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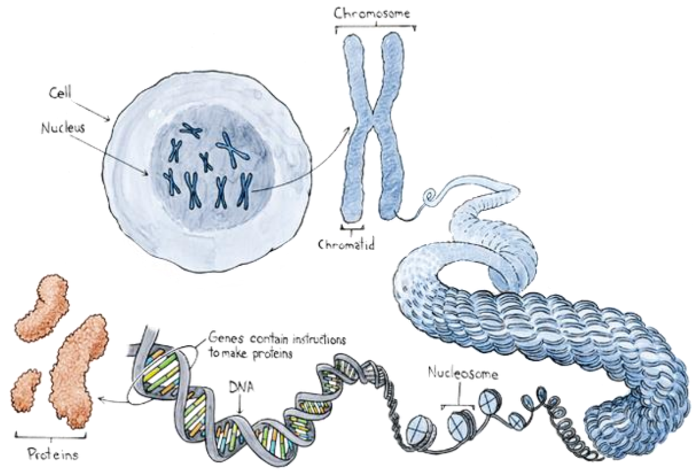
Unit 7, Topic 1: Mendel and Basic Crosses

By the end of this topic, you should be able to…

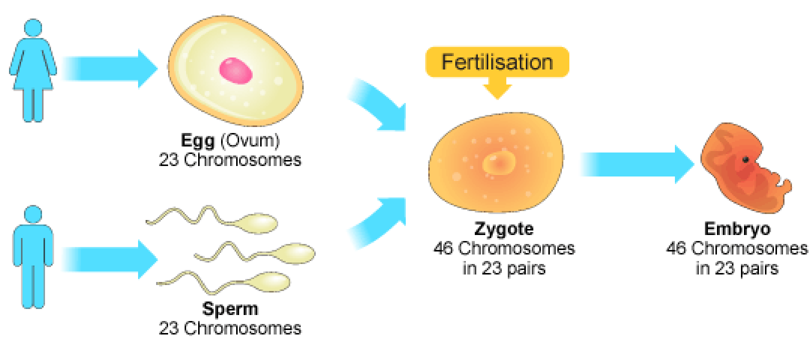
1. *Use basic genetic vocabulary (genotype, phenotype, homozygous, heterozygous, dominant, recessive)*
2. *Describe the experiments of Gregor Mendel and the laws he established*
3. *Produce and analyze Punnett squares for basic monohybrid crosses*



Important Genetics Vocabulary:

- **Genetics** – the study of ________________________________
- **Heredity -** characteristics passed from __________________ to _____________________ through genes (*passing of traits from parent to offspring*)
- **Trait** - specific characteristic that can be passed from parent to offspring (*hair color, flower color, seed pod*)
- **Gene** – _________________________________ found on the DNA that determines a trait (*section of DNA that codes for a protein/trait*)
- **Allele** – a _____________________ form of the same gene that specifically designates what that trait will look like *(variation of a gene/trait*)
- **Dominant** – the trait that is visible (seen), always ________________________ (BB)
- **Recessive** – the trait that is **sometimes hidden** (not seen) when paired with a dominant trait. Only visible (seen) when there are 2 recessive alleles being expressed (bb)
- **Homozygous:** organisms that have 2 ______________________ alleles for a particular trait and are called true-breeds (purebred – BB)
- **Heterozygous**: organisms have 2 ___________________ alleles for the same trait and are called hybrids (Bb).
- **Genotype:** Refers to the genetic make up of an organism. (Tt, Ss)
- **Phenotype**: Refers to the ____ of an organism. (Tall or short, yellow or green, short tail or long tail)

How are genes inherited?



- Humans have _____________ of chromosomes for a total of 46 chromosomes. Each parent contributes only _________ of chromosomes to their child.
    - *Body cells are diploid. Gametes (sex cells) are haploid.*
- When a sperm cell (____ chromosomes) and an egg cell (____ chromosomes) join during fertilization, it results in a _____________________ (___ chromosomes).

Mendelian Genetics

- Gregor Mendel is known as "The Father of Genetics"
- Studied English Pea Plants (1800s) to determine inheritance of traits.

