PEER-LED TEAM LEARNING
INTRODUCTORY BIOLOGY

MODULE 12: MENDELIAN GENETICS 2

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I. Introduction

Patterns of inheritance are often much more complex than those encountered in the first genetics module, Module 11. Mammals, birds, plants like garden peas and insects have thousands of different genes in their genomes. Frequently scientists wish to study inheritance patterns for two or more genes simultaneously. When two different genes are involved, **dihybrid crosses** are made and the distribution of the alleles from parent to filial generations is traced. In some cases, when the genes have loci on different chromosomes, the alleles assort *independently*. From Mendel's work came the **Principle of Independent Assortment**. However, all alleles are not distributed independently into gametes. If the gene loci are **linked—**that is, located on the same chromosome, they move together most of the time. The phenomenon of **linkage** adds another dimension to the patterns of inheritance.

Most complex organisms have separate **sex chromosomes** as distinguished from the others which are called **autosomes**. In mammals the females have two full-sized X sex chromosomes. Males, in contrast, have one **X** and one **Y** chromosome. The **Y** chromosome is not full sized, and lacks most of the loci on the **X** chromosome. It follows that, if a gene is located on the X chromosome, a female will get two alleles for that gene while the male gets only one. This creates some potential problems for males related any gene that is **sex-linked**. We will study the inheritance of sex-linked genes that result in some diseases and disabilities that occur mainly in males.

Although we will not be covering the subject in this module, you should know that not all phenotypic characters and traits exhibit simple patterns of Mendelian inheritance. They can result from complex interplays among many genes (epistasis) and their interactions with the environment. Human height and intelligence are among these complex polygenic characters.

Benchmarks. Having completed this workshop, you will be able to:

1. Explain the principle of independent assortment using diagrams representing parental genotypes and the alleles carried by their gametes.
2. Solve problems for dihybrid crosses using all the skills introduced in Module 11.
3. Explain by diagramming the concept of linked vs. non-linked genes.
4. Solve problems involving linked genes.
5. Demonstrate using a Punnett square how sex is determined in mammals.
6. Compare the structures of X and Y chromosomes and explain implications for sex-linked genes.
7. Solve problems involving sex-linked genes.

Being successful in mastering these topics depends in large part on your mastery of skills and concepts introduced in Module 11. Make sure you have a good grasp of that material before proceeding. Prepare for your workshop by reading assignments in your textbook [and completing the Pre-Workshop activities below. Show your work for review in the workshop.

II. Pre-Workshop

Activity 1. Dihybrid crosses

In this activity you review the skills for genetic problem solving as they apply to setting up and solving a dihybrid cross. Write out all the answers and be ready to share them at the workshop.

1. In garden peas, purple flower color is dominant over white flower color, and smooth seed coat is dominant over wrinkled seed coat. The genes for seed coat and flower color are located on separate chromosomes. Shown below in Fig 12.1 is a cross between a parent plant that produces smooth seeds and purple flowers and one with wrinkled seeds and white flowers. Each is homozygous for both genes. Using the rules for writing genotypes, assign a genotype to each plant:

_____

2. Label the alleles in Fig 12.1 for the parents, gametes and offspring. What is the genotype of the F1 offspring? _____ Are any other combinations possible? Explain. _____

3. What kinds of seed coats and flowers will be produced by the F1 offspring? _____

4. Set up and complete a Punnett square for this cross. What are the genotypic and phenotypic ratios?

_____

5. The F1 offspring are called **dihybrids**, referring to the fact that each of two gene pairs is heterozygous. [NOTE: there are two definitions for this term. You have given one, the other is dihibrids = the offspring of parents differing in two specific pairs of genes. That is the one we use elsewhere in this workshop.]

6. A cross of the F_1 dihybrids (PpRr x PpRr) produces a somewhat more complex situation, although the steps are largely the same as in a monohybrid cross of heterozygous individuals. Fig 12.2 shows how to do the most difficult step, forming the gametes.

a. The first pair of alleles (P and p) assorts into 2 different gametes.

b. The second pair of alleles (R and r) **assorts independently** of the first pair so that **R** may be in the same gamete as either **P** or **p** forming **PR** or **pR**. Likewise, **r** ends up about half the time with **P** and half the time with **p** making **Pr** or **pr**.

7. Label alleles in the F1 parent and the gametes in Fig 12.2. How many different types of gametes will be produced by a dihybrid heterozygous parent? _____What is their ratio?

