMALL WINGS WERE DOMINANT, THEN THE MALE WOULD BE HOMOZYGOUS (SINCE PARENTAL STRAINS WERE TRUE= BREEDING) AND ALL PROGENY WOULD BE SMALL

b. Define allele symbols:

\[
\begin{align*}
Z^L & = \text{large} \\
Z^l & = \text{small}
\end{align*}
\]

\[
\begin{align*}
L & = \text{large} \\
l & = \text{small}
\end{align*}
\]

c. On cross above, show genotypes of Parental and F1 generations
Problem 8  You find two fruitflies crawling around on some bananas at home. The male fruitfly has a mutant wing and the female mutant bristles (see below). Inspired by your Biol 321 course, you decide to mate them and deduce the mode of inheritance of each trait.

<table>
<thead>
<tr>
<th>Trait</th>
<th>wild-type allele symbol</th>
<th>mutant allele symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>wing edge</td>
<td>( w^s = \text{wing edge straight} )</td>
<td>( w^f = \text{wing edge jagged} )</td>
</tr>
<tr>
<td>color of bristles</td>
<td>( c^b ) brown</td>
<td>( c^y = \text{yellow} )</td>
</tr>
</tbody>
</table>

You do the following crosses and score lots of progeny:

\[
\begin{align*}
&w^s w^s c^y c^b \quad \text{P straight & yellow female} \quad \times \quad \text{jagged & brown male} \quad w^j Y c^b c^b \\
\end{align*}
\]

\[
\begin{align*}
\text{F1} & \quad w^s w^f c^y c^b \\
1/2 \quad \text{females are straight & yellow} & \quad 1/2 \quad \text{males are straight & yellow} \\
1/2 \quad \text{females are straight & brown} & \quad 1/2 \quad \text{males are straight & brown} \\
\end{align*}
\]

You then cross a

\[
\begin{align*}
&w^s w^f c^y c^b \quad \text{straight & yellow F1 female} \quad \times \quad \text{straight & yellow F1 male} \quad w^s Y c^y c^b \\
\end{align*}
\]

\[
\begin{align*}
\text{F2} & \quad \downarrow \\
3/4 \quad \text{females are straight & yellow} & \quad 3/8 \quad \text{males are straight & yellow} \\
1/4 \quad \text{females are straight & brown} & \quad 3/8 \quad \text{males are jagged & yellow} \\
\end{align*}
\]

\[
\begin{align*}
1/8 \quad \text{males are straight & brown} & \quad 1/8 \quad \text{males are jagged & brown} \\
\end{align*}
\]

a. Which traits are dominant? (no explanation necessary)

From F2, yellow is dominant

b. Is the wing gene autosomal or sex-linked? (no explanation necessary)

From F2 data: sex-linked

c. Is the bristle color gene autosomal or sex-linked? (no explanation necessary) autosomal

d. Using the designated allele symbols, next to each cross clearly indicate the genotypes of the parental and F1 and F2 generations
Problem 9 Answers to Komodo Dragon Problem

Part A: NO. Progeny #1 & #3 are homozygous for C137 and Kimann doesn’t carry this allele.

Part Bi: Probability of genotype #2 = (use product rule)
\( \frac{1}{4} \) (A134A134) X 1 (B198 B198) X \( \frac{1}{4} \) (C141 C141) X \( \frac{1}{4} \) (D211 D211) X 1 (E154 E154) X 1 (F190 F190) = \( [1/4]^3 = 1/64 \)

Part Bii:
Probability of homozygosity at locus A = \( \frac{1}{4} \) (A134A134) + \( \frac{1}{4} \) (A136A136) = 1/2
either or

Probability of homozygosity at locus B = 1
Probability of homozygosity at locus C = \( \frac{1}{2} \)
Probability of homozygosity at locus D = \( \frac{1}{2} \)
Probability of homozygosity at locus E = 1
Probability of homozygosity at locus F = 1
OVERALL probability = \( [1/2]^3 = 1/8 \)

Part Biii: \([1/8]^4\)

Part C
In the blank before each statement, indicate the appropriate number

__4__ The products of a Meiosis I division fuse with each other

__3__ One of the products of Meiosis I fails to undergo MII and starts embryonic development

__1__ One of the products of Meiosis II starts embryonic development

__3__ One of the products of Meiosis II fuses with its sister cell (produced in the same cell division) and starts embryonic development.