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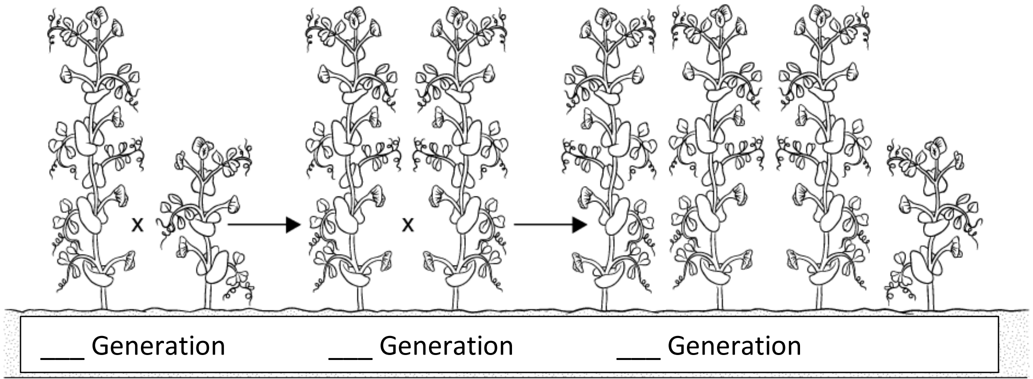
- Used self and cross pollination in plants to determine the process of inheritance.
- Determined Generations:
  1. <u>Parental Generation</u> (purebreds – ______________________________ : PP or pp genotypes)
  2. <u>F1 Generation</u> (hybrids – ______________________________ : Pp genotypes)
  3. <u>F2 Generation</u> (3:1 ratio of traits PP, Pp, pp)

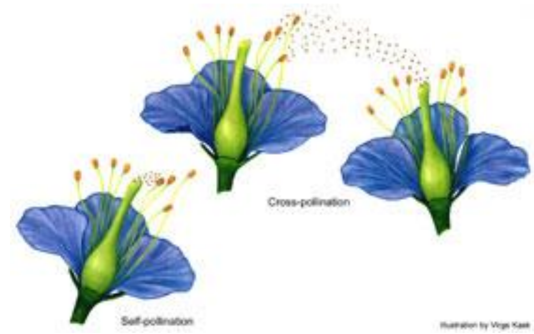


Why Use Pea Plants?

______________ reproduction	________________________ traits
__________________________ parts on the same flower	Ability to control ____________________ and fertilization

Some terms to know:

- Self-pollinating--sperm cells in pollen fertilize egg cells in the ______________________________________
- Fertilization--during sexual reproduction, male and female reproductive cells join and produce a new cell.
- True-breeding peas--when they self-pollinated, they would produce offspring ____________________ to themselves.
- Cross-pollination-____ plants pollinating to produce seeds.
- He wanted to produce seeds from two different plants.
  - He took off the pollen-bearing male parts
  - He dusted pollen from another plant 1st set of experiments



1st Set of Experiments

- __________________ factor cross (looking at one trait: ____________________________)
- Cross pollinated plants with __________________ characteristics to see which trait would appear in the F1 hybrid
- Concluded individual factors called genes (that have different forms called alleles) control each trait of a living thing (and one may be dominant over another)

<u>The Law of Dominance (LAW 1)</u>

- Alleles can be either ______________________ or ___________________________ (strong or weak)
- _______________________________ alleles are observable
  - Represented using a ______________________ letter
- Recessive alleles are not usually observable, when the dominant allele is present (can still be in genotype)
  - Represented using a _____________________ letter
- Each trait requires TWO alleles (the following table examines flower color, with purple being dominant over white):

Genotype	Phenotype	Genotypic Description
AA		
Aa		
aa		

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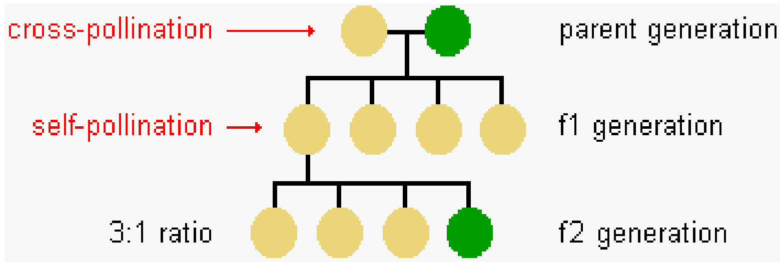
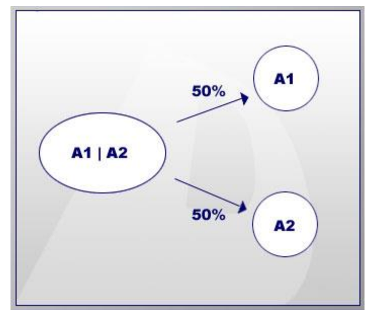
2nd set of experiments

