Unit B: Understanding Animal Body Systems

Lesson 8: Understanding Animal Genetics

Student Learning Objectives: Instruction in this lesson should result in students achieving the following objectives:

1. Explain the importance of understanding genetics.
2. Explain how genotype and phenotype are different.
3. Explain how to estimate the heritability of certain traits.
4. Describe sex determination, linkage, crossover, and mutation.

Recommended Teaching Time: 4 hours

List of Resources: The following resources may be useful in teaching this lesson:

Gillespie, J.R. (2002) *Modern Livestock & Poultry Production,* 6th Edition. Albany, NY: Delmar. (Unit 9)

www.athro.com/evo/gen/punexam.html

http://users.adelphia.net/~lubehawk/BioHELP!/psquare.htm

List of Equipment, Tools, Supplies, and Facilities:

Writing surface
PowerPoint Projector
PowerPoint Slides
Transparency Masters
Copies of student lab sheet
Paper
Live animals if available

Terms: The following terms are presented in this lesson: **PowerPoint Slides 2 and 3.**

Alleles
Chromosome
Codominance
Crossover
Deoxyribonucleic acid
DNA
Dominant

Genetic code
Genome
Genotype
Heredity
Heritability
Heritability estimate
Heterozygous
Homozygous
Incomplete dominance
Linkage
Mutation
Phenotype
Probability
Punnett Square
Qualitative traits
Quantitative traits
Recessive
Sex chromosomes

Interest Approach: Use an interest approach that will prepare the students for the lesson.

Teachers often develop approaches for their unique class and student situations. A possible approach is included here.

Have students count the number of students in class who have brown eyes, blue eyes, and green eyes. Then ask the eye color of each student's parents. Record these observations on the writing surface. Discuss the relationship between parent's eye color and student's eye color. How many students had the same eye color of at least one of their parents? How many had the same eye color as the parent of the same sex?

Summary of Content and Teaching Strategies

Objective 1: Explain the importance of understanding genetics.

Anticipated Problem: Why is it important for a livestock producer to understand genetics?
Ask students to describe an ideal bull on a sheet of paper. They can draw or write their description. Then, ask students how we know that the bull is "ideal"? Most likely by how he looks on the outside. But, what about his genetics?

I. Genetics is the study of the laws and processes of biological inheritance. The study of genetics is concerned with the transfer of traits. Gregor Mendel discovered that these traits are inherited through units called genes. Mendel further discovered that genes were found in pairs and half of the inherited traits come from the father and half from the mother. This passing of traits from parents to offspring is called ***heredity***. Not all differences in animals are caused by genetics. Some are caused by the environment, or conditions under which the animal is raised. **PowerPoint Slide 4.**

A. A ***chromosome*** is a tiny threadlike part in a cell that contains the genetic material.
   1. Chromosomes are found in the nucleus of cells. The genetic material found in the chromosomes is called the ***genome*** of the organism. When animals mate, the genome of the offspring is a combination of the traits from the mother and the father. All of the cells within the animal are genetically identical. Each cell contains identical numbers of chromosomes. The number found in a cell varies between species. Chromosomes are made of genes that consist of ***deoxyribonucleic acid*** or DNA. ***DNA*** is a protein-like nucleic acid on genes that controls inheritance. Each DNA molecule consists of two strands shaped as a double helix or spiral structure. These strands are nucleotides bonded together by pairs of nitrogen bases. The nucleotides are made up of sugar molecules held together by phosphates. There are four nitrogen bases found in DNA. They are: cytosine, guanine, adenine, and thymine. Cytosine always pairs with Guanine and Adenine always pairs with Thymine. **PowerPoint Slide 5.**
   2. The ***genetic code*** is the sequence of nitrogen bases in the DNA molecule. This sequence code is for amino acids and proteins. The ability of DNA to replicate itself allows for the molecule to pass genetic information from one cell generation to the next. **PowerPoint Slide 6.**

Use TM: 8-1 and TM: 8-2 to aid in the discussion on this topic. Note taking will be essential for this lesson. Use PowerPoint Slides to assist with note taking. Using TM: 8-2 have students respond out loud when you ask which Nitrogen bases pair together. For example, if you say "Cytosine" students would say "Guanine" and so on. Repeat as necessary.

