

UNIT EIGHT: PATTERNS OF INHERITANCE

Upon completion of this unit you will be able to:

1. State Mendel's three laws of inheritance.
2. Distinguish between genotype and phenotype.
3. Provide examples of homozygous and heterozygous genotypes.
4. Define and describe a gene and homologous chromosomes.
5. Define and describe alleles.
6. Use the Punnett Square as a tool in solving genetic problems.
7. Predict the probability of outcomes for various genetic crosses.
8. Discuss the need to be able to deal with probability vs. possibility vs. reality when dealing with the outcomes of genetic crosses.
9. Obtain the possible gametes from any given genotype.
10. Use proper symbols for genes and generations to illustrate crosses with one pair of alleles (monohybrid) and two pairs of alleles (dihybrid).
11. Determine the genotype and phenotype ratios of the F1 and F2 generations when given the genotype of the parents.
12. Set up a back cross (test cross) to determine the genetic make-up of an individual.
13. Explain how crossing-over occurs and what results from it.
14. Explain why genes located on the same chromosome tend to be inherited together.
15. Differentiate between autosomes and sex chromosomes.
16. Explain chromosomal determination of sex in man.
17. Define nondisjunction and explain its relevance to chromosomal genetics (repeat objective from unit 7).
18. Compare the gene composition of the X and Y chromosomes.
19. Work genetic problems dealing with multiple alleles, polygenic inheritance and X-linked characteristics.
20. Cite examples of incomplete dominance.
21. Contrast sex-linked and sex-influenced genes.
22. Explain the significance of lethal genes.
23. Give examples which tend to illustrate that the environment influences the phenotypic development of the genotype.
24. Explain why one inherits the potential for characteristics rather than the characteristics per se.
25. Explain why many genetic studies utilize *Drosophila melanogaster*.
26. Explain the importance of statistical tests regarding genetic studies.

Unit References:

Text Chapter 10

<http://www.mhhe.com/enger13>

[An Online Biology Text Book](#)

Unit 8: Patterns of Inheritance

When Dealing with Genetics you must deal with: (Objective #8)

Possibility vs. Probability vs. Reality

Gregor Mendel: Father of Modern Day Genetics, Austrian Monk (1860) **Pg 204-206**

Modern day modifications to what we learned from Mendel's thinking:

Traits controlled by genes passed from generation to generation

Traits expressed by 2 genes, one maternal, one paternal

1. Meiosis creates gametes, one chromosome of each pair passed
2. Upon fertilization, each parent contributes matching chromosomes (Homologous)
3. Chance alone determines which chromosome goes to which gamete.
4. Dominant (default) gene -----> codes for protein (symbol = capital letter)
Recessive gene -----> does not transcribe (symbol = lower case letter)

Additional Vocabulary: (Objective #2, 3, 5) text pg 200-202

Genotype-

Phenotype-

Genome-

Homozygous (dominant or recessive)-

Heterozygous-

Alleles-

Mendel's Laws of Heredity: (Objective #1) text pg. 205-206

1. Law of Dominance:
2. Law of Segregation (meiosis chapter 9):
3. Law of Independent Assortment (meiosis chapter 9):

Check Out: [Talking Glossary of Genetic Terms](#)
[Mendel Web](#)

SOLVING GENETICS PROBLEMS: (Objective #6, 7, 8, 9, 10, 11) text pgs 206- 211

Probability vs. Possibility vs. Reality

Predict: Offspring phenotypes, genotypes and ratios represented

Single Factor Cross: Monohybrid

5 step process: pg 206-209

Earlobes pg 200: Free vs. Attached

Step 1: Assign a symbol for each allele

E = free e = attached

Step 2: Determine genotypes of parents and indicate a mating
Mate two Heterozygous parents $Ee \times Ee$ (could have been $EE \times EE$; $EE \times Ee$ etc.)

Step 3: Determine all possible gametes each parent can produce
 Ee can produce (or pass to offspring) gametes containing E or e .

Use Punnett Square to show mating

Each box represents a possible offspring

Gametes		

Step 4: Determine all gene combinations resulting when these gametes unite (fill in Punnett)

Step 5: Determine Phenotype of each gene combination

$EE = \text{Free}$ $Ee, eE = \text{Free}$ $ee = \text{attached}$

*Genotype ratio 1:2:1 Phenotype ratio 3:1

Mendel's Classic Pea Plant Cross (Objective #6 – 11)

Mate: Homozygous Dom Tall (T) X Homozygous Rec Short (t)

Parents ??? (Considered to be the P generation)

Offspring ??? (Considered to be the F_1 generation)

Gametes		

Mate: Two F₁ Individuals of previous cross (heterozygous tall)

Mating ???