_____ .

8. A Punnett square is set up to determine the genotypes of the offspring produced by the cross. This Punnett square (Table 12.1) has 4 rows and 4 columns. Why? _____

9. Complete the Punnett square for this dihybrid cross by:

a. entering the gametes for each parent across the top and down the left side.

b. fill in the genotypes of the offspring in the 16 cells using the genotype rules

10. The final step is to determine the phenotypic ratio of offspring. (The genotypic ratio is complex and will not be used in our study.)

a. determine the phenotype of each individual in the 16 cells of the Punnett square.

b. list each of the *different phenotypes* expressed (ex: purple-round) in the space below.

c. count the number of each phenotype and enter it below the phenotype.

d. write out the phenotypic ratio: _____

purple-round : _____ : _____ : _____

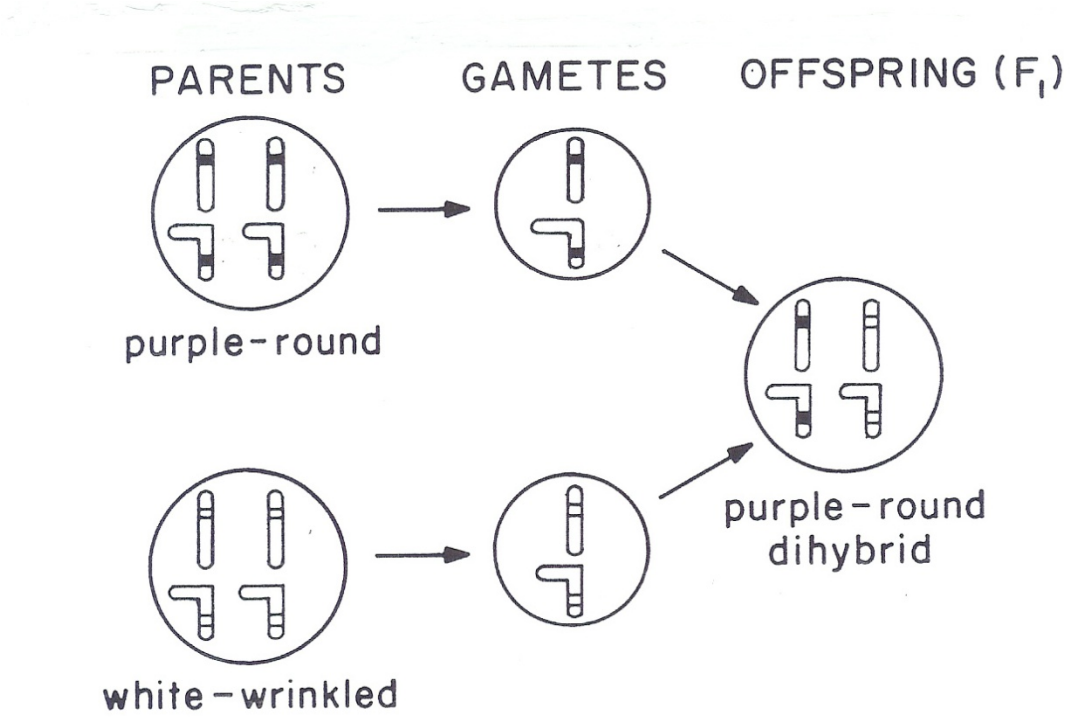


Fig. 12.1 Dihybrid cross of garden pea plants

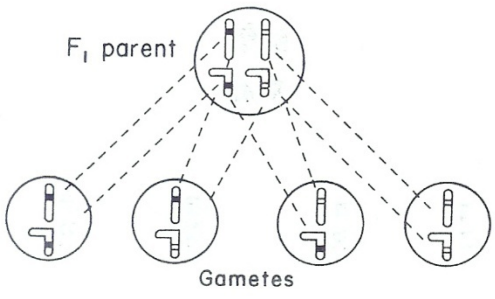


Fig. 12.2. Formation of gametes

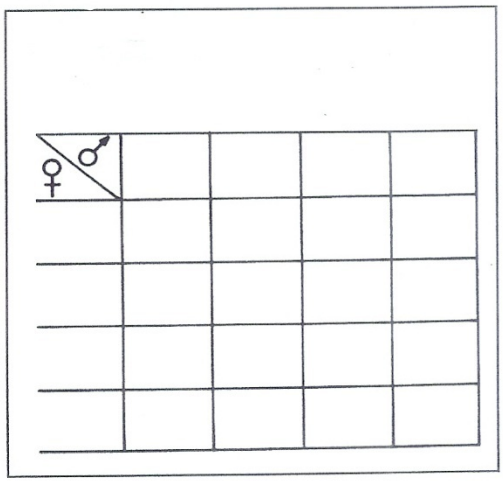
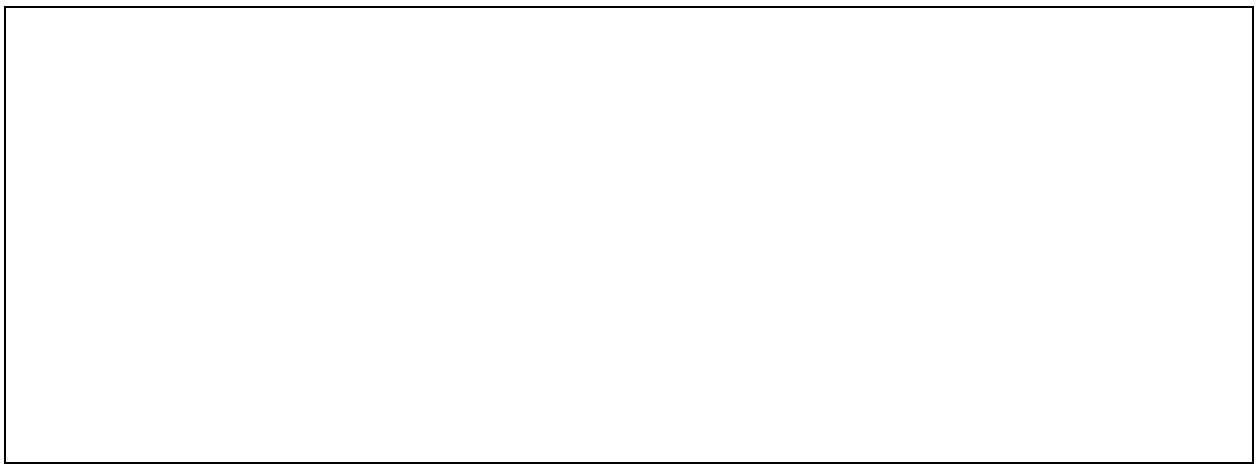


Table 12.1. Punnett square for a dihybrid cross

11. State in your own words the **Principle of Independent Assortment.** Use the cross you just completed to illustrate your definition. _____
_____ .

12. Summarize the steps in solving a dihybrid cross as a flow chart in the box below.



Activity 2. Linkage

1. In Figure 12.3, three genes are shown. Two have loci on the larger chromosome, and one on the smaller chromosomes. Based on physical appearances alone, which gene pairs (ex. E/e & F/f) are linked and which are not linked? Indicate all possible pairs. _____

