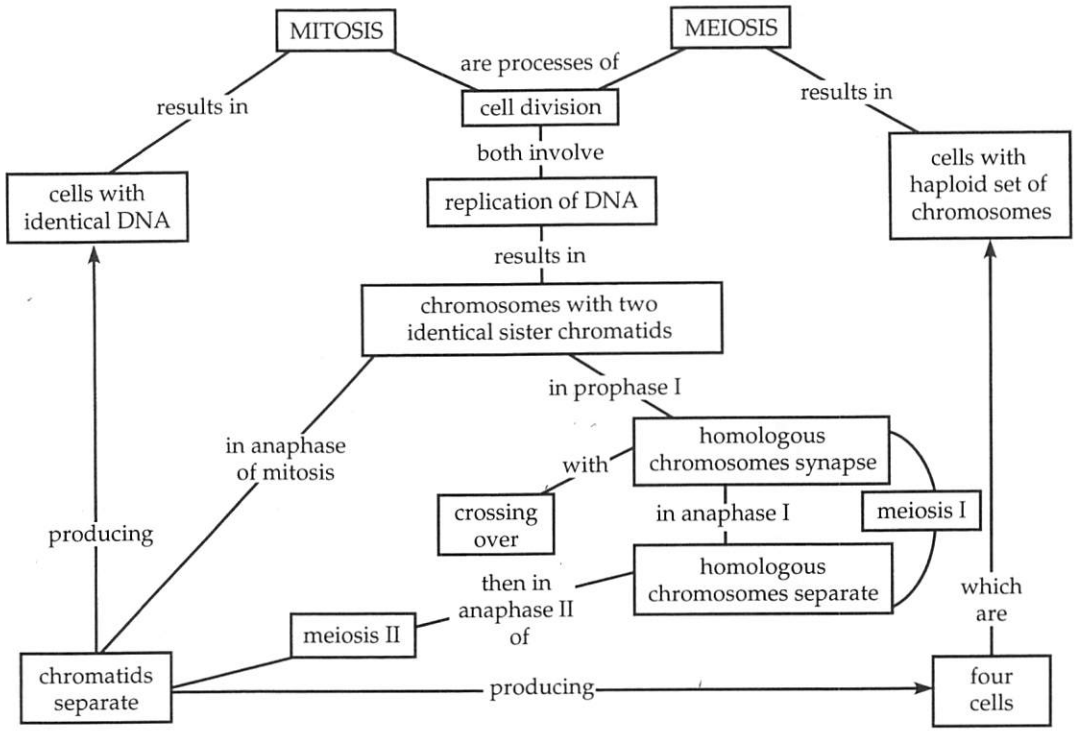
3.



ANSWERS TO TEST YOUR KNOWLEDGE

Multiple Choice:

1. c	**4.** e	**7.** c	**10.** e	**13.** b	**16.** b	**19.** b
2. e	**5.** b	**8.** b	**11.** b	**14.** d	**17.** d	**20.** e
3. b	**6.** a	**9.** b	**12.** c	**15.** b	**18.** e	**21.** c

CHAPTER 11: MENDEL AND THE GENE IDEA

FOCUS QUESTIONS

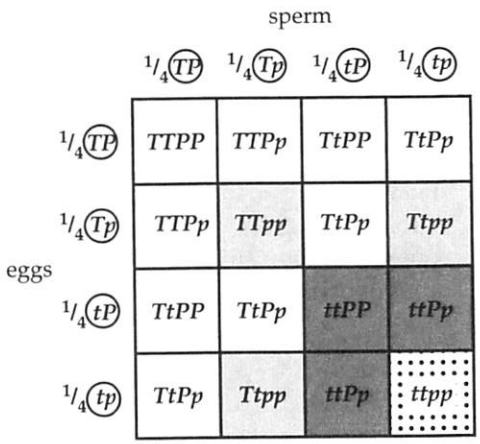
11.1. **a.** *R*
b. *r*
c. F_1 Generation
d. *Rr*
e. F_2 Generation
f. *R*
g. *r*
h. *Rr* ○
i. *Rr* ○
j. *rr* ≋
k. 3 round:1 wrinkled
l. 1 *RR*:2*Rr*:1*rr*

11.2. **a.** all tall (*Tt*) plants, because the tall plant can only contribute a *T* allele and the dwarf plant can only contribute a *t* allele

b. 1:1 tall (*Tt*) to dwarf (*tt*), because the tall plant can contribute either a *T* or a *t* allele
You can use a Punnett square to determine the expected outcome of a testcross, but a shortcut is to use only one row or column for the recessive individual's gametes, since they produce only one type of gamete. For example, in Figure 11.7 you could use only one column for sperm because all sperm contain the recessive *p* allele.