- Wanted to know what happened to ___________________ factors so let F1 hybrids __________pollinate
- Concluded that a dominant allele had covered up (masked) the recessive allele in the F1 generation
- Observed that a recessive allele had _______________________ from dominant allele in the F2 generation



<u>*The Law of Segregation (LAW 2)*</u>

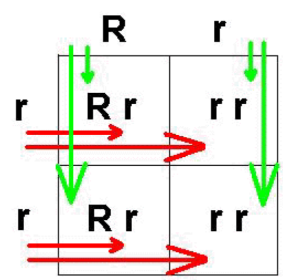


- Alleles for a gene ____________________ when forming a sperm and egg (meiosis)
- There are TWO alleles for each trait (1 in each of the chromosome pairs)
- When eggs and sperm are made, the <u>two alleles are separated from each other</u> (on their respective homologous chromosomes)

<u>*Law of Independent Assortment (LAW 3)*</u>

- Alleles for different genes are distributed to sperm and egg independently
- Explains why all siblings do not look exactly alike
- Each pair of alleles sorts out independently during gamete formation
- Ex. Brown hair and brown eyes aren't connected
- INDEPENDENT ASSORTMENT: "the random alignment of _______________________________ chromosomes at metaphase plate (Metaphase I)"

What is a Punnett Square ?



- A tool or grid used to _____________ and compare the ______________ variations that will result in a cross of two organisms traits.
- Probability:
  - Probability predicts average outcome from a *LARGE* # of events
  - Small # of events not always "accurate"
- Punnett squares are used to predict and compare the genetic variations that result from a cross using the <u>*principles of probability*</u>
- Ratios:
  - ¼ : fractions
  - 3:1 (dominant phenotype to recessive phenotype)
  - 1:2:1 (DD: Dd: dd)
- Percentages:
  - ½ = 50%

Dominant and Recessive
(T = Tall & t = short
Cross: Tt x Tt

	T	t
T	TT	Tt
t	Tt	tt

Genotypic ratio: 1 : 2 : 1 (TT=25% Tt=50% tt=25%)
Phenotypic ratio: 3 : 1 (Tall=75% Short=25%)

Two Types of Punnett Squares

- <u>Monohybrid:</u> A Punnett Square that tests for the inheritance of ___________ trait (example: long necks)
- <u>Dihybrid:</u> A Punnett Square that tests for the inheritance of ____________ traits (example: long necks and fur color).

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Example 1: Homozygous x Homozygous

Situation: One parent is homozygous for green pods (GG) and the other parent is homozygous for yellow pods (gg).

Parent Genotypes: __________________________

Offspring Ratios

-Genotype: _____________________

-Phenotype: _____________________

Example 2: Homozygous X Heterozygous

Situation: One parent is homozygous for green pods, and the other parent is heterozygous.

Parent Genotypes: ________________________

Offspring Ratios

-Genotype: ______________________________

-Phenotype: ______________________________

Example 3: Heterozygous X Heterozygous

Situation: Both parents are heterozygous for pod color

Parent Genotypes: ___________________

Offspring Ratios

-Genotype: ____

-Phenotype: ____

Test Cross

Process of crossing an unknown genotype individual to a
____ individual to determine what the unknown genotype is.

Example 4: Testcross

Situation: a green-podded plant with an unknown genotype is crossed with a yellow-podded plant. The offspring genotype ratios are given below.

- Genotype Ratio: 50% Gg, 50% gg

Question: What was the genotype of the parent green-podded plant? ___________

Language Targets for this unit are embedded in the topic practice.

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Unit 7, Topic 2: Variations of Dominance

By the end of this topic, you should be able to…

1. *Use Punnett squares for exceptions to Mendelian Genetics (incomplete dominance, codominance, blood types, and sex-linkage)*
2. *Use Punnett squares for dihybrid crosses*

Exceptions to Simple Dominance

- Incomplete Dominance: alleles **"____________"** (ex: pink flowers)
- Codominance: both alleles show up in their "__________________**"** (ex: red and white splotchy flowers)

Incomplete Dominance

- There is no _______________ allele or ________________ allele
- Blending: Red and White flowers
  - C^R or R=Red
  - C^W or W=White
  - C^R C^W or RW=Pink
- ***Situation:*** *If red and white flower alleles show* ***incomplete dominance,*** *what offspring ratios will you see if you cross a red-flowered plant with a white-flowered plant?*

Parent Genotypes: _________________________

Offspring Ratios:

