

Lesson B4–4

Understanding Genetics

Unit B. Animal Science and the Industry

Problem Area 4. Understanding Animal Reproduction and Biotechnology

Lesson 4. Understanding Genetics

New Mexico Content Standard:

Pathway Strand: Animal Systems

Standard: IV: Know the factors that influence an animal's reproductive cycle to explain species response.

Benchmark: IV-B. Discuss reproductive cycles to show how they differ from species to species.

Performance Standard: 2. Discuss the implications of genetic variation.

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.

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

Recommended Resources. One of the following resources should be selected to accompany the lesson:

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

Other Resources. The following resources will be useful to students and teachers:

Baker, M. & Mikesell, R.E. (1996) *Animal Science Biology and Technology*. Danville, IL: Interstate Publishers, Inc. (Chapter 6)

Ensminger, M.E. (1991) *Animal Science*, 9th Edition. Danville, IL: Interstate Publishers, Inc. (Chapter 3)

Lee, J.S., Hutter, J., Rudd, R., Westrom, L., Bull, A.M., Embry Mohr, C. & Pollock, J. (2000) *Introduction to Livestock and Companion Animals*, 2nd Edition. Danville, IL: Interstate Publishers, Inc. (Chapter 6)

List of Equipment, Tools, Supplies, and Facilities

Writing surface
Overhead projector
Transparencies from attached masters
Copies of student lab sheet

Terms. The following terms are presented in this lesson (shown in bold italics):

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 who have brown eyes, blue eyes, and green eyes. Then ask the eye color of each student's parents. Discuss the relationship between parent's eye color and student's eye color.

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?

- 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.
 - 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.

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.

There are many techniques that can be used to assist students in mastering this material. Students need text material to aid in understanding the importance of understanding genetics. Chapter 6 in Introduction to Livestock and Companion Animals is recommended. Use TM: B4-4A and TM: B4-4B to aid in the discussion on this topic.

Objective 2: Explain how genotype and phenotype are different.

Anticipated Problem: How do genotype and phenotype differ?

- 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.
 - 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.
 - 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.

A variety of techniques can be used to help students master this objective. Students need text material to help understand the difference between genotype and phenotype. Chapter 6 in Animal Science Biology and Technology is recommended to assist your students in mastering this information.

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

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

- 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. 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.
 - 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.
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.
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.
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.

A variety of techniques can be used to help students master this objective. Students need text material to help understand how to estimate the heritability of certain traits. Chapter 6 in Introduction to Livestock and Companion Animals is recommended to assist your students in mastering this information. Use TM: B4-4C thru TM: B4-4F to aid in discussion on this topic.

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

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

- 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.
 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).
 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.
 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.
 4. Crossover—**Crossover** is the formation of new chromosomes resulting from the splitting and rejoining of the original chromosome. This explains why the predicted re-

sults 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.

5. Mutation—**Mutation** is the appearance of a new trait in the offspring that did not exist in the genetic makeup of the parents.

A variety of techniques can be used to help students master this objective. Students need text material to help understand sex determination, linkage, crossover, and mutation. Unit 9 in Modern Livestock & Poultry Production is recommended to assist your students in mastering this information. Use TM: B4–4G and TM: B4–4H to aid in discussion on this topic.

Review/Summary. Use the student learning objectives to summarize the lesson. Have students explain the content associated with each objective. Student responses can be used in determining which objectives need to be reviewed or taught from a different angle. Questions at end of chapters in the textbook may also be used in the review/summary.

Application. Have students complete LS: B4–4A.

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

Test

Lesson B4–4: Understanding Genetics

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

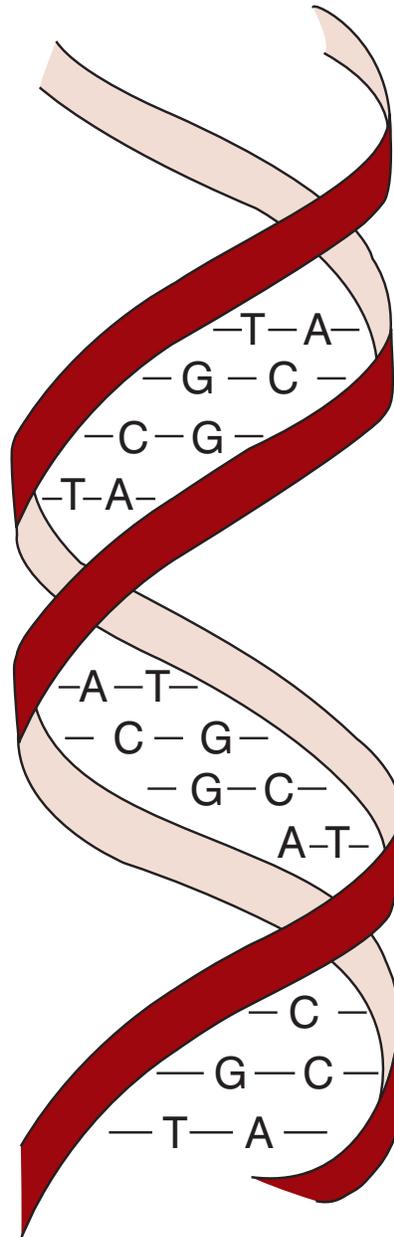
Instructions. Provide the word or words to complete the following statements.