2. Draw all possible gametes that could be formed from the meiotic divisions of this cell and label all the alleles. Is it possible that a gamete could contain E, D, and F? If so, how does this happen? [NOTE: this alerts the students to crossing over, which they otherwise might miss]

3. How many different combinations did you get for the genes D/d and F/f? _____ . How many for the genes D/d and E/e? _____ . Why is the number of combinations different? Explain using the cell diagram. _____ .
4. Genes that are linked on the same chromosome assort independently into gametes during meiosis. True or false? Explain._____ .

5. How does the Mendel's law of independent assortment apply to:
   a. different genes with loci on different chromosomes?
   b. different genes with loci on the same chromosome?

6. Two plants with the same genotype as the one in Fig 12.3 were crossed. Provide the following information about the cross.
   a. genotypes of the parents
   b. the gametes each parent can produce
   c. a Punnett square showing the cross
   d. a genotypic ratio
   e. a phenotypic ratio.

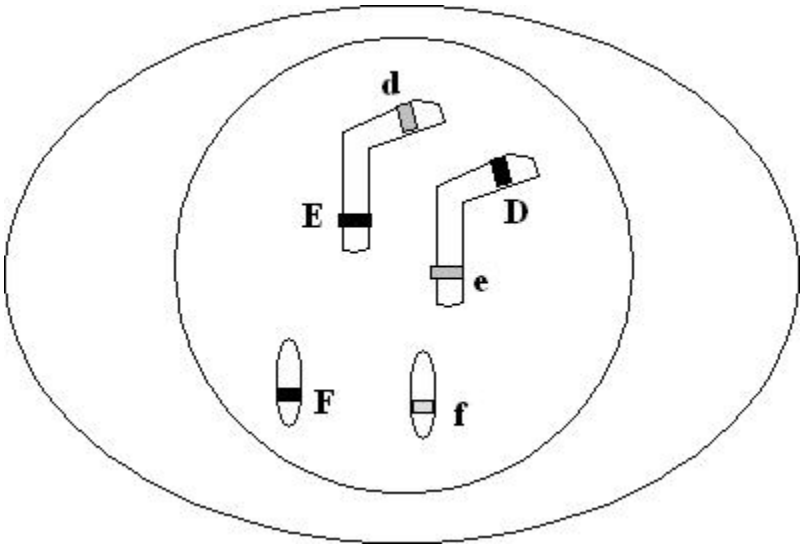


Figure 12.3. Linked and Non linked Genes

Activity 3. Sex chromosome and sex linked genes

1. In human cells there are 46 chromosomes making up 23 homologous pairs. How many of these pairs are **autosomes**? _____ How many pairs are **sex chromosomes**?_____

2. The two chromosomes in an autosomal pair are the same size and shape. What about in the sex chromosome pair for women? _____ For men? _____ . Give the symbols for male and female sex chromosomes _____ .