Genotype: _____________

Phenotype: ____________

Codominance

- There is no dominant or recessive allele but both are expressed
  - Ex: a chicken with white & black feathers
- ***Situation:*** *If black and white chicken alleles show* ***codominance,*** *what offspring ratios will you see if you cross a black chicken with a white chicken? Hybrids display speckled coloration.*

Parent Genotypes: _________________________

Offspring Ratios:

Genotype: _____________

Phenotype: ____________

Multiple Alleles

- Sometimes there are more than ___________ alleles for a particular gene. We call this inheritance pattern multiple alleles. For example, there are ______________ alleles controlling human blood type—__, __, and __. A and B are both dominant (express codominance) over O.

The ABO blood system

Genotypes	Phenotypes (Blood types)
$I^A I^A$	A
$I^A I^B$	AB
$I^A i$	A
$I^B I^B$	B
$I^B i$	B
ii	O

Note:
- Blood types A and B have two possible genotypes – homozygous and heterozygous.
- Blood types AB and O only have one genotype each.

Blood Type	Genotype		Can Receive Blood From:
A	$i^A i$ $i^A i^A$	AA AO	A or O
B	$i^B i$ $i^B i^B$	BB BO	B or O
AB	$i^A i^B$	AB	A, B, AB, O
O	$i\ i$	OO	O

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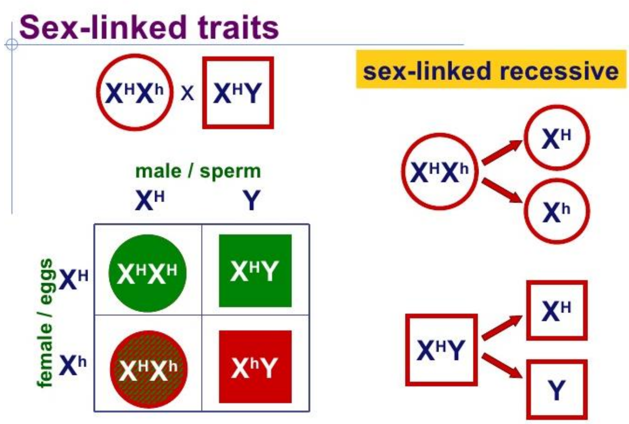
Situation: If two parents with blood type AB have children, what offspring ratios will you see?
Parent Genotypes: _________________________________
Offspring Ratios
-Genotype: ______________________________
-Phenotype: ____________________________

Sex linked inheritance



- Sex linkage = the presence of genes on a sex chromosome (_______________)
    - X-linked Genes = genes found on the X chromosome
    - Y-linked Genes = genes found on the Y chromosome
- Sex linkage was discovered by Thomas Morgan while working with fruit flies…tiny and easy to mate!
- Fruit flies can have red or white eyes
- Morgan noticed that there were a few white eyed males, but almost no white-eyed females…
    - The gene for fruit fly eye color is on the ____ chromosome
    - Compare the size of the X and Y chromosomes!
    - Remember, males have only 1 X chromosome, while females have 2
- Red Eye Allele: X^R
- White Eye Allele: X^r

Example 1: X^RX^R x X^rY

___________ eyed female x _____________-eyed male
Phenotype ratio: _______________________________________

Example 2: X^RX^r x X^RY

______________-Eyed Female (HETEROZYGOTE) x ____________-Eyed Male
Phenotype Ratio: ____

A Human Example of Sex Linkage

- Hemophilia is a human X-linked disorder that causes blood to clot incorrectly → patient "bleeds out" after a minor cut
- Normal Allele: X^H
- Hemophilia Allele: X^h

Situation: Carrier Mother X Normal Father
Parent Genotypes:
X^HX^h x X^HY
Phenotype Ratio:
________ normal females
________ normal males
________ hemophilic males

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Dihybrid Cross

- Involves ____________ characteristics (two pairs of contrasting traits) for each individual.
- Predicting the results of a dihybrid cross is more complicated than predicting the results of a monohybrid cross.
- All possible combinations of the four alleles from each parent must be considered.

