Name Leonie Hoeher Period _____

Chapter 14: Mendel and the Gene Idea

If you have completed a first-year high school biology course, some of this chapter will serve as a review for the basic concepts of Mendelian genetics. For other students, this may be your first exposure to genetics. In either case, this is a chapter that should be carefully mastered. Spending some time with this chapter, especially working genetics problems, will give you a solid foundation for the extensive genetics unit in the chapters to come.

Overview:

1. In the 1800s the most widely favored explanation of genetics was blending. Explain the concept of blending, and then describe how Mendel's particulate (gene) theory was different. Blending was the idea that DNA from parents combined to form the child's phenotype, which would mean that over time, a population would become uniform. Mendel's theory was that parents pass heritable units on to their children that do not combine, but form a sort of collection of genes that make up the offspring's DNA.

Concept 14.1 Mendel used the scientific approach to identify two laws of inheritance

2. One of the keys to success for Mendel was using pea plants. Explain how using pea plants allowed Mendel to control mating; that is, how did this approach let Mendel be positive about the exact characteristics of each parent?
Mendel probably chose peas because there were different varieties with different traits that also exhibited complete dominance. This means he could tell clearly which trait the parent and offspring showed fully. Also, pea plants can mate and self-fertilize and produce a lot of offspring. Mendel could control mating.
3. Define the following terms. Then, consider your own family. Which generation would your Mom's grandparents be? Your Mom? You?

P generation
parental generation (true-breeding)

F_1 generation
first filial generation after P generation (hybrids)

F_2 generation
second filial generation after F_1 self- or cross-pollinate with other F_1 hybrids

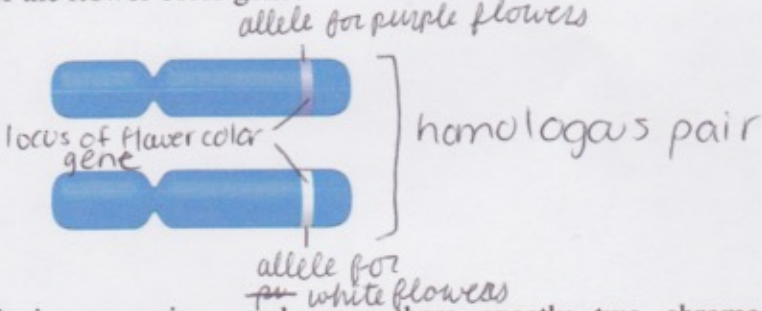
4. Explain how Mendel's simple cross of purple and white flowers did the following:

refuted blending
the white flowers were not "deleted" from the genes (came up again in F_2)
determined dominant and recessive characteristics
F_1 generation exhibited only purple, but F_2 had a white & "unmasked" flower
demonstrated the merit of experiments that covered multiple generations
he showed that observing multiple generations could explain much more about inheritance of certain traits

5. Alternate versions of the same gene, like purple and white flower color, are termed

alleles.

6. On the figure at below, label the *allele* for both purple and white flower color, a *homologous pair*, and the *locus* of the flower color gene.



7. In sexually reproducing organisms, why are there exactly two chromosomes in each homologue?
There are two because there is one from each parent present in the homologous pair

8. Mendel's model consists of four concepts. Describe each concept in the appropriate space below. Indicate which of the concepts can be observed during meiosis by placing an asterisk by the concept.

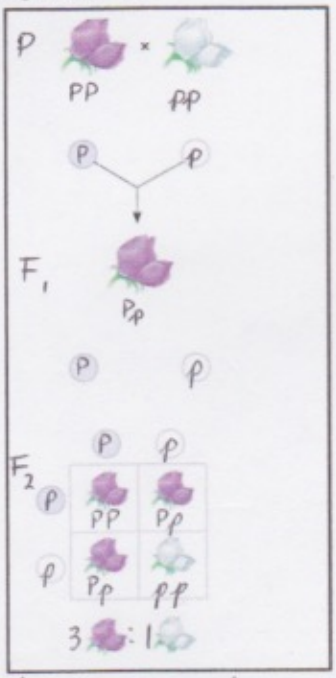
Mendel's Four Concepts	Description of Concept
1st concept	Different alleles accant for the variations in the inherited characteristics
2nd concept	An organism inherits two copies of a gene from each parent for each character
3rd concept	If the alleles are different, then the dominant allele will determine the phenotype
4th concept * (*law of segregation*)	The two alleles for a character seperate from each other during gamete formation and end up in different gametes

9. Using Figure 14.5 as your guide, provide the missing notations for the figure below. (P, F_1, F_2).

a. What is the F_2 phenotypic and genotypic ratio?
The phenotypic ratio is 3:1
The genotypic ratio is 1:2:1

b. Which generation is completely heterozygous?
The F_1 generation.

c. Which generation has both heterozygous and homozygous offspring?
The F_2 generation.



law of segregation

10. In pea plants, *T* is the allele for tall plants, while *t* is the allele for dwarf plants. If you have a tall plant, demonstrate with a *test cross* how it could be determined if the plant is homozygous tall or heterozygous tall. TT or Tt x tt P

TT x tt → all heterozygous, therefore all tall offspring
Tt x tt → hano- and heterozygous, therefore some dwarf plants
Depending on what the offspring looks like after the tall plant is crossed with a nanozygous recessive one, the plant will either be TT or Tt.