11.3. **a.** all tall purple plants
b. *TtPp*
c. *TP*, *Tp*, *tP*, *tp*

d.



e. 9 tall purple:3 tall white:3 dwarf purple:1 dwarf white

f. 12:4 or 3:1 tall to dwarf; 12:4 or 3:1 purple to white

11.4. **a.** Consider the outcome for each gene as a monohybrid cross. The probability that a cross of *Aa* × *Aa* will produce an *A_* offspring is ¾. The probability that a cross of *Bb* × *bb* will produce a *B_* offspring is ½. The probability that a cross of *cc* × *CC* will produce a *C_* offspring is 1. To have all of these events occur simultaneously, multiply their probabilities: ¾ × ½ × 1 = ⅜.

b. First determine what genotypes would fill the requirement of at least two dominant traits. Offspring could be *A_bbC_*, *aaB_C_*, or *A_B_C*. The genotype *A_B_cc* is not possible. Can you see why?

Probability of *A_bbC_* = ¾ × ½ × 1 = ⅜
Probability of *aaB_C_* = ¼ × ½ × 1 = ⅛
Probability of *A_B_C_* = ¾ × ½ × 1 = ⅜

Probability of offspring showing at least two dominant traits is the sum of these independent probabilities, or ⅛.

c. There is only one type of offspring that can show only one dominant trait (*aabbCc*). Can you see why? Its probability is ¼ × ½ × 1 = ⅛. As you may notice, this would have been an easier way to determine the answer to **b.** With problems such as these, always consider what the question is asking from as many different angles as you can.

11.5. **a.** A: I^AI^A and I^Ai
b. B: I^BI^B and I^Bi
c. AB: I^AI^B
d. O: *ii*

11.6. The ratio of offspring from this *MmBb* × *MmBb* cross would be 9:3:4, a common ratio when one gene is epistatic to another. All epistatic ratios are modified versions of 9:3:3:1.

Phenotype	Genotype	Ratio
Black	*M_B_*	¾ × ¾ = 9/16
Gray	*M_bb*	¾ × ¼ = 3/16
White	*mm*	¼ × 1 = ¼ or 4/16

11.7. **a.** The parental cross produced 25-cm tall F_1 plants; all *AaBbCc* plants with 3 units of 5 cm added to the base height of 10 cm.

b. As a general rule, in the polygenic inheritance of a quantitative character the number of phenotypes resulting from a cross of heterozygotes equals the number of alleles involved plus one. In this case, six alleles (*AaBbCc*) + 1 = 7. So, there will be seven different phenotypes in the F_2 among the 64 possible combinations of the eight types of F_1 gametes. (See why you wouldn't want to go through a Punnett square to figure that out!) These phenotypes will range from six dominant alleles (40 cm), five dominant (35 cm), four dominant (30 cm), and so on, to all six recessive alleles (10 cm), yielding a total of seven phenotypes.

11.8. **a.** This trait is recessive. If it were dominant, then albinism would be present in every generation, and it would be impossible to have albino children with two nonalbino (and thus homozygous recessive) parents.

b. father *Aa*; mother *Aa*, because neither parent is albino and they have albino offspring (*aa*)

c. mate # 1 *AA* (probably); mate # 2 *Aa*; grandson # 4 *Aa*

d. The genotype of son # 3 could be *AA* or *Aa*. If his wife is *AA*, then he could be *Aa* (since both his parents are carriers), and the recessive allele never would be expressed in his offspring. Even if he and his wife were both carriers (heterozygotes), there would be a 243/1024 (¾ × ¾ × ¾ × ¾ × ¾) or 24% chance that all five children would be normally pigmented.

11.9. **a.** ¼

b. ⅔. Of offspring with a normal phenotype, ⅔ would be predicted to be heterozygotes and, thus, carriers of the recessive allele.