Offspring (considered to be the F₂)??? Ratios ???

Gametes		

Problem #3 of problem sheet details similar crosses and will be very similar to Monohybrid test question

Practice

(Objective #6-11)

Monohybrid examples (text pg 208-209):

Do genotype and phenotype ratios change according to cross?

In humans: P is the gene for normal phenylalanine metabolism

p is the gene possessed by PKU individuals

What ratios result from:

Homozygous normal X heterozygous (carrier) normal

Gametes		

Heterozygous normal X homozygous PKU

Gametes		

Check Out: [Punnett Square Animations](#)

(Objective #6-11)

Double Factor Cross: Dihybrid Inheritance- inheritance patterns when two traits are involved Text pgs 209-210

Alleles: T - Tall t - short R - Rough r- smooth

1. Cross homozygous Tall/Rough with homozygous short/smooth

Parents Genotypes?:

Gametes				

2. Cross two F₁ offspring (both heterozygous for both traits)

Parents Genotypes?:

Gametes				

Problem: Since homozygous dominant and heterozygous individuals appear the same how do we tell them apart genetically? (Ex. TT and Tt both appear tall; TTRR and TtRr both appear to be Tall and Rough)

Test Cross (back cross) Somewhat old school (Objective #12)- crosses used to preserve pure lines; identify heterozygotes

*Cross questionable dominant with a **HOMOZYGOUS RECESSIVE** individual

***Monohybrid** - tall plant, is it TT or Tt?

if TT then $TT \times tt$ will only produce Tt (tall) offspring

if Tt then $Tt \times tt$ will give Tt (tall) or tt (short) 1:1 ratio

***Dihybrid** - Tall/ Rough, is it TTRR or TtRr? (or TTRr; TtRR)

if TTRR then $TTRR \times ttrr$ will only produce TtRr (Tall/ Rough) offspring

if TtRr then $TtRr \times ttrr$ will produce TtRr; Ttrr, ttRr, ttrr in 1:1:1:1 ratio

Check Out: [Biology Project- Dihybrid Cross Problems](#)

(Objective #13) Text pg 190-191

CROSSING OVER- swap of homologous genetic info; occurs during meiosis, creates genetic variability

Check Out: [Crossingover of Chromosomes during Meiosis](#)

Homologous chromosomes (no crossover)

Homologous chromosomes (single crossover)

chiasma

Alert!! Trivial info coming pencils could explode if attempts are made to copy all of this!

*Crossing over contributes to variability of genome

Total possible combos for one individual = 2^n (2 possible outcomes; n = total # of chromosome pairs; humans n = 23)

Example, one coin two possibilities $2^1 = 2$ (head or tail)

two coins two possibilities for each coin $2^2 = 4$ possible outcomes

Humans $2^{23} = 8,388,608$ possible combos (remember the party?)

if one crossover (there are usually many)

$4^{23} = 70,368,744,000,000$ possible combos for one individual

When fertilization takes place: with one crossover $(4^{23})^2$ or

4,951,760,200,000,000,000,000,000 different possible offspring/couple!

Chromosome Theory (Objective #14, 15, 16)- Chromosomes carry hereditary units (genes), since traits are more numerous than chromosomes, then each chromosome carries many traits.

-Gene linkage and linkage groups. Text pg 216-220

Humans: 23 pairs of chromosomes, therefore, 23 linkage groups

22 pairs of autosomes (not involved in sex determination)

1 pair of sex chromosomes (alone determine sex of individual), X and Y

XX = female; XY = male

Upon meiosis: female gametes can only contain an X

male gametes can contain an X or a Y (50:50 prob of either)

Male determines sex of offspring (did Henry the VIII know?!?!)