11. Explain the difference between a *monohybrid* cross and a *dihybrid cross*.
A monohybrid cross is for heterozygote mating where one trait is being followed, while a dihybrid cross follows two characteristics of heterozygotes and determines whether the traits are inherited together.

12. As you start to work word problems in genetics, two things are critical: the parent's genotype must be correct, and the gametes must be formed correctly. Using Figure 14.8 as your guide, explain how the gametes are derived for the following cross. (You should have four different gametes).

YyRr × *YyRr*

The possible gametes from this cross will be: YR, Yr, yR, yr
Each allele can combine with every other allele from the parent in one gamete.

13. Complete the cross given in questions 12 by placing the gametes in a *Punnett square*. Then provide the phenotypic ratio of the offspring.

	YR	Yr	yR	yr
YR	YYRR	YYRr	YyRR	YyRr
Yr	YYRr	YYrr	YyRr	Yyrr
yR	YyRR	YyRr	yyRR	yyRr
yr	YyRr	Yyrr	yyRr	yyrr

Phenotypes/Phenotypic Ratio

9 yellow and rand
3 green and rand
3 yellow and wrinkled
1 green and wrinkled

9:3:3:1

14. Explain Mendel's *law of independent assortment*.
Every pair of alleles segregates independently of each other pair of alleles during gamete formation.

Before leaving this concept, it would be helpful to complete the three problems in the 14.1 Concept Check on page 269 of your textbook. The problems are worked and explained in the Answer section on page A-10 at the back of the book.

Concept 14.2 The laws of probability govern Mendelian inheritance

15. An event that is certain to occur has a probability of __1__, while an event that is certain not to occur has a probability of __0__.

16. In probability, what is an *independent event*?
An independent event is one where the outcome is unaffected by previous trials.

17. State the *multiplication rule* and give an original example.
To determine the probability of a die rolling a 3 twice, fore example, the probability of one event is multiplied by the probability of the other event. (in this case: $1/6 \cdot 1/6 = 1/12$)

18. State the *addition rule* and give an original example.
The probability that any one of two or more mutually exclusive events will occur can be calculated by adding their individual probabilities.

A 5 and a 2 on a die can be rolled either 5, then 2 or 2 then 5. Rolling a 5 then a 2: 1/12 Rolling a 2 then 5: 1/12
Adding these will give you the probability of getting a 5 and a 2: $\frac{1}{12} + \frac{1}{12} = \frac{2}{12} = \frac{1}{6}$

19. What is the probability that a couple will have a girl, a boy, a girl, and a boy in this specific order? 1/2 · 1/2 · 1/2 · 1/2 = 1/16

Concept 14.3 Inheritance patterns are often more complex than those predicted by simple Mendelian genetics

20. Explain how *incomplete dominance* is different from *complete dominance*, and give an example of incomplete dominance.
Incomplete daminance is when the phenotype is a mixture of the two parental phenotypes, rather than exactly one of the two parental ones. If a flower is a combination of the two parental colors (red + white = pink) the alleles are incompletely dominant.

21. Compare and contrast *codominance* with *incomplete dominance*.
Codominance is when the alleles affect the phenotype in distinguishable ways. For example a red flower and a white flower give rise to a red and white flower.

22. Dominant alleles are not necessarily more common than recessive alleles in the gene pool. Explain why this is true.

23. Explain what is meant when a gene is said to have *multiple alleles*.
Genes exist in more than two allelic forms often, meaning a gene could have one allele, or two, or none, each with different characteristics

24. Blood groups are so important medically that you should be able to solve genetics problems based on blood types. The first step in accomplishing that is to understand the genotypes of each blood type. Before working any problems, complete this ABO blood type chart.

Genotype	Red Blood Cell Appearance	Phenotype (blood group)
$I^A I^A$ $(I^A i)$		A
$I^B I^B$ $(I^B i)$		B
$I^A I^B$		AB
ii		O

25. Question 2 in the 14.3 Concept Check is a blood type problem. Complete it here, and show your work.

	I^A	I^B
i	I^Ai	I^Bi
i	I^Ai	I^Bi

You would expect either blood type A or B in their children. Half of their children are A, half are B.