3. Compare the number of loci on the two sex chromosomes in a man's cells using Fig 12.4. Label the X and Y chromosomes.

4. In Fig 12.5 complete the Punnett square by:
   a. entering the gametes with sex chromosomes identified (X or Y) for the two parents
   b. completing the cells
   c. determining the phenotypic ratio for the cross

5. In random assortment of sex chromosomes into gametes what is the expect ratio of girl and boy babies? _____.

6. On the Y sex chromosome there are only a few genes related to male traits. On the X chromosome there are hundreds of genes, most of which are absent from the Y chromosome. For a **sex-linked gene** (present on X and absent on Y), how many alleles are present in female cells?___ How many in male cells? _____

7. Sex-linked genes control the expression of **sex-linked traits.** Examples are genes for blood clotting and color vision.

8. a. Draw a pair of sex chromosomes for a female. Near the top place a locus for a color vision gene C/c. Make the pair heterozygous for the alleles.
   b. Next to your first drawing, make a second for a male. Place the color vision gene on the X chromosome, but not the Y. Place a recessive allele on the X chromosome.

9. We represent sex-linked genes as superscripts over the "**X**" symbol. For example, in the case of the gene for color vision (C/c), X^C represents the allele for normal vision, while X^c is the recessive allele which is expressed in colorblindness. The **Y** chromosome is represented with no superscript since it lacks either allele. A colorblind male would be _____**.**

10. If the C allele is expressed in the phenotype, a person will have normal color vision. If the c allele is expressed, the person will be colorblind. What are the phenotypes of the man and woman you represented in your drawings in #8? _____

11. Make the following cross using the steps for solving a genetics problem: a woman who is heterozygous for the color vision allele and a normal man.

a. show the genotypes of the parents
b. show the gametes each can produce
c. set up the Punnett square and fill it in
d. determine the genotypic and phenotypic ratio (be sure to include gender as well as vision in the phenotypes you identify).

12. Explain why colorblindness is more common in males. [NOTE: the one cross is not enough to tell one the frequency in males and females from other crosses. This reformulation of the question forces them to think more generally]

13. With what combination of alleles could you get a colorblind female?

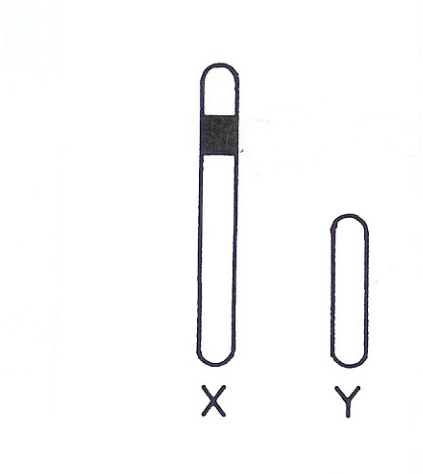


Fig 12.4. Sex chromosomes

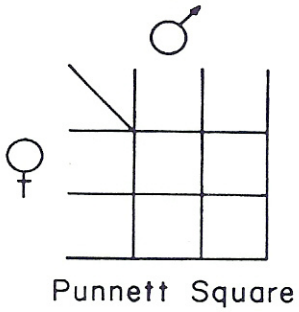


Fig 12.5. Sex determination

III. Workshop

<u>Activity 1. Skills in genetic problem solving</u>

Pair-problem solving. Each pair gets one of the following problems and has two minutes to solve it. Each pair presents its solution in jigsaw fashion to the rest of the workshop. Use table 12.2 for genotypes of the parent cell.

Table 12.2. Genotypes for garden pea plants and people.

Organism	***Genotypes***	***Phenotypes (Traits)***
Garden Pea Plants	PP or Pp	Purple flowers
	pp	White flowers
	YY or Yy	Yellow seeds
	yy	Green seeds
	RR or Rr	Smooth seed coat
	rr	Wrinkled seed coat
	TT or Tt	Tall plants
	tt	Short plants
Humans	EE or Ee	Free earlobes
	ee	Attached earlobes
	RR or Rr	Rh positive blood
	rr	Rh negative blood
	FF or Ff	Freckles
	ff	Uniform pigment distribution

1. Represent the parent cell and different gametes that come from that cell by the alleles they carry. (In some problems there may be more than one possibility. List all possibilities.)
   a. A dihybrid heterozygous tall pea plant with purple flowers
   b. A short pea plant that is heterozygous for seed coat
   c. A pea plant that produces yellow seeds with a smooth coat
   d. A human who is heterozygous for earlobes and freckles
   e. A human with Rh positive blood type and has attached earlobes
   f. A pea plant that produces green seeds with smooth coats
   g. A tall pea plant with white flowers
   h. A Rh- person with free earlobes
   g. A freckled person with attached earlobes

2. . Using the symbols in Table 12.2, represent the following crosses. Include all possible genotypes.
   a. Tall pea plant with purple flowers x a short plant with white flowers
   b. A short pea plant with a smooth seed coat x a tall plant with a smooth seed coat
   c. An Rh+ man with free earlobes (heterozygous) x an Rh-woman with attached earlobes
   d. An unfreckled man with attached earlobes x a freckled woman with free earlobes
   e. A pea plant with purple flowers and yellow seeds x plant with white flowers and yellow seeds
   f. Rh+ man with freckles and Rh- woman with freckles

3. Now set up Punnett squares for the six crosses you summarized in #2a-f and fill in the F_1 genotypes.

4. Determine the **genotypic ratios** for six crosses in #2 (select one cross to do for those with more than one possibility) and express them with the genotypes written below the numbers.