Objective 2: Explain how genotype and phenotype are different.

Anticipated Problem: How do genotype and phenotype differ?

Ask students to remember back to the interest approach about eye color. Now, ask students who can roll their tongue? How many students have attached earlobes? These are all physical things that we see, but what determines these physical characteristics is our genotype or genetics.

II. Resulting offspring of reproduction have both genotype and phenotype heredity.
   A. ***Genotype*** is the actual genetic code. It controls physical and performance traits. The genotype of an organism cannot be changed by environmental factors. **PowerPoint Slide 7.**
   B. ***Phenotype*** is the organism's physical or outward appearance. This is the part of the genotype the organism expresses or shows. In some instances, phenotype may be altered by the organism's environment. **PowerPoint Slide 8.**
   C. A ***homozygous*** organism is one having similar ***alleles*** or genes on the DNA molecule for a particular trait. While a ***heterozygous*** organism is one having different alleles for a particular trait. **PowerPoint Slide 9.**

Use PowerPoint Slides to assist with note taking. If possible, have a local livestock producer provide phenotypic traits on animals for the class to discuss. Then, have pictures of animals, or live specimens. Have students give example of genotypic traits and phenotypic traits.

Objective 3: Explain how to estimate the heritability of certain traits.

Anticipated Problem: How can I estimate which traits will be inherited by offspring?

Ask students how many of them have younger siblings or relatives. Who can remember someone in the family saying "I hope the baby has my eyes." Or, "I hope the baby has your sense of direction." These things can be determined using genetics. Lead this discussion into objective.

III. Estimating is based on probability. ***Probability*** is the likelihood or chance that a trait will occur. Mating animals of particular traits does not guarantee that the traits will be expressed in offspring. ***Heritability*** is the proportion of the total variation (genetic and environmental) that is due to additive gene effects. **PowerPoint Slide 10.** A ***heritability estimate*** expresses the likelihood of a trait being passed on from parent to offspring. If a trait has a high heritability, the offspring are more likely to express that same trait. **PowerPoint Slides 11 and 12.**

A. The genes contained in an animal control traits of that animal. Some traits are controlled by only one pair of genes, while others require several pairs.

1. ***Qualitative traits*** are traits controlled only by a single pair of genes and cannot be altered by the environment. Their phenotype is either one thing or the other. These traits most easily show how genes are inherited. An example is coat color. **PowerPoint Slide 13.**
2. ***Quantitative traits*** are traits controlled by several pairs of genes. These traits are expressed across a range. These traits can also be altered by environment. Examples include rate of gain, growth rate, backfat depth, etc. **PowerPoint Slide 14.**
3. Not all traits contained within an organism are expressed. ***Dominant*** traits cover up or mask the alleles for ***recessive*** traits. In some organisms there are cases of ***codominance*** of traits in which both dominant and recessive genes are expressed. ***Incomplete dominance*** happens when a blending of the allele pair is expressed. **PowerPoint Slide 15.**
4. The ***Punnett Square*** is a technique for predicting genotype. It considers the dominant and recessive genes of the male and female parents for one trait. **PowerPoint Slides 16, 17, and 18.**

Use TM: 8-3, TM: 8-4, and TM: 8-5 to help illustrate the points of the objective. Also, have students do many worksheets and examples involving the punnett square. Examples are shown on the TM's, but feel free to make your own. Also, have students complete LS: 8-1 over punnett squares.

Objective 4: Describe sex determination, linkage, crossover, and mutation.

Anticipated Problem: What are sex determination, linkage, crossover, and mutation and why are they important?

Ask students if they have every heard of diseases that only one type or sex of animal can get. Have students share these out loud.