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

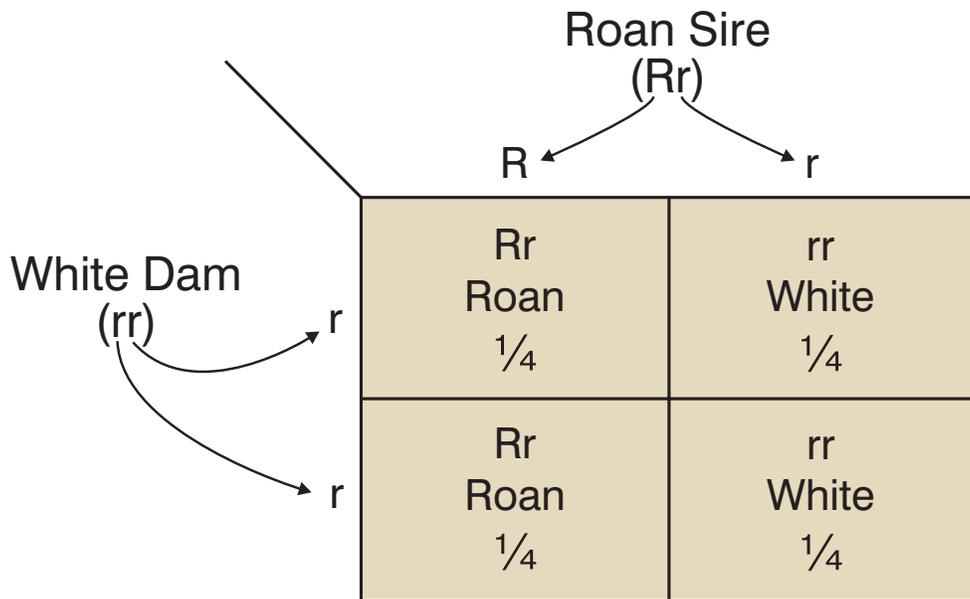
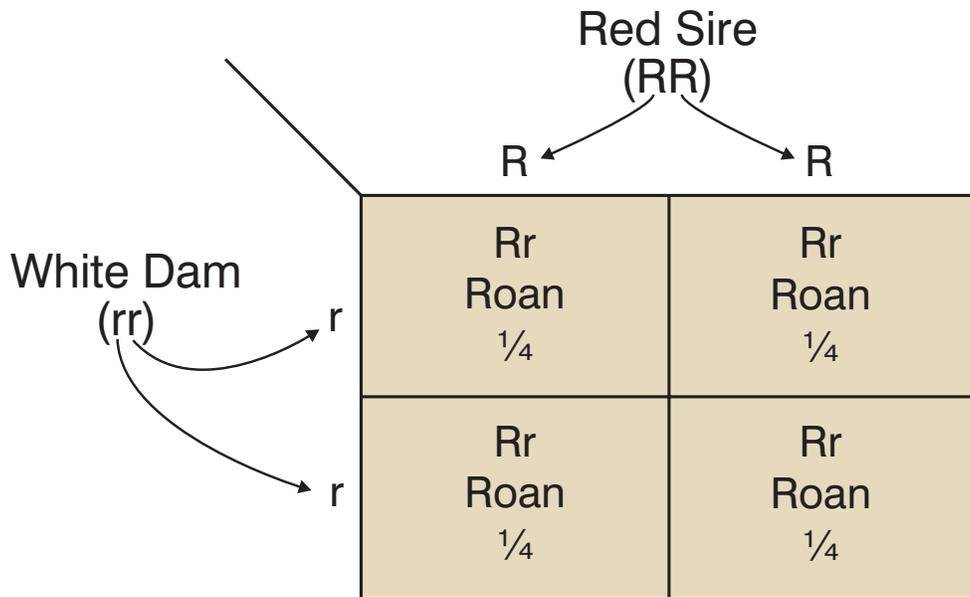
NUMBER OF CHROMOSOMES FOR SELECTED ANIMAL SPECIES