26. What is *pleiotropy*? Explain why this is important in diseases like cystic fibrosis and sickle-cell disease.

Pleiotropy is when genes can have multiple effects on phenotype. Pleiotropic alleles are responsible for the multiple symptoms associated with diseases like sickle-cell or cystic-fibrosis.

27. Explain *epistasis*.

In epistasis, the expression of a gene at one locus alters the phenotypic expression of another gene at a different locus.

28. Explain why the dihybrid cross detailed in Figure 14.12 has 4 white mice instead of the 3 that would have been predicted by Mendel's work.

Figure 14.12 shows 4 yellow labs because the gene that determines if pigment will be deposited or not is epistatic to the gene for what color pigment. The E/e gene overrules the gene for pigment color.

29. Why is height a good example of *polygenic inheritance*?

Polygenic inheritance is the additive effect of two or more genes on a single phenotypic character. Height could be a good example because of the broad variation in height seen among a population. There is no either-or for height.

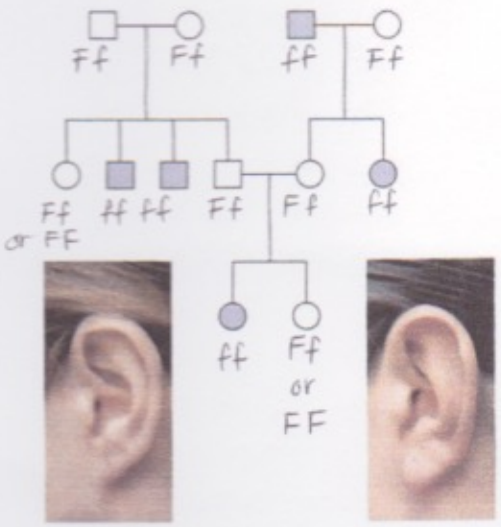
30. *Quantitative variation* usually indicates polygenic inheritance.

31. Using the terms *norm of reaction* and *multifactorial*, explain the potential influence of the environment on phenotypic expression.

The norm of reaction is the range of phenotypic possibilities for a genotype due to environmental influences. This shows how phenotypes can be affected by environmental factors, like red blood cell count. Multifactorial characters can be influenced by genetic and environmental factors, which collectively determine the phenotype.

Concept 14.4 Many human traits follow Mendelian patterns of inheritance

32. Pedigree analysis is often used to determine the mode of inheritance (dominant or recessive, for example). Be sure to read the "Tips for pedigree analysis" in Figure 14.15; then complete the unlabeled pedigree by indicating the genotypes for all involved. What is the mode of inheritance for this pedigree?



purple → attached earlobe
white → unattached earlobe

The attached earlobe trait is recessively inherited. This can be seen by the third generation's first daughter. She has ~~un~~attached earlobes, while both parents have free earlobes. This can be explained by both parents having heterozygous genotypes. If the trait was not inherited recessively, at least one parent must have had unattached earlobes as well, which they didn't.

33. Explain why you know the genotype of one female in the third generation, but are unsure of the other.

The second daughter's genotype could be Ff or FF because both variations would lead to free earlobes.

34. Describe what you think is important to know medically about the behavior of recessive alleles.

If recessive alleles lead to a harmful trait or disease, it would be important to know if parents have the gene for a disorder and could make a child with a disability or fatal disease.

35. Students are expected to have a general knowledge of the pattern of inheritance and the common symptoms of a number of genetic disorders. Provide this information for the disorders listed below.