IV. There are several other factors that are important for livestock producers to understand. Some of them are:

A. Sex determination—Determination of the sex of zygote depends on the ***sex chromosomes***. The process differs slightly among species. **PowerPoint Slide 19.**

1. Mammals—Male sex chromosomes are either X or Y. A zygote that receives a Y chromosome from sperm will be male. A zygote that receives an X chromosome from sperm will be female. The male makes sex determination as all eggs from female

receive an X chromosome. Therefore, a female zygote will have two X chromosomes (XX) while a male zygote will have one X and one Y chromosome (XY). **PowerPoint Slide 20.**

2. Poultry—The female determines the sex of the offspring. The male carries two sex chromosomes (ZZ). The female carries only one sex chromosome (ZW). After meiosis, all the sperm cells carry a Z chromosome. Only half of the egg cells carry a Z chromosome; the other half carries a W chromosome. **PowerPoint Slide 21.**
3. Linkage—The tendency for certain traits to appear in groups in the offspring is called ***linkage***. Early studies in genetics were based on the idea that all genes are redistributed in each mating. It was found, however, that some groups of traits seemed to stay together in the offspring. **PowerPoint Slide 22.**
4. Crossover—***Crossover*** is the formation of new chromosomes resulting from the splitting and rejoining of the original chromosome. This explains why the predicted results of a mating do not always happen. During one stage of meiosis the chromosomes line up together. They are very close to each other. Sometimes the chromosomes cross over one another and split. This forms new chromosomes with different combinations of genes. **PowerPoint Slide 23.**
5. Mutation—***Mutation*** is the appearance of a new trait in the offspring that did not exist in the genetic makeup of the parents. **PowerPoint Slide 24.**

Use TM: 8-6 and 8-7 to help students master this objective. Also, if possible, have a local livestock specialist visit the classroom to talk about this objective. If this is not possible, have students research different types of mutations common for animals in your area.

Review/Summary: Use the student learning objectives to summarize the lesson. Ask students how are genotypes and phenotypes different? How is heritability estimated in animals? What happens during crossover and mutation?

Application: Have students complete LS: 8-1

Evaluation: Evaluation should focus on student achievement of the objectives for each lesson. Various techniques can be used, such as performance on the application activities. A sample written test is attached.

Answers to Sample Test:

Part One: Matching

1 = e, 2 = f, 3 = b, 4 = c, 5 = g, 6 = d, 7 = h, 8 = a

Part Two: Completion

1. DNA
2. different
3. Codominance
4. Mutation
5. linkage
6. replicate

Part Three: Short Answer

1. Refer to objective 4 in the lesson for scoring this question.

2.

	b	b
B	Bb	Bb
b	bb	bb

Sample Test 8-1 Name_____

Test

Part One: Matching

Instructions. Match the term with the correct response. Write the letter of the term by the definition.

a. Crossover	e. Genome
b. Heritability	f. Phenotype
c. Quantitative traits	g. Genotype
d. Heritability estimate	h. Qualitative traits

_____ 1. Genetic material found in the chromosomes

_____ 2. The organism's physical or outward appearance

_____ 3. The likelihood of a trait being passed of from parent to offspring

_____ 4. Traits controlled by several pairs of genes. These traits are expressed across a range. These traits can also be altered by environment

_____ 5. The actual genetic code

_____ 6. The proportion of the total variation (genetic and environmental) that is due to additive gene effects

_____ 7. Traits controlled only by a single pair of genes and cannot be altered by the environment

_____ 8. The formation of new chromosomes resulting from the splitting and rejoining of the original chromosome

Part Two: Completion

Instructions. Provide the word or words to complete the following statements.

1. _____ is a protein-like nucleic acid on genes that controls inheritance.
2. A heterozygous organism is one having _____ alleles for a particular trait.
3. _____ of traits in which both dominant and recessive genes are expressed.
4. _____ is the appearance of a new trait in the offspring that did not exist in the genetic makeup of the parents

5. The tendency for certain traits to appear in groups in the offspring is called _____.
6. The ability of DNA to _____ itself allows for the molecule to pass genetic information from one cell generation to the next.

Part Three: Short Answer

Instructions. Provide information to answer the following questions.