Potential Problems with Meiosis: (Objective #17) text pg 193-194

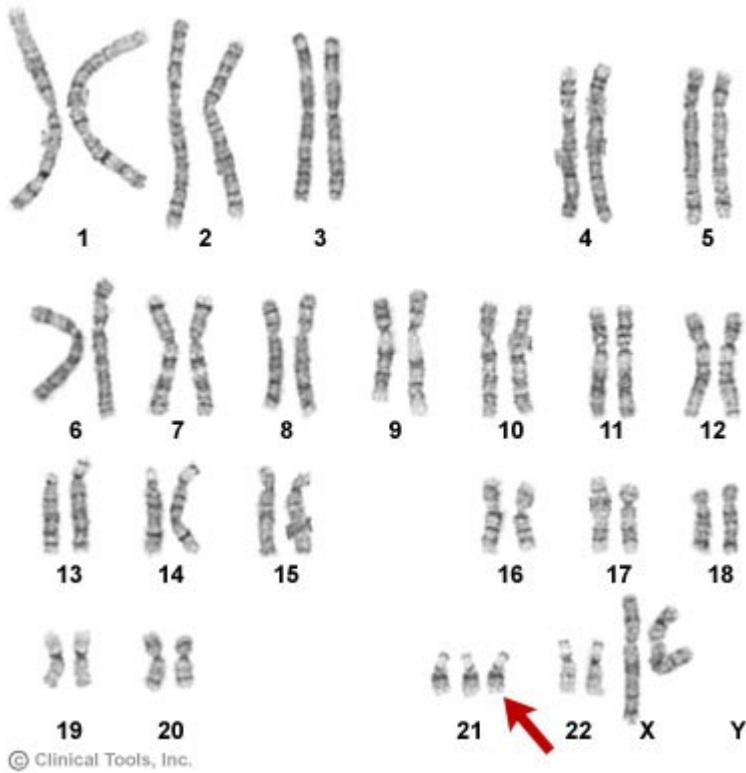
Nondisjunction- failure of chromosomes to properly divide during meiosis

In Sex Chromosomes can be tolerated: Turners = XO; Klinefelters = XXY

***XYY male

In Autosomes, nondisjunction is rarely tolerated: Down's syndrome

Karyotype from a female with Down syndrome (47,XX,+21)



Check Out: [Introduction to Chromosome Abnormalities](#)

REAL WORLD GENETICS: GENE INTERACTION

1. **Incomplete Dominance (lack of dominance); Codominance** (Objective #20) text pg 210- 213

-two unlike alleles both expressed equally, appear to produce intermediate phenotype in the heterozygote

Snap dragon petal color (roan cattle, 4 O'clocks)
 F^W - white flower; F^R - red flower (alleles at same locus)

$F^W F^W \times F^R F^R \rightarrow F^W F^R$ (all Pink)

Gametes	F^W	F^W
F^R		
F^R		

$F^W F^R \times F^W F^R \rightarrow F^W F^W : F^W F^R : F^R F^R$ (in 1:2:1 ratio)

Gametes	F^W	F^R
F^W		
F^R		

2. **Multiple Alleles** (Objective #19) text pg 213-214- characteristics determined by more than two different alleles.

(Multiple alternative forms of a gene) Ex. Cystic Fibrosis, 350 different forms of that gene.

Human Blood Types: A, B, AB, o

Alleles: A, B (are codominant) and o (A and B are dominant to o)
to be type o you must be homozygous recessive

Type AB mother says Type o man is father of her Type A child. Possible?

Gametes	A	B
o		
o		

Type AB mother says Type o man is father of her Type AB child. Possible?

Gametes	A	B
o		
o		

Check Out: Genes and Blood Type

3. **Polygenic inheritance** (Objective #19) text pg 214- ("Mailman", "Milkman", "UPS man", "Schwan man" Syndrome)

-inheritance determined by several genes at different locations. Ex. Eye color, skin

color, height.

*Results in wide variation in the expression of the trait, statistically will fit a bell shaped curve.

Skin color: AABBCc (Black) X aabbcc (White) -----> AaBbCc (Mullato)

AaBbCc ---> 3 different genes each with 2 possible outcomes = 8 combos

Check Out: Polygenic Inheritance

4. Pleiotropy pg 215-216

One gene/many effects: Marfans, PKU

5. Sex Linked Inheritance (Objective #18, 19, 21) text pg 217-218 - refers to inheritance of genes on the X chromosome.

-since females have XX and males XY then all the genes on the X for the male are expressed whether they are dominant or recessive