11.10. Both sets of prospective grandparents must have been carriers. The prospective parents do

not have the disorder, so they are not homozygous recessive. Thus, each has a ⅔ chance of being a heterozygote carrier. The probability that both parents are carriers is ⅔ × ⅔ = ⅘; the chance that two heterozygotes will have a recessive homozygous child is ¼. The overall chance that a child will inherit the disease is ⅘ × ¼ = ⅕. The fact that the first two children are unaffected does not establish the genotype of the parents. Thus, the third child would also have a ⅕ chance of inheriting the disorder. Should the third child have the disease, however, this would establish that both parents are carriers, and the chance that a subsequent child would have the disease is now estimated at ¼.

SUGGESTED ANSWERS TO STRUCTURE YOUR KNOWLEDGE

1. Mendel's law of segregation occurs in anaphase I, when alleles segregate as homologs move to opposite poles of the cell. The two cells formed from this division have one-half the number of chromosomes and one copy of each gene (although sister chromatids still have to separate in anaphase II). Mendel's law of independent assortment relates to the lining up of homologous chromosome pairs at the equatorial plate in a random fashion during metaphase I. Genes on different chromosomes will assort independently into gametes.

2. *Aa* = 2 different gametes *AaBb* = 4 gametes
AaBbCc = 8 gametes *AABbCc* = 4 gametes
A general formula is 2^n, where *n* is the number of gene loci that are heterozygous. Note that in the last example, *AABbCc*, all gametes will contain a dominant *A* allele.

3. Always look to the F_1 heterozygote resulting from a cross of true-breeding parents. If alleles show complete dominance/recessiveness, then the heterozygote will have a phenotype identical to one parent. In incomplete dominance, the F_1 phenotype will be intermediate between that of the parents. If codominant, the phenotype of both alleles will be exhibited in the heterozygote.

ANSWERS TO GENETICS PROBLEMS

1. White alleles are dominant to yellow alleles. If yellow were dominant, then you should be able to get white squash from a cross of two yellow heterozygotes.

2. **a.** ¼ [½ (to get *AA*) × ½ (*bb*)]
b. ⅛ [¼ (*aa*) × ½ (*BB*)]
c. ½ [1 (*Aa*) × ½ (*Bb*) × 1 (*Cc*)]
d. 1/32 [¼ (*aa*) × ¼ (*bb*) × ½ (*cc*)]

3. Since flower color shows incomplete dominance, use symbols such as C^R and C^W for those alleles. There will be six phenotypic classes in the F_2 instead of the normal four classes found in a 9:3:3:1 ratio. You could find the answer with a Punnett square, but multiplying the probabilities of the monohybrid crosses is more efficient.

Tall red	$T\_C^RC^R$	¾ × ¼ = 3/16
Tall pink	$T\_C^RC^W$	¾ × ½ = ⅜ or 6/16
Tall white	$T\_C^WC^W$	¾ × ¼ = 3/16
Dwarf red	$tt\ C^RC^R$	¼ × ¼ = 1/16
Dwarf pink	$tt\ C^RC^W$	¼ × ½ = ⅛ or 2/16
Dwarf white	$tt\ C^WC^W$	¼ × ¼ = 1/16

4. Determine the possible genotypes of the mother and child. Then find the blood groups for the father that could not have resulted in a child with the indicated blood group.
a. no groups exonerated
b. A or O
c. A or O
d. AB only
e. B or O

5. The parents are *CcBb* and *Ccbb*. Right away you know that all *cc* offspring will die and no *BB* black offspring are possible because one parent is *bb*. Only four phenotypic classes are possible. Determine the proportion of each type by applying the law of multiplication.

Lethal (*cc*_ _)	¼ of all offspring die
Normal brown (*CCBb*)	¼ × ½ = ⅛
Normal white (*CCbb*)	¼ × ½ = ⅛
Deformed brown (*CcBb*)	½ × ½ = ¼
Deformed white (*Ccbb*)	½ × ½ = ¼
Ratio of viable offspring:	1:1:2:2

6. Father's genotype must be *Pp* since polydactyly is dominant and he has had one normal child. Mother's genotype is *pp*. The chance of the next child having normal digits is ½ or 50% because the mother can only donate a *p* allele and there is a 50% chance that the father will donate a *p* allele.