1. Explain how sex of offspring is determined in mammals and in poultry.

2. Use the Punnett Square method to estimate the possible gene combinations for the following situation. Mating a black cow (Bb) to a red bull (bb).

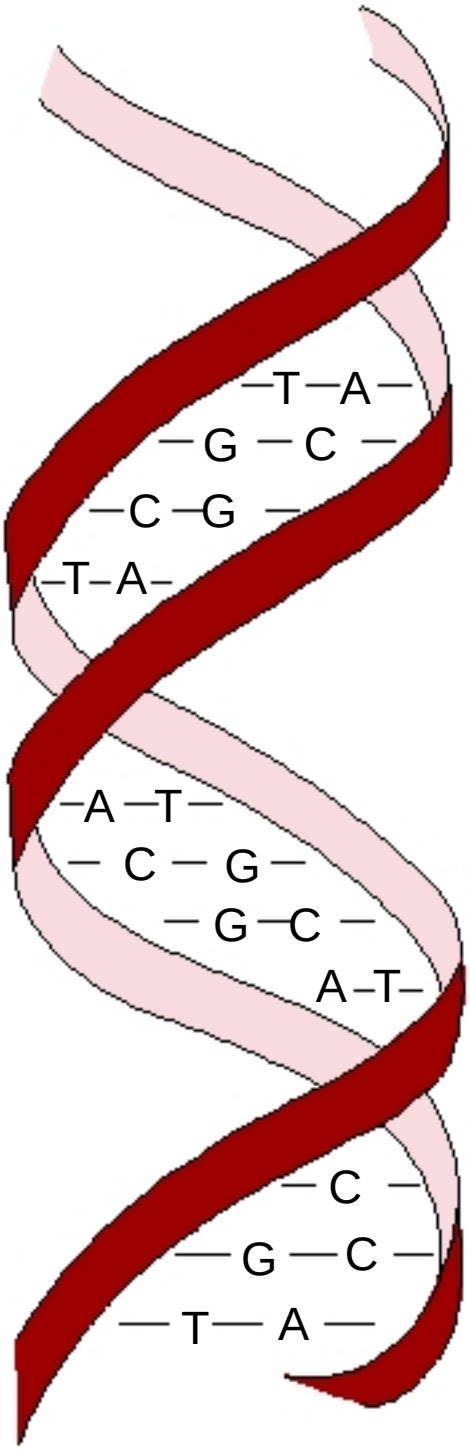
TM: 8-1

NUMBER OF CHROMOSOMES FOR SELECTED ANIMAL SPECIES

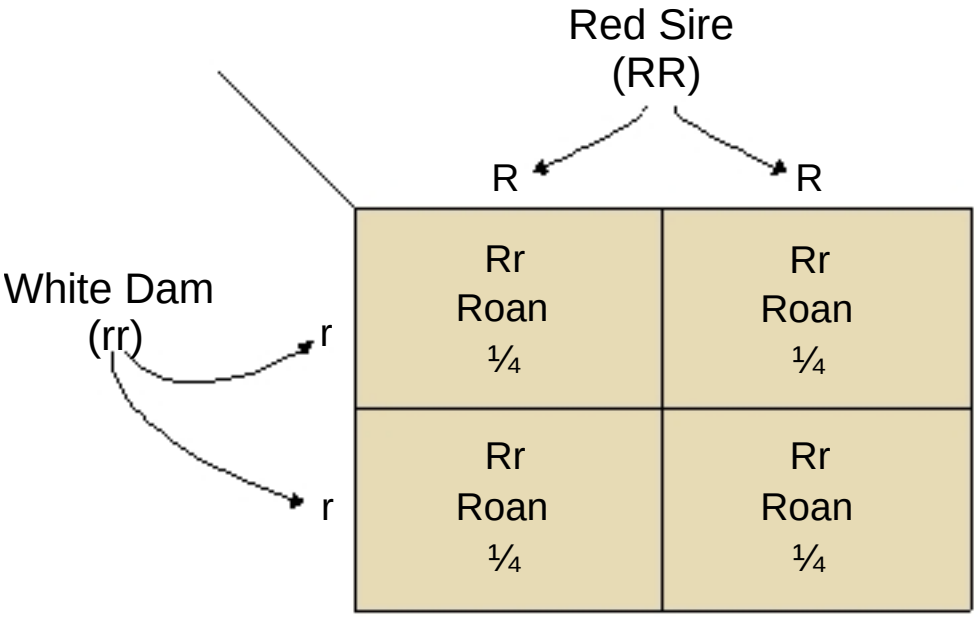
Species	Number of Chromosomes
Cat	**38**
Cattle	**60**
Chicken	**78**
Dog	**78**
Donkey	**62**
Horse	**64**
Human	**46**
Mule	**63**
Sheep	**54**