5.. Determine the **phenotypic ratios** for the crosses in #2. Indicate the phenotypes next to the numbers.

Activity 2. Concepts in patterns of inheritance

Pair problem solving with jigsaw. (Note here that questions #3 and #6 are especially challenging and help may need to be given).

1. a. Explain briefly Mendel's Law of Independent assortment.
   b. Give an illustration that helps in your explanation.
   c. Give an example of situations in which it applies and doesn't apply to inheritance patterns.

2. a. Using a diagram, illustrate the physical basis for linkage or non-linkage between two alleles.
   b. Explain a linkage pattern between genes can be changed. Use a diagram.
   c. Using two genes, compare the number of offspring of different genotypes expected when the genes are linked and non-linked. Explain with a diagram. [NOTE: the expected number of genotypes is the same for linked and unlinked, but the ratios differ]

3. What type of test cross might you conduct in order to tell if two genes are linked or non-linked? Set it up and show the expected outcomes.

4. Using a diagram, explain the difference between a sex-linked and autosomal gene.

5. a. Using a diagram, explain why sex-linked recessives genes are more often expressed in male than female mammals.
   b. In what situation can the recessive alleles be expressed in females?

6. What type of test cross might you conduct to determine if a gene is sex-linked or not? Set up a specific cross and its outcomes in either case.

Activity 3. Genetics Problems

For each of the problems below:

a. *state the category* of which it is an example (e.g., dihybrid cross with dominance, sex-linked, linkage, etc.).
b. *state what clues* led to your decision.
c. *solve the problem* showing your work, step by step.

1. In humans, tasters of a bitter substance (PTC) are TT or Tt, while non-tasters are tt. Normally pigmented people are either AA or Aa, while albinos are aa. A normally pigmented woman, who is a nontaster, has an albino taster father. Her albino taster husband has a mother who is a non-taster. Indicate all genotypes and phenotypes possible in their children. T/t and A/a genes occur on different chromosomes.

2. A couple has three girls and one boy. How does this compare with the expected ratio of boys to girls among four offspring? Are their chances of a boy greater now if they have a fifth child than when they had their first child? Explain why or why not.

3. Queen Victoria of England was married to Prince Albert. Neither had hemophilia (an expression of a sex-linked recessive gene) but one son, Leopold, was a hemophiliac and two of their normal daughters had grandsons with hemophilia.
   a. Which parent, king or queen, carried the recessive hemophilia gene? Explain.
   b. What is the expected ratio in their offspring of
      normal sons : hemophiliac sons?
      normal daughters : hemophiliac daughters?
   c. In the descendants of Victoria and Albert there were 10 male hemophiliacs and no female hemophiliacs. Explain why this was so.

4. In poultry, black color is due to a dominant allele **E** and red color to a recessive **e**. Crested head is due to a dominant allele **C** and plain head to the recessive **c**. A male bird, red and crested, is crossed with a black, plain-headed female. They produce many offspring, half of which are black and crested; the other half red and crested. What would you predict is the genotype of the parents?

5. A mating is made between two black, crested birds. The F_1 contains 13 offspring in the following proportions: 7 black, crested; 3 red, crested; 2 black, plain; and 1 red, plain. What are the probable genotypes of the parents?

6. Red-green color blindness is a sex-linked recessive trait.

a. A color-blind man marries a woman who is heterozygous for the color vision gene. What are the expected genotypic ratios of their sons? of their daughters? Give the phenotypic ratios.

b. A man with normal color vision marries a heterozygous woman. What are the expected genotypic ratios of their sons? Of their daughters? Give the phenotypic ratios.

7. A color-blind man marries a woman with normal vision whose father was color-blind. What are the chances that their male children will be color-blind? Their female children? Give the genotypic ratios and phenotypic ratios by sex as well as color-blindness.

8. A woman with AB blood is heterozygous for free-earlobes and her husband has type O blood and attached earlobes. They have four children.

a. What is the genotype for each parent?

b. What are the possible genotypes and phenotypes of their four children?

9. In fruit flies, body color is normally gray, the expression of a dominant allele (b+), while black color is the expression of a recessive allele (b). Normal long wings result from an allele (vg+) and short vestigial wings are the expression of a recessive allele (vg). A male that is heterozygous for both genes is mated with a black, vestigial winged female.