__2__ All of these explanations are barking up the wrong tree. Clearly this is a type of asexual reproduction where a premeiotic germline cell (that is, one that has not entered meiosis) started embryogenesis spontaneously.

Problem 10 From info, the dumpy phenotype is dominant.
Following standard conventions, correct answers are a & b
**Problem 11**

*For each of the ten progeny of a heterozygote:*

3/4 chance it shows the dominant phenotype
1/4 chance it shows the recessive phenotype (which would reveal the genotype of the parent)

\[(3/4)^{10} = 0.056\] chance that all ten progeny of a heterozygous plant will show the dominant phenotype

\[(3/4)^{10} = 1 \text{ in } 18\] Rr heterozygous plants will produce only dominant progeny and be miscored as homozygotes for the dominant allele

**OPTIONAL Challenge Problem 1**

*Homozygotes for the dominant allele* will breed true and always be scored correctly: 0.33 of F2 with dominant phenotype scored correctly

*For each of the ten progeny of a heterozygote:*

3/4 chance it shows the dominant phenotype
1/4 chance it shows the recessive phenotype (which would reveal the genotype of the parent)

\[(3/4)^{10} = 0.056\] chance that all ten progeny of a heterozygous plant will show the dominant phenotype

1 - 0.056 = probability that *at least one* progeny of a heterozygous plant is homozygous recessive = 0.944

2/3 \([\text{fraction of F2 with dominant phenotype that are } \text{het}] [(3/4)^{10}]\] = 0.0375 scored incorrectly

scored as RR = 0.33 (correct) + 0.0375 (incorrect) = 0.37

scored as Rr = 0.67 (0.944) = 0.63

0.63 Rr to 0.37 RR = 1.7 to 1

**OPTIONAL Challenge Problem 2**

*Part A*

a. \((1/2)^4\)

b. yes, \((1/2)^4\)

c. 1-\([2(1/2)^4]\)
d. The number of different gametic chromosomal combination is $2^n$ where \( n \) = number of chromosome pairs.

Part B  If you are having problems with this calculation, think about it in this way: determine the probability that the mother and father both produce gametes that contain only paternal chromosomes (that is, chromosomes from their fathers).

- from paternal grandfather: \((1/2)^{22}\) [probability of Y chromosome = 1]
- from maternal grandfather: \((1/2)^{23}\)

Overall: \((1/2)^{22} \times (1/2)^{23}\)

**OPTIONAL Challenge Problem 3**  SEE ALSO figure below

First figure out the probability that any given autosome is the same or different in two siblings. (If the siblings are of the same sex, then you know they carry the same sex chromosome from the father. The sex chromosome from the mother can be treated the same as an autosome.) Assume that the parents are heterozygous for four different versions of a given autosome \(A^1, A^2, A^3, A^4\) (where the superscript differentiates homologs); that is, the cross would be \(A^1A^2 \times A^3A^4\). Then, for a given offspring there is a 50% chance that two siblings share a given autosome: If offspring #1 gets \(A^1\) from the mother, then there is a 1/2 probability that offspring #2 will get the same version of that autosome from mom. Extrapolate this to all chromosomes and on the average then, siblings share about 50% of their genes.

(Another way to look at the cross is consider that there is a 1/4 probability of each of these genotypes: \(A^1A^3, A^1A^4, A^2A^3\) and \(A^2A^4\). Say offspring #1 gets \(A^1A^3\). There is a 1/4 probability that offspring #2 gets \(A^1A^3\) (a 100% match), a 1/4 probability of \(A^1A^4\) (a 50% match), a 1/4 probability of \(A^2A^3\) (also a 50% match) and a 1/4 probability of \(A^2A^4\) (a 0% match). This averages out to an overall match probability of 50%.

How would the numbers change if one or both parents were homozygous for many of their genes or if, for many genes, they shared at least one version in common?

On the next page are some actual data comparing the genome of your instructor and her brother. The comparisons were generated by a company called **23andMe** (does genetic tests for health and ancestry). Note that crossing over events explain why the pattern varies along the length of each chromosome.

Black shading: siblings received the same homolog copy (or homologous section if there was a crossing over event) from each parent

Blue shading: siblings received the same homolog copy (or homologous section if there was a crossing over event) from one parent and a different homolog copy from the other parent

White: siblings received a different homolog copy (or homologous section if there was a crossing over event) from each parent

Grey: not enough info to assess (or, in the case of the Y chromosome, not relevant)

Gb = giga base pairs = \(10^9\) base pairs