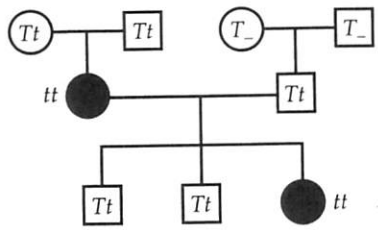
7. The genotypes of the puppies were ⅜ *B_S_*, ⅜ *B_ss*, ⅛ *bbS_*, and ⅛ *bbss*. Because recessive traits show up in the offspring, both parents had to have had at least one recessive allele for both genes. Black:chestnut occurs in a 6:2 or 3:1 ratio, indicating a heterozygous cross. Solid:spotted occurs in a 4:4 or 1:1 ratio, indicating a cross between a heterozygote and a homozygous recessive. Parental genotypes were *BbSs* × *Bbss*.

8. **a.** First figure out possible genotypes: _ _*E*_ = golden (any *B* combination with at least one *E*),

B_ee = black, *bbee* = brown. All you know at the start is that both parents are _ _*E*_. Since you see non-golden offspring, you know that both parents had to be heterozygous for *Ee*, and at least one was heterozygous for *Bb* (to get black and brown offspring). Since black and brown are in a 1:1 ratio (like a testcross ratio), then one hamster was *Bb* and the other was *bb*. You need to consider the results from the second cross to know which hamster was *Bb*.

b. For the second cross, you now know that the black hamster 3 is *B?ee* and the golden hamster 2 is *?bEe*. A ratio of approximately 3:1 black to brown looks like the results of a monohybrid cross, so both parents must be *Bb*. So hamster 3 is *Bbee*, and hamster 2 must be *BbEe*. That means that hamster 1 must be *bbEe*.

9.



(At least one of these grandparents must have been *Tt*)

10. Since the parents were true-breeding for two characters, the F_1s would be dihybrids. Since all F_1s had red, terminal flowers, those two traits must be dominant, and their genotypes could be represented as *RrTt*. One would predict an F_2 phenotypic ratio of 9 red, terminal:3 red, axial:3 white, terminal:1 white, axial. If 100 offspring were counted, one would expect approximately 19 ($\frac{3}{16} \times 100$) plants with red, axial flowers.

ANSWERS TO TEST YOUR KNOWLEDGE

Multiple Choice:

1. c	**5.** a	**9.** c	**13.** b
2. b	**6.** c	**10.** d***	**14.** b
3. c	**7.** d*	**11.** d	**15.** a
4. c	**8.** d**	**12.** e	**16.** c

*There are three different ways to get this outcome: HHT, HTH, THH. Each outcome has a probability of $\frac{1}{8}$.

**Remember that only homozygotes are true-breeding. There are four possible homozygous genotypes: AABB, aabb, AAbb, and aaBB, with a probability of $\frac{1}{16}$ for each one.

***The 34-cm plant would be quadruply homozygous dominant, and the F_1 would be quadruply heterozygous. The number of phenotypic classes in the F_2 would equal the number of alleles plus 1.

CHAPTER 12: THE CHROMOSOMAL BASIS OF INHERITANCE

FOCUS QUESTIONS

12.1.

F_2 Generation

Eggs \ Sperm	X^{w+}	Y
X^{w+}	$X^{w+}X^{w+}$	$X^{w+}Y$
X^{w}	$X^{w+}X^{w}$	$X^{w}Y$

Genotype	$X^{w+}X^{w+}$	$X^{w+}X^{w}$	$X^{w+}Y$	$X^{w}Y$
Phenotype	red-eyed female	red-eyed female	red-eyed male	white-eyed male

12.2. The gene is X-linked, so a good notation is X^N, X^n, and Y so that you will remember that the Y does not carry the gene. Capital *N* indicates normal sight. Genotypes are:

1. X^NY
2. X^NX^n
3. X^NX^N or X^NX^n (probably X^NX^N since four sons are X^NY)
4. X^NX^n
5. X^NY
6. X^nY
7. X^NX^n

12.3. **a.** The phenotypes of offspring that are parental types are tall, purple-flowered and dwarf, white-flowered.

b. The phenotypes of offspring that are recombinants are tall, white-flowered and dwarf, purple-flowered.

12.4. If linked genes have their loci close together on the same chromosome, they travel together during meiosis and *more* parental offspring are produced. Recombinants are the result of crossing over between nonsister chromatids of homologous chromosomes.

12.5. Solving a linkage problem is often a matter of trial and error. Sometimes it helps to lay out the loci with the greatest distance between them and fit the other genes between or on