The cross produced 1000 offspring of which 470 had gray bodies and long wings and 480 had black bodies and vestigial wings. 24 had gray bodies and vestigial wings and 26 had black bodies and long wings. Determine if the two genes are linked or not by showing the predicted outcomes with and without linkage. What explains the gray-vestigial and black-long winged flies?

10. In the following cross: **AaBB** x **aaBb**

where **A**, red eye color is dominant over **a**, green eye color
and **B**, bald is dominant over **b**, lots of hair,

a. What are the resulting genotypes and what are their ratios (assuming no linkage between the two gene loci)?
b. What are the resulting phenotypes and what are their ratios?
c. What fraction of the offspring is heterozygous for eye color?
d. What fraction of offspring is homozygous for baldness?

11. Consider the following cross: AabbCcDd x aaBbccDd

a. What are the odds of the F1 generation being homozygous recessive at gene locus B?

b. What are the odds of the F1 generation being homozygous dominant at gene locus D?

c. What are the odds of the F1 generation being both homozygous recessive at gene locus B and homozygous dominant at gene locus D? [Hint: just combine the two results above. Can you determine how the combination is to be done?]

d. Using the way you answered the above three questions, can you think of a general way to approach such multiple-gene-locus probabilities?

12. Consider the following pedigree. squares = males; circles = females. A filled square or circle indicates that the individual has a disorder that causes premature aging. **Procedure:** Break the group into three teams. Have each team decide on the answer to questions a and b, below, and then have team one determine the genotype of individual 1, above; team two determine the genotype of individual 2, above; and team three determine the genotype of individual 3, above. Reassemble to discuss the answers and reasons for them. [MOVE fig. 12.6 here, if possible]
To answer the questions, use A = dominant allele, a = recessive allele.

a. Is the trait dominant or recessive? How do you know?

b. Is there any indication that the trait is sex-linked? Give your reasoning.

c. What is the genotype of the three individuals (1, 2, 3) indicated above?

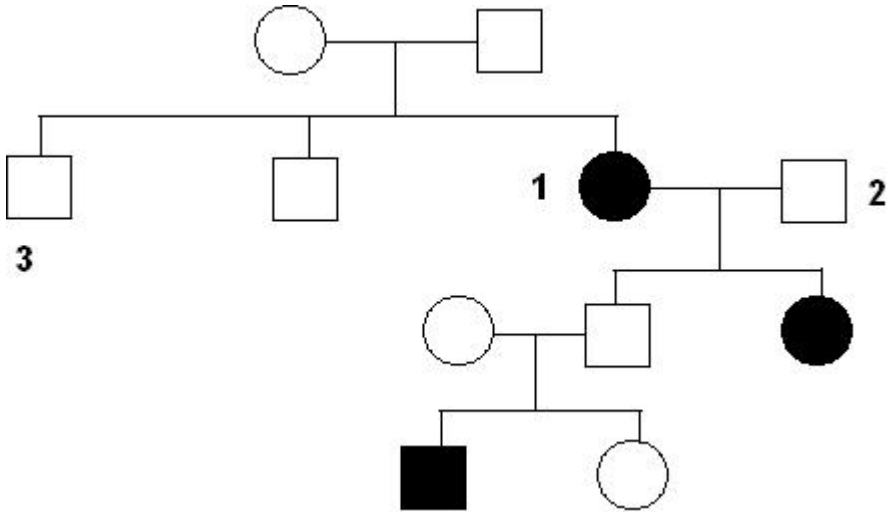


Figure 12.6. Pedigree 1 (Question 14)

13. In a similar manner, consider the following pedigree:

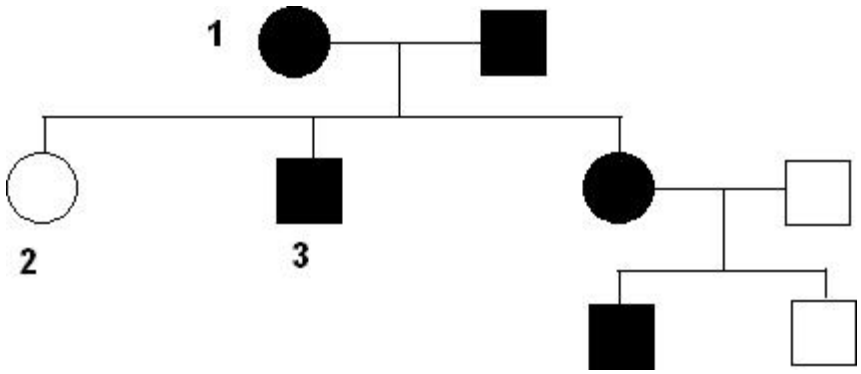


Figure 12.7. Pedigree 2 (Question 15)

14. Finally, what would be the result of reversing the filled and open squares/circles in each of the above pedigrees?

Activity 4. Linked Genes and Mapping

Background: Genes can be close enough to one another on a chromosome that they are more likely to be inherited together. These are linked genes. Only recombination through crossing-over allows them to be separated during meiosis. The fraction of recombinant offspring can be used as a measure of how close the two gene loci are on the chromosome. A series of such fractions among mutually linked genes also can be used to map genes on chromosomes.