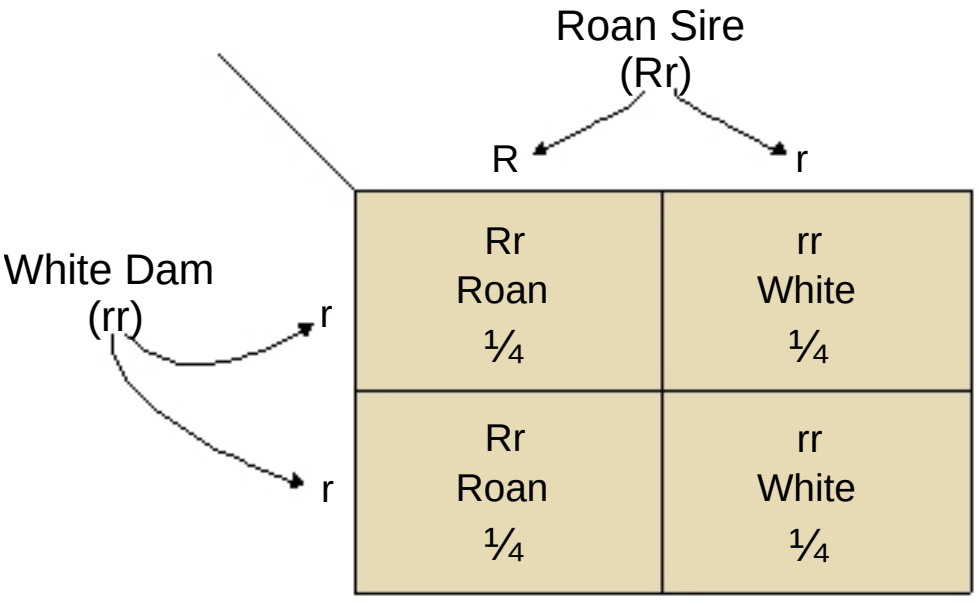
TM: 8-2

DNA STRUCTURE



ESTIMATING THE HERITABILITY OF CERTAIN TRAITS





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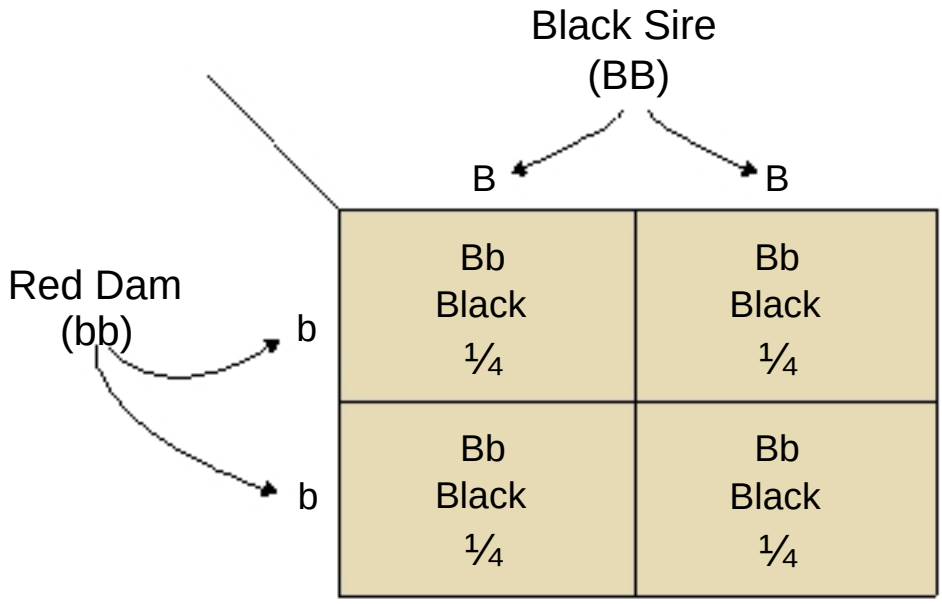
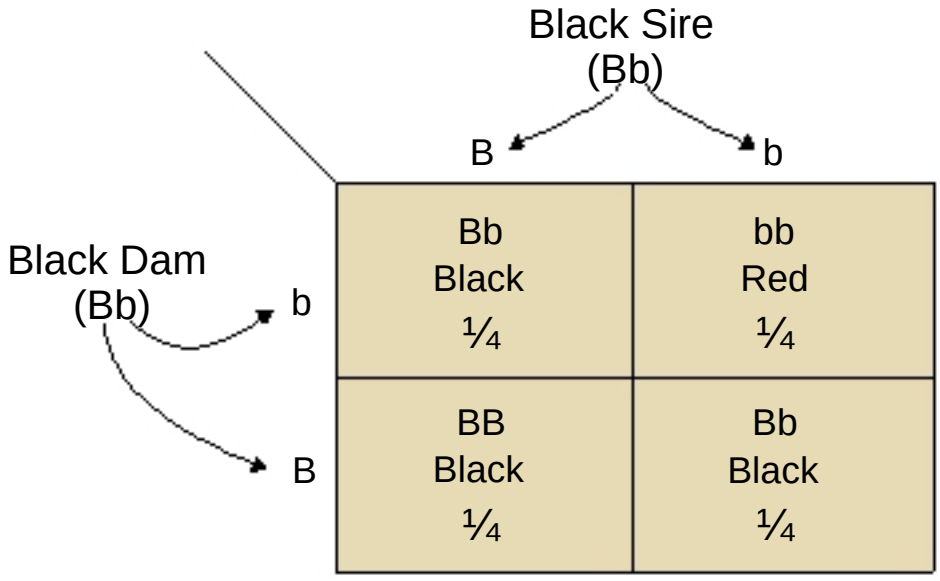




TM: 8-5

HERITABILITY ESTIMATES FOR BEEF CATTLE

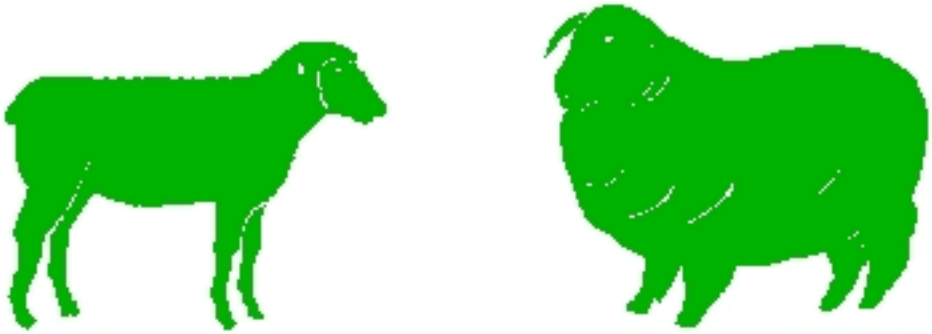
Trait	Heritability (%)
Number born	5
Calving interval (fertility)	10
Percent calf crop	10
Services per conception	10
Conformation score at weaning	25
Cancer eye susceptibility	30
Gain on pasture	30
Weaning weight	30
Yield grade	30
Carcass grade	35
Age at puberty	40
Birth weight	40
Body condition score	40
Carcass—percent lean cuts	40
Conformation score at slaughter	40