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

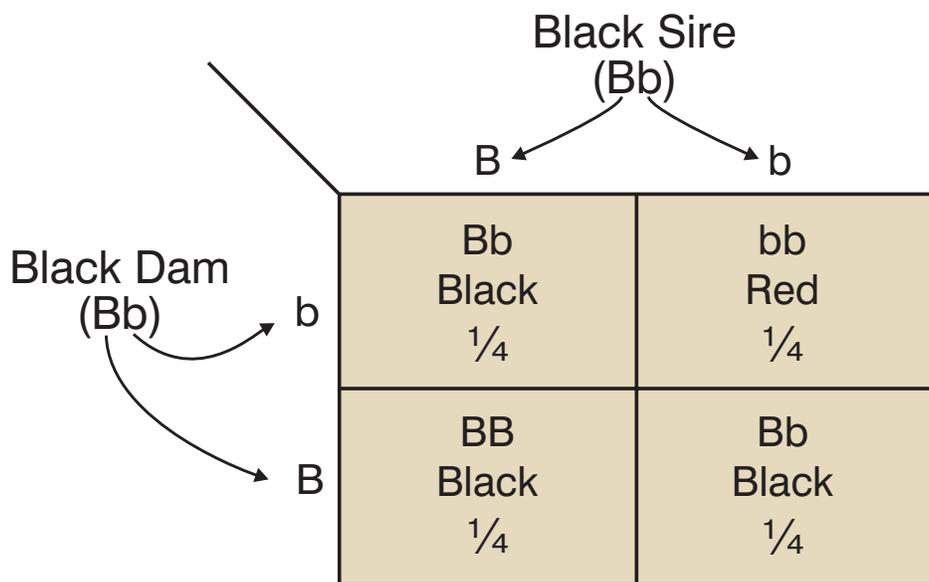
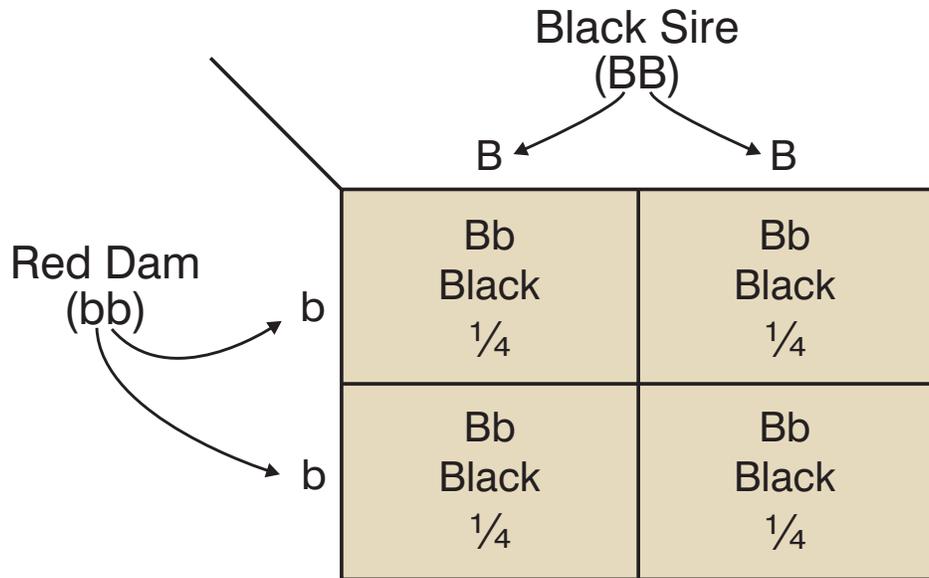
DNA STRUCTURE