Procedure: Pair problem solving. All pairs answer question 1. Each pair is assigned to answer one of the questions #2-4. The pairs should be ready to present their results to the other students.

1. Make a drawing of a cell with 2N = 4 with the following genes and loci identified. On a large pair of homologous chromosomes place 3 gene loci. Near one end of the chromosomes, place loci for gene **A/a** (heterozygous). Near the other end, place loci for gene **B/b**. Place allele **B** on the chromosome with allele **a**, and allele **b** with **A**. Between loci **A/a** and **B/b**, place loci **C/c**, but position it close to **A/a** and more distant from **B/b**. Make the cell heterozygous for **C/c**, with **C** linked to **A** and **c** linked to **a**.

a. Which of the genes are linked to each other? Which are not linked? [How can one tell from the info. given? It would be possible that there is no linkage between any, if the chromosome were long enough.]

b. Explain the mechanism by which the linkage patterns would change, giving an example.

c. Between which pairs is the linkage pattern going to be changed most frequently? Least frequently? Explain why.

d. If the percentage of offspring in which the pattern is changed is 20% between **A/a** and **C/c**, predict the approximate percentages between **A/a** and **B/b**. Between **B/b** and **C/c**.

e. Share your results with the group before going on.

2. Imagine that you have performed a cross and seen that there are 499 parental types and 502 recombinants, for a total of 1,001 offspring.

a. What is the recombination frequency?

b. Are these two genes linked?

c. Could they still be located on the same chromosome?

3. In a cross there are 500 parental types and 100 recombinants.

a. What is the recombination frequency?

b. Are these two genes linked?

4. If the recombination frequency between gene A and gene B is 4% and that between gene A and gene C is 8%, is gene B or gene C closer to gene A?

Procedure: For question #5, pairs of workshop participants should come forward to a blackboard and add/subtract options on a growing map of the four genes whose recombination frequencies are listed below. They should discuss and justify their reasons (The recombination frequencies below are given in percents, which are the same as map units).

5. a. Use the following recombination frequencies to map four genes, A-D.

Workshop pair	Genes	Recombination frequency
One	A, B	8%
Two	A, C	4%
Three	A, D	4%
Four	B, C	4%
Five/One	B, D	11%

Procedure: For the whole workshop group to discuss:

5. b. Consider that there is a fifth gene E that also is linked. If you know that the A-to-E recombination frequency is 4%, can you locate E on the map you constructed above?

5. c. Why isn't the recombination frequency between B and D = 12%?

Activity 5. Complex Patterns of Inheritance: Challenge Section

If time permits in the workshop, divide the group into two teams and have each solve one of the two problems below. At the end of a prescribed period, the teams should present their work, even in a partially complete state to the other team. Together with guidance from the peer leader, the problems can be solved.

1. Consider the following cross:

AabbCcDd x aaBbccDd

a. What are the odds of the F1 generation being homozygous recessive at gene locus B?

b. What are the odds of the F1 generation being homozygous dominant at gene locus D?

c. What are the odds of the F1 generation being both homozygous recessive at gene locus B and homozygous dominant at gene locus D? [Hint: just combine the two results above. Can you determine how the combination is to be done?]

d. Using the way you answered the above three questions, can you think of a general way to approach such multiple-gene-locus probabilities?

2. The product of one gene can influence the phenotypic expression of another gene. Consider the Black/Brown gene locus in mice and the influence of the alleles at a second gene locus, designated C. BB and Bb animals are black, and bb animals are brown UNLESS the animals also are homozygous recessive at the C locus, in which case they have white fur color.

a. Consider the cross:

BBCc x BbCc

i What color are each of these parents?

ii. What percent of the F1 offspring will be black, what % brown, and what % white?

b. Consider the cross:
BBCc x Bbcc

i. What color are each of these parents?

ii. What percent of the F1 offspring will be black, what % brown, and what % white?