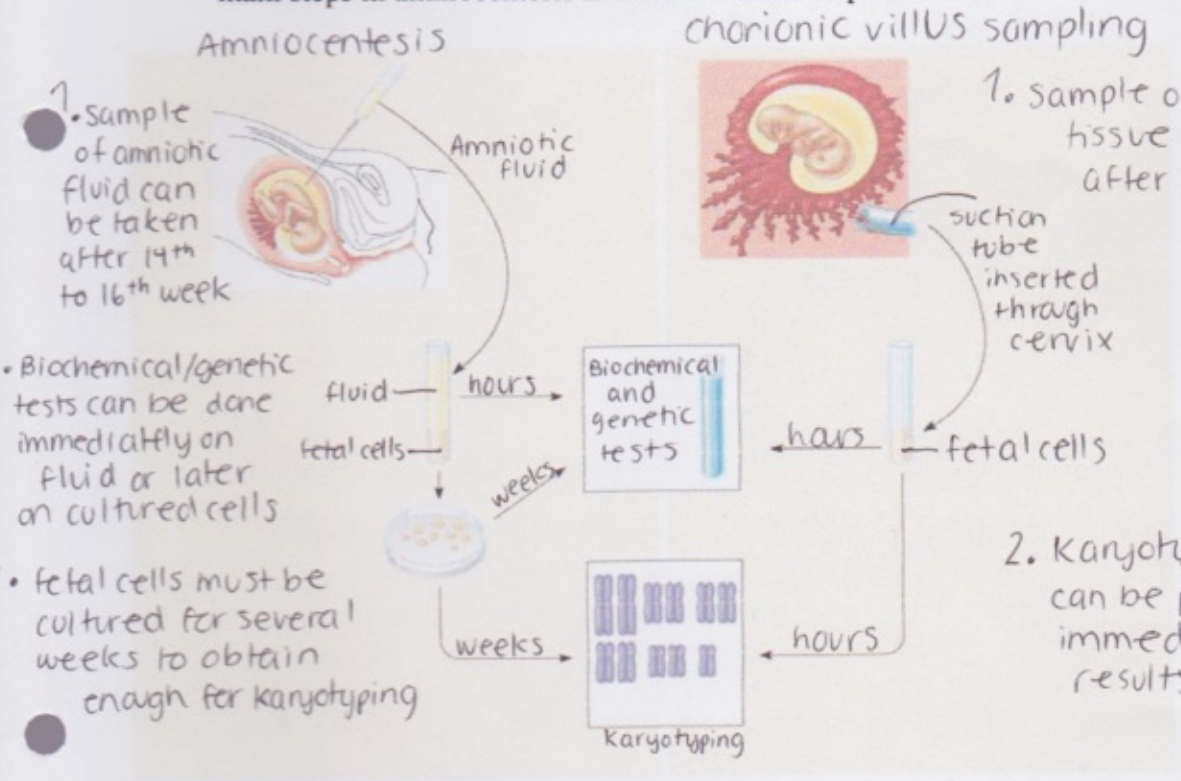
a. cystic fibrosis
- → recessively inherited
- → defective membrane protein for chloride, mucus builds up in lungs, pancreas, digestive tract, poor absorption of nutrients, chronic bronchitis, infections, premature death

b. sickle-cell disease
- → recessively inherited
- → substitution of amino acid in hemoglobin protein
- → low oxygen content leads to deformed red blood cells
- → clumping & clogging of cells, physical weakness, pain, organ damage, even paralysis, brain damage
- → can be beneficial in heterozygotes against malaria

c. achondroplasia
→ dominantly inherited
→ heterozygotes have dwarf phenotype
→ bone defects
→ 99.99% of pop. have homozygous recessive genotype

d. Huntington's disease
→ dominantly inherited
→ degenerative disease of nervous system
→ movement and psychiatric disorders

36. ***Amniocentesis*** **and** ***chorionic villus sampling*** **are the two most widely used methods for testing a fetus for genetic disorders. Use the unlabeled diagram below to explain the three main steps in amniocentesis and the two main steps of CVS.**



37. **What are the strengths and weaknesses of each fetal test?**
CVS gives results very fast and can be done earlier, but may cause complications.
Amniocentesis only requires some amniotic fluid and can be done quite early in the pregnancy, however it takes a few weeks and could cause complication.

38. **Explain the symptoms of** ***phenylketonuria***, **and describe how newborn screening is used to identify children with this disorder.**
Phenylketonuria causes children not to be able to metabolize the amino acid phenylalanine. This compand can accumulate to toxic levels and cause severe intellectual disability. Newborn screening can identify this disorder and a special diet can be administered and allow normal development.

Testing Your Knowledge: Genetics Problems (pg. 284)
Now you should be ready to test your knowledge.

This chapter does not have a Self-Quiz, but rather asks you to do a series of problems. One of the ways to determine your understanding of Mendelian genetics is to work many genetic problems. Complete the questions from the problems at the end of the chapter.

Before starting, it would be productive to read the "Tips for Genetic Problems" on page 283. Work neatly, and show all work. As you know, you can check your solutions in your text. Nope 329

Questions 1, 2, 3, 5, 6, 7, 8, 9, 13, 16, 17, 19

7) Aa Tt Rr

a) homozygous for dominant traits
AATTRR
$1/2 \cdot 1/2 = 1/4$ $1/4 \cdot 1/4 \cdot 1/4$
$1/2 \cdot 1/2 = 1/4$ $= 1/64$
$1/2 \cdot 1/2 = 1/4$

b) homozygous for recessive traits
aattrr
$1/64$

c) heterozygous for all three
AaTtRr

	A	a
A	AA	Aa
a	Aa	aa

$\cdot 1/2 \cdot 1/2 \cdot 1/2$
$= 1/8$ (8/64)
$\downarrow$
$1/2$ Aa

d) homozygous for axial + tall, hetero. for shape
aatt Rr
$1/4 \cdot 1/4 \cdot 1/2$
$= 1/32$ (2/64)