ESTIMATING THE HERITABILITY OF CERTAIN TRAITS



ESTIMATING THE HERITABILITY OF CERTAIN TRAITS



HERITABILITY ESTIMATES FOR BEEF CATTLE

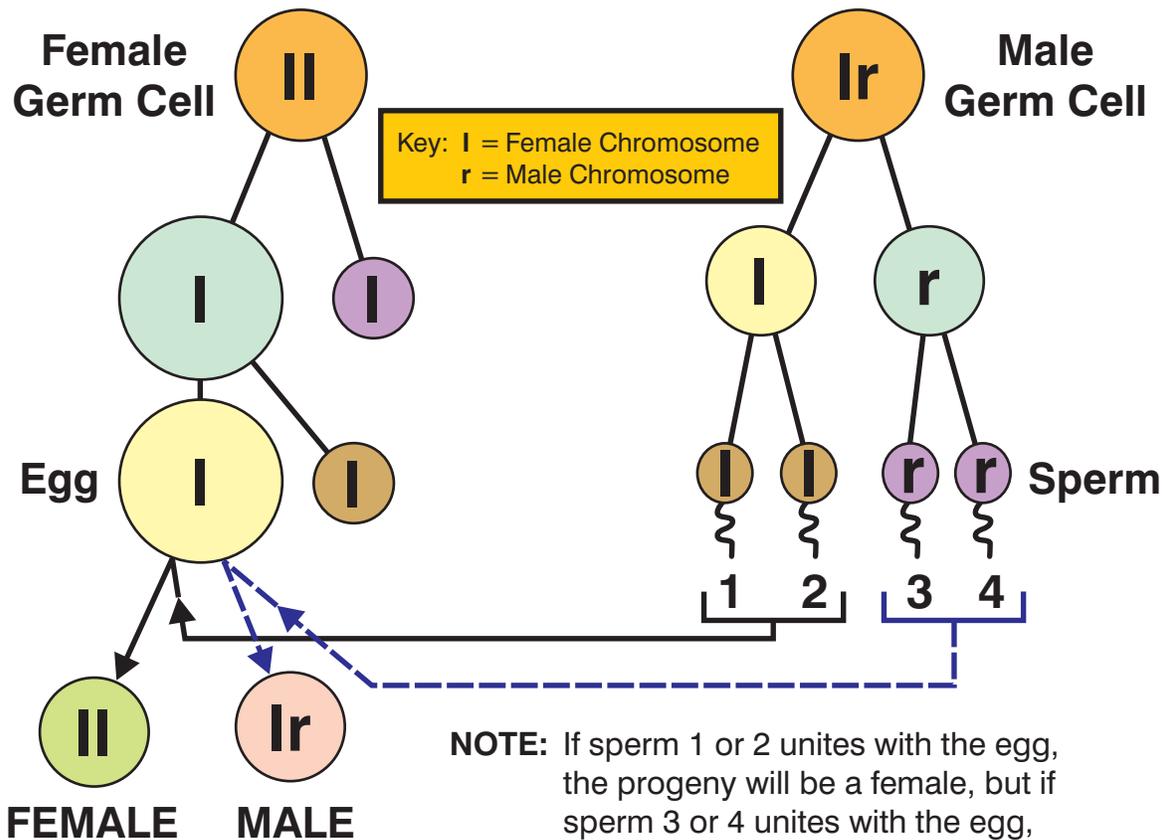
Trait	Heritability (%)
Number born	5
Calving interval (fertility)	10
Percent calf crop	10
Services per conception	10
Conformation score at weaning	25
Cancer eye susceptibility	30
Gain on pasture	30
Weaning weight	30
Yield grade	30
Carcass grade	35
Age at puberty	40
Birth weight	40
Body condition score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

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

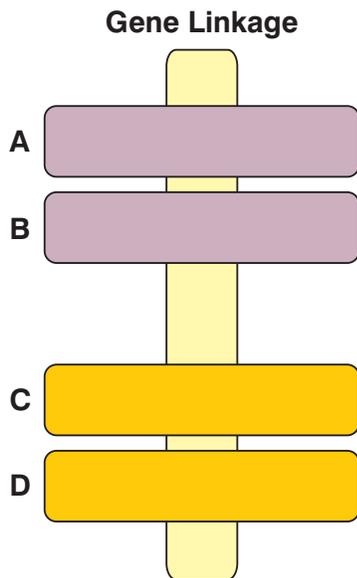
HERITABILITY ESTIMATES FOR SWINE

Trait	Heritability (%)
Litter survival to weaning	5
Litter size	10
Number farrowed	10
Number of pigs weaned	12
Weaning weight (3 weeks)	15
Birth weight	20
Five month weight	25
Number of nipples	25
Conformation	30
Feed efficiency	30
Age at puberty	35
Percent lean cuts	45
Probe backfat (live at 200 pounds [99.8 kg])	45
Carcass length	50
Loin muscle area	50
Percent of shoulder	50
Percentage carcass muscle	50
Percent ham	55
Percent fat cuts	60

CHROMOSOME COMBINATIONS DETERMINE SEX

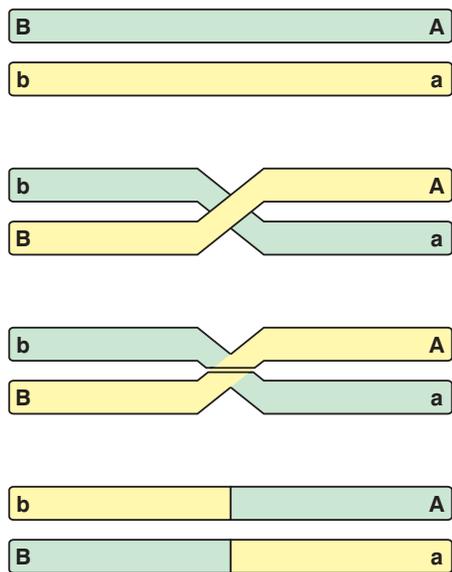


GENE LINKAGE AND CHROMOSOME DIVISION, CROSS OVER, AND SPLIT



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.



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.