IV. Post-Workshop

Activity 1. Linking concepts

With this vocabulary list make as many mini-concept maps as you can that show important relationships between individual concepts. Follow the rules for concept mapping. [NOTE: this is the same concept list as appeared in Module 11]

genotype	phenotype	trait
blood type	dominance	dominant
recessive	Law of Segregation	cross
P generation	progeny	sex determination
Punnett square	genotypic ratio	phenotypic ratio codominance
multiple alleles	incomplete dominance	
independent Assortment	first filial generation (F_1)	gametes
second filial generation (F_2)		

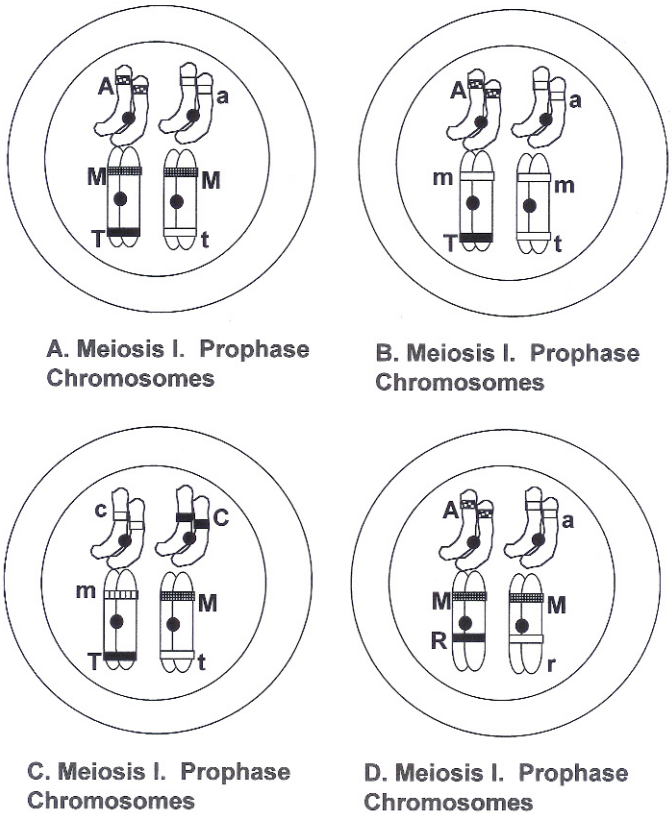


Fig. 12.8. Cells prepared for meiotic divisions to form gametes.

Activity 2. Determining the genetic makeup of gametes

For each of the diploid cells in Fig. 12.8, show the genetic makeup of gametes that could result from meiotic divisions of each cell. Note that the chromosomes can be distributed in different ways, giving rise to different genetic combinations. Show all the possible combinations.

Activity 3. Genetics Problems

For each of the problems below:

a. *state the category* of which it is an example (e.g., dihybrid cross with dominance, sex-linked, linkage, etc.).
b. *state what clues* led to your decision.
c. *solve the problem* showing your work, step by step.

1. In guinea pigs, black fur is expressed by a dominant gene **B** while brown fur is the expression of the recessive allele **b.** Short hair **S** is dominant to long hair **s**. In a cross of individuals with dominant phenotypes for both characters, the total F1 offspring of several matings were as follows: 18 black, short-haired, 7 black long-haired.

a. What were the genotypes of the parents?
b. Show how the cross would result in the observed outcome of offspring
c. What is the relationship between predicted numbers of offspring and actually observed numbers?
d. How is cross similar to and different from a monohybrid cross of two heterozygous individuals?

2. If a woman who is homozygous for normal color vision marries a man who is color blind (a sex-linked, recessive trait), what proportion of their offspring (separately indicate results for males and females among their offspring) would:

a. be carriers of the colorblindness trait?

b. be colorblind?

3. If a woman is heterozygous for colorblindness (sex-linked, recessive) and marries a male with normal color vision, among their offspring (separately consider males and females), what proportion would:

a. be carriers?

b. be colorblind?

4. In sweet pea plants, two forms of the flower color gene are **P** and **p**, the first expressed as purple flowers and the second as red flowers. Also pollen grains (sperm containing reproductive cells) can be with long (**L**) or round (**l**). The two genes are found on the same autosome. Two plants that are heterozygous for both genes are crossed. What are the predicted genotypes and phenotypes of their offspring? Give the genotypic and phenotypic ratios. Set up the problem and show your work.

5. A person who did not have the information about linkage in the previous problem decided to determine if the two genes were linked or not.

a. Show the expected outcome of the cross above if the two genes were not linked.

b. Compare it to the results in the previous question.

c. Suggest some things to look for in distinguishing linked and non-linked genes.

6. Tomato plants generally have round fruit which is an expression of a dominant allele **R** while the recessive allele **r** is expressed in elongated fruit shape. Likewise smooth skin is an expression of **S** while the recessive **s** produces tiny hairs (fuzz) on the skin.

a. A dihybrid homozygous dominant plant was crossed with a homozygous recessive plant. Show the genotypes of the parents, the possible gametes and the genotypes of the F1 offspring. What are the genotypic and phenotypic ratios?

b. Show the cross of two F1 offspring, including the genotypic and phenotypic ratios of the F2 generation.

c. Among the F2 are a large number that show both dominant phenotypes. What are the potential genotypes of such individuals?

d. Show how you would determine if a particular individual was homozygous for heterozygous for the two genes.

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