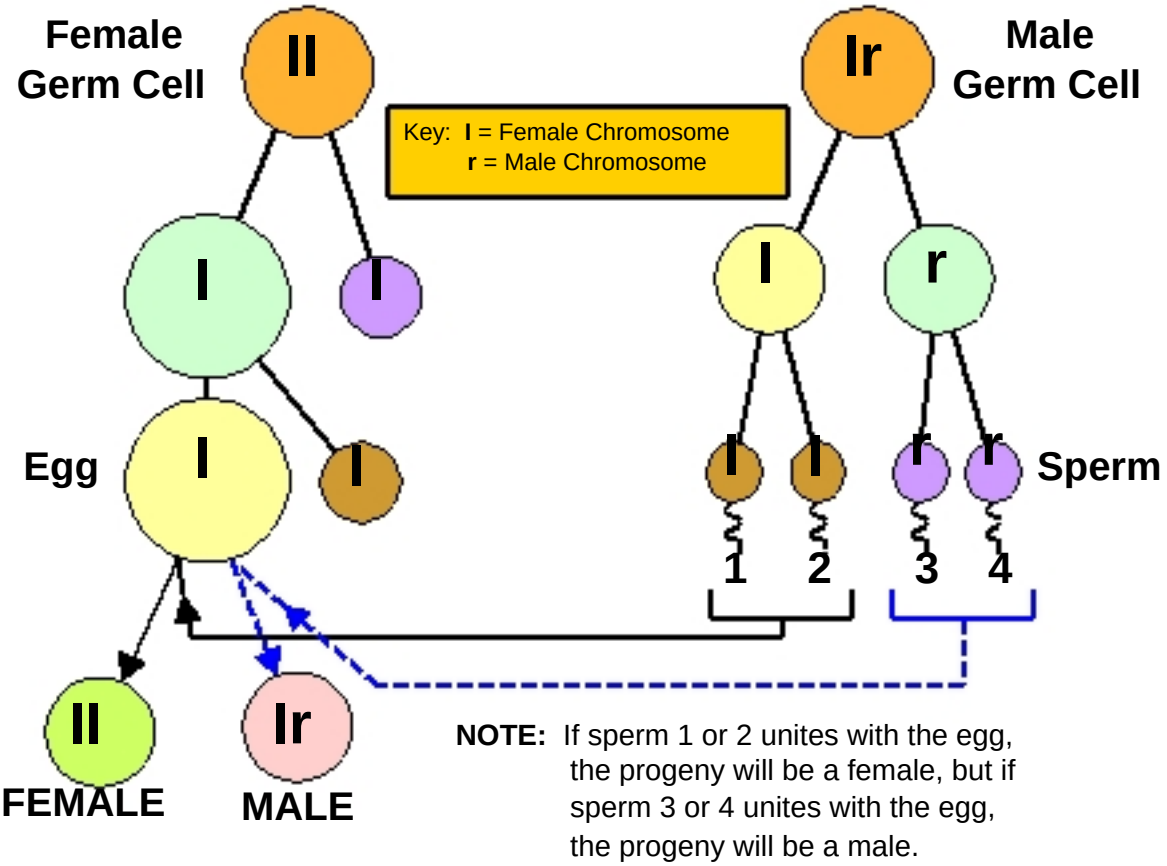
(Continued)

Trait	Heritability (%)
Cow maternal ability	**40**
Efficiency of gain	**40**
Preweaning gain	**40**
Yearling frame size	**40**
Yearling weight	**40**
Fat thickness	**45**
Feedlot gain	**45**
Dressing percent	**46**
Marbling score	**50**
Mature weight	**50**
Scrotal circumference	**50**
Tenderness	**50**
Final feedlot weight	**60**
Retail yield	**60**
Rib eye area	**70**

TM: 8-6

CHROMOSOME COMBINATIONS DETERMINE SEX



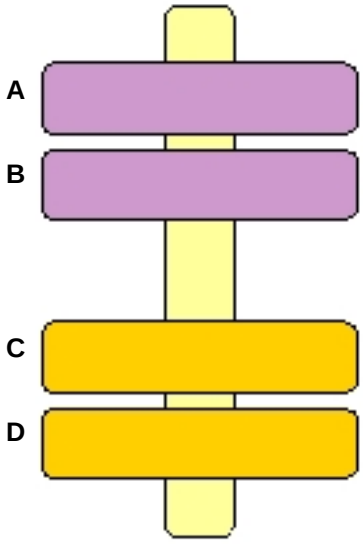


NOTE: If sperm 1 or 2 unites with the egg, the progeny will be a female, but if sperm 3 or 4 unites with the egg, the progeny will be a male.