How to's of Dihybrid Crosses

1. Figure out the **alleles**:
   Identify what trait/letter is <u>Dominant</u> (B – Black fur)
   Identify what trait/letter is <u>Recessive</u> (b – Brown fur)
2. Draw your **box** (<u>16</u> squares for dihybrids!)
3. Determine the Possible **gametes** (sex cells) that could be made from the parents.
   You should have <u>4</u> combinations (For AaBb: AB, Ab, aB, & ab)
   The letters should be all **different** for each combination! (Yr or Ab)
4. **Label** each side of Box, **Plug & Chug**!
   Put the <u>same</u> <u>letters</u> together again (AABb)
   Make sure to put **dominant** alleles First! (AaBb)
5. Determine your possible **Genotypes**! (1/16 bbrr, etc)
   Double check your work, all the possible genotypes should add up to 16!
6. Determine your possible **Phenotypes**! (1/16 brown wrinkled, etc)
   Double check your work, all the possible phenotypes should add up to 16!

Expressing probabilities for genotypes & phenotypes (2 factor cross)

Ratios:

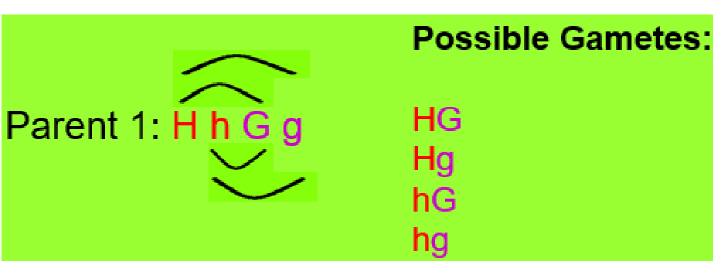
- 4/16 : fractions (parts of the total – don't reduce)
- Genotype ratios are typically not used in 2 factor crosses
- Phenotype ratios use the DD:DR:RD:RR pattern
- Example- 9:3:3:1 (DD: DR: RD: RR)

Percentages:

- Need to label with trait

Finding the Gametes for Dihybrid Crosses

- Remember, each gamete must have ONE COPY of the two genes
- To find possible gametes for each parent, use the FOIL method
- **Dihybrid Crosses:** a cross between individuals that involves two traits (e.g., pod color and plant height)
  Tall = H Green pods = G
  Short = h Yellow pods = g



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- **Homozygous X Homozygous**

Parent Genotypes: HHGG X hhgg

Offspring Ratios

-Genotype:

-Phenotype:

- **Heterozygous X Heterozygous**

Parent Genotypes: HhGg X HhGg

Offspring Ratios:

-Genotype:

-Phenotype:

Language Targets for this unit are embedded in the topic practice.

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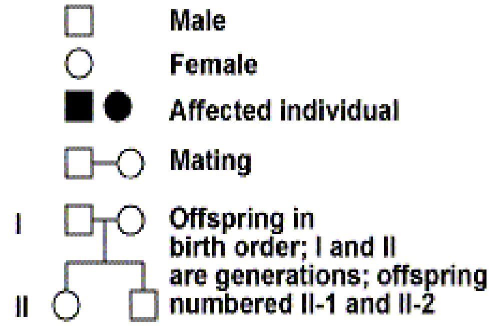
Unit 7, Topic 3: Pedigrees

By the end of this topic, you should be able to…

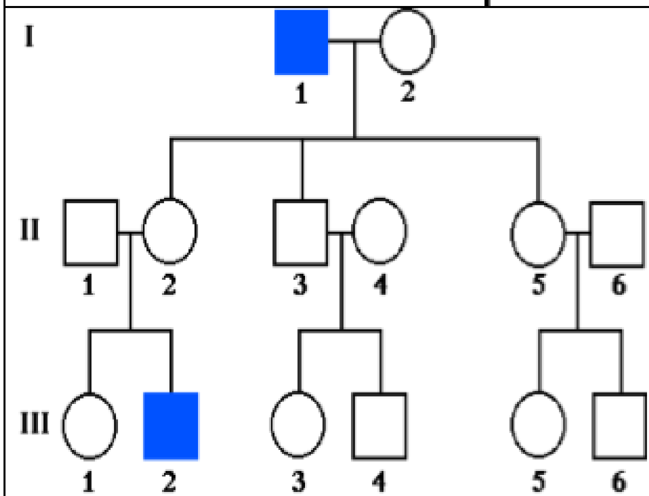
- *Analyze pedigrees*
- *Create a pedigree*

Pedigree

- A diagram representing a family tree that shows how a ____________ is passed from generation to generation
- The alleles that each person in the family has



On Your Own: Answer the questions for Pedigree 1 using your key above.