X chromosome

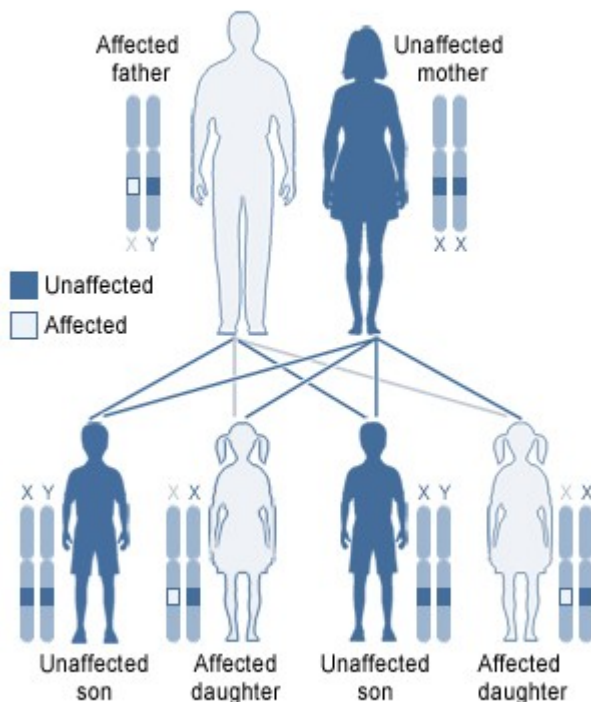
Long
many genes, many alleles

Y chromosome

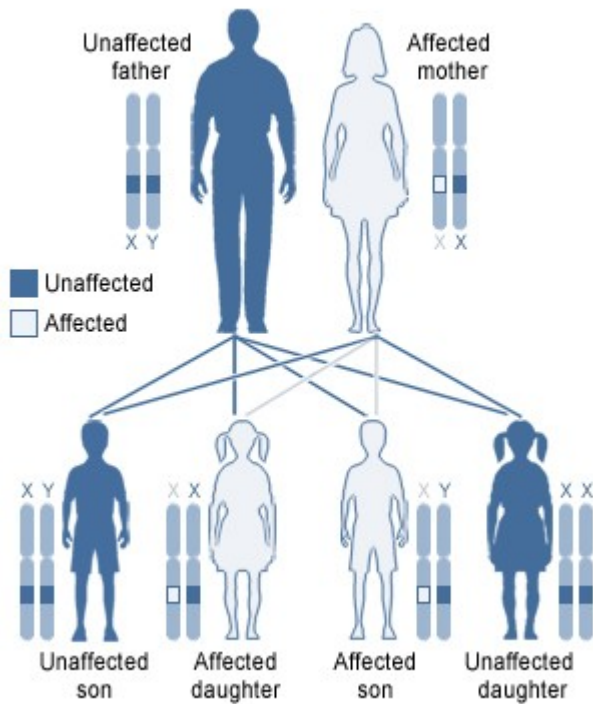
short
few alleles (perhaps a few in common with X)
Y contains male determining genes

**X and Y are not homologous

X-linked dominant, affected father



X-linked dominant, affected mother



Red/ Green Colorblindness: X^N = normal; X^n = colorblind; Y = male, contains no cb genes

Cross: Normal male ($X^N Y$) X heterozygous female (normal carrier; $X^N X^n$)

Gametes	X^N	X^n
X^N		
Y		

*Did son inherit colorblindness from father?

*What do sons inherit from their fathers?

Calico Cats are females: X^B = black; X^G = gold and are sex linked

Check Out: [NOVA Sex Determination](#)

- 6. Sex- influenced (Objective #21)-** Determined by autosomes (not X or Y). Phenotype appears in both sexes but different genotypes are necessary in males and females to produce phenotype

Ex. pattern baldness; Index finger longer than or equal to 4th finger dom in females

**Hormonal differences between sexes usually responsible

7. **Lethal genes** (Objective #22)- mutations to genes that lead directly to the death of organism before reproductive age ex. Huntingtons disease (rare in that it appears after reproductive age)

INHERITANCE CONDITIONS

Nature vs. Nurture (Objective #23, 24) pg 218- 220

debate but no clear answer, wise person agrees influence is from both
-possible for two identical genotypes (twins) to differ in phenotypes

Environment effects expression- even though you inherit a trait, the environment may not allow you to express it

Internal environment (chemical)- Ex. male voice, genes for pitch;

pre puberty vs. post puberty

External environment- Ex. Snowhare rabbit, siamese cat

Coat color genes may not reveal themselves unless the temp of skin is above/below a certain point, *most dramatically seen on feet, ears

Humans- freckles appear upon exposure to sun

Check Out: [Your Genes, Your Health](#)
[National Society of Genetic Counselors](#)

[Back to General Biology at WNCC](#)