TM: 8-7

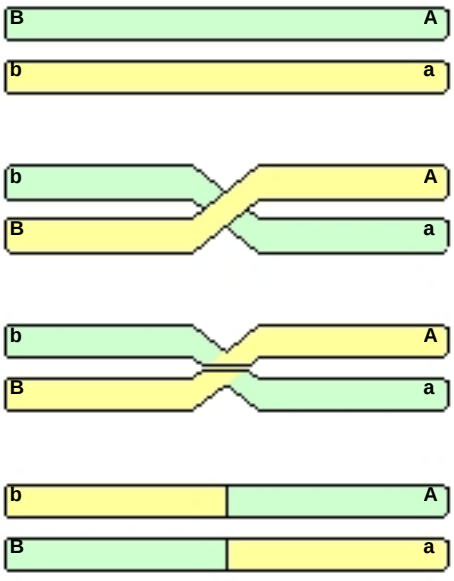
GENE LINKAGE AND CHROMOSOME DIVISION, CROSS OVER, AND SPLIT

Gene Linkage



Genes A and B will tend to stay together when the chromosomes divide, as will genes C and D. Genes A and D are not as likely to stay together because they are farther apart.

New combinations of genes are formed when chromosomes cross over and split.



LS: B4-4A Name_____

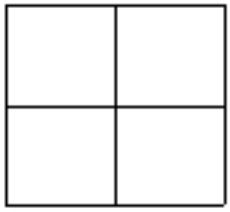
Lab Sheet

Punnett Square

Instructions:

Use the Punnett Square method to estimate the possible gene combinations. Write the required information in the squares.

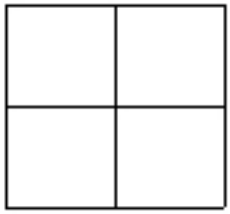
1. Mating a female, which is heterozygous for horns (Pp) to a horned bull (pp).



   a. What would be the genotype ratio? _____

   b. What would be the phenotype ratio? _____

2. Mating a corn plant that is heterozygous for green leaf color (Gg) with a corn plant that is homozygous for the recessive white leaf color (gg).



   a. What would be the genotype ratio? _____

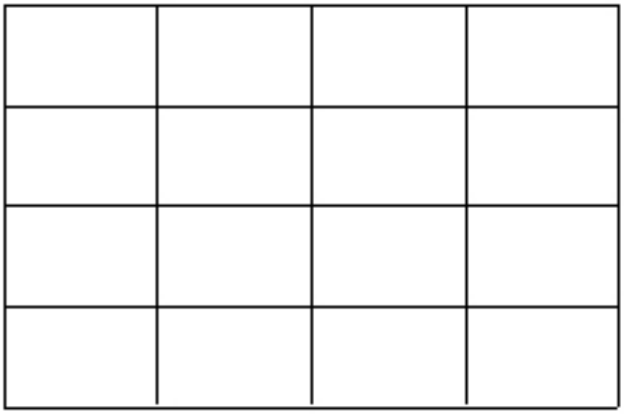
   b. What would be the phenotype ratio? _____

3. Mating a plant carrying a heterozygous gene for height (Tt) with another heterozygous plant. (T = tall, t = short)

c. What would be the genotype ratio? _____

d. What would be the phenotype ratio? _____

4. Mate a polled, black cow (PpBb) with a polled, black bull (PpBb) P = polled; p = horned; B = black; b = red.



a. How many phenotypes are possible? _____

b. List each phenotype and the number of offspring with that phenotype.