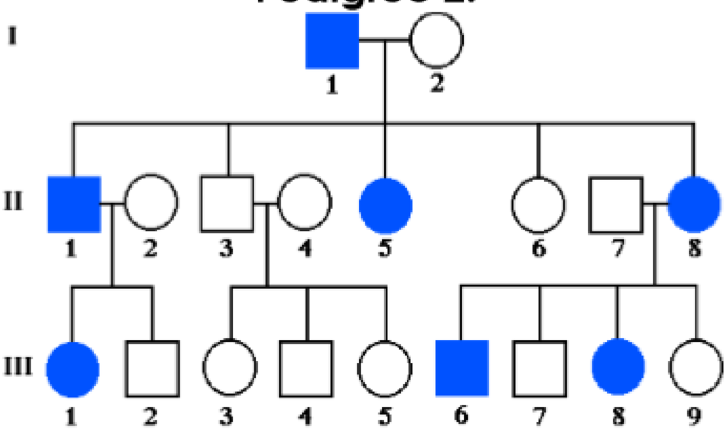
1. Place an **M** next to all of the males
2. How many males are there? ________
3. Place an **F** next to all the females
4. How many females are there? ________
5. How many people in the family have the trait? _______
6. **Circle** the marriage lines in the pedigree.
7. How many generations are shown in this pedigree? ____________
8. How many children did the first generation have of parents have? ____________
9. How many of the children in generation 3 have the trait? __________

** **We label each individual by their ____.**

→ **Examples: I-2, II-4, III-5.**

Example Question: In pedigree 1, how are individuals II-1 and II-2 related? _______________

Pedigree 2:



1.How many people in the family have the trait? __________
2. What is the **sex** of **individual I-1** _____
3. Does **individual I-1** have the trait? ___
4. List the individuals in generation III that have the trait:
________ _________ __________
5. How many children did the couple from generation 1 have? ___________
6. What is the relationship between individual II-8 and III-9.________________________

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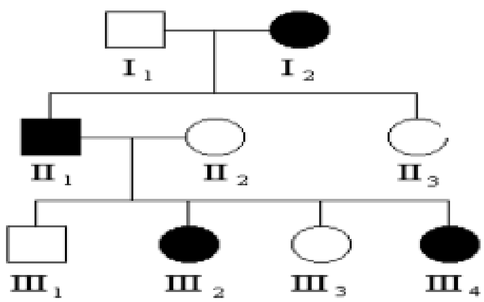
Example 1: The pedigree below shows the inheritance of handedness in humans over three generations. The allele for right-handedness (R) is dominant over left-handedness (r). **The shaded individuals below are recessive for handedness.**



1. How many generations are there? ________________

2. How many individuals are left handed? ____________

3. Which individuals in the third generation are right handed?

____

5. What is the genotype and phenotype of individual I-2

Genotype _______ Phenotype __________________________

4. If the father (I-1) is heterozygous, what is the genotype of his two children? II -1 _____________ II – 3 ____________

Example 2: Huntington's Disease (H) is a dominant disorder.

1. What is the relationship between individual III-1 and III-2

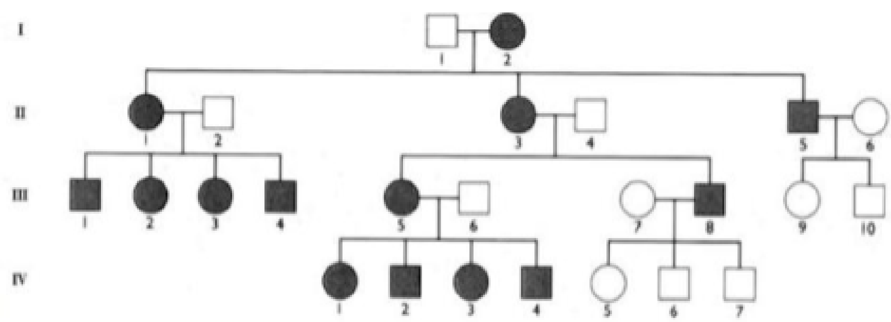
____

2. What is the relationship between individual II-3 and III-4.

____

3. How many individuals in generation II do not have Huntington's disease?

____



4 Based on the traits of IV-5, IV-6, and IV-7, what MUST the **genotype** of III-8 be? ___________________________

5. If individual IV-7 mated with a heterozygous individual, what is the percentage their offspring has Huntington's?

Genotype of IV-7: _________

Heterozygous Genotype: __________

Answer:

**** Note on Sex-linked Pedigrees:**

For sex-linked traits, female carriers are always represented as ____,

even though they do not express the recessive trait.

A female carrier looks like:

Language Targets for this unit are embedded in the topic practice.