Unit B: Understanding Animal Reproduction

Lesson 4: Understanding 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: 1 hour

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

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

Gillespie, J.R. *Modern Livestock and Poultry Production, 6th Edition*. Albany, NY: Delmar. 2002.

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

Taylor, R.E. Scient*ific Farm Animal Production: An Introduction to Animal Science, 4th Edition*. New York: MacMillian Publishers Co. 1992.

List of Equipment, Tools, Supplies, and Facilities:

- Writing surface
- PowerPoint Projector
- PowerPoint Slides
- Transparency Masters
- Copies of student worksheets

Terms: The following terms are presented in this lesson (shown in bold italics and on 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:

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?

(PowerPoint Slide 4)

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 Slides 5 and 6)

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.

Use TM: 4-1 and TM: 4-2 to aid in the discussion of Objective 1. Ask students how many chromosomes there are in Cattle. Compare this number to several other animal species including humans.

Objective 2: Explain how genotype and phenotype are different.

Anticipated Problem: How do genotype and phenotype differ?

(PowerPoint Slide 7)

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 in the DNA molecule for a particular trait. While a ***heterozygous*** organism is one having different alleles for a particular trait.

Use TM: 4-3 to aid in the discussion of Genotype, Phenotype, Homozygous and Heterozygous. Students may need to access the internet to learn more about how they impact heredity.

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

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

(PowerPoint Slides 8, 9, 10, and 11)

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 the offspring. ***Heritability*** is the proportion of the total variation (genetic and environmental) that is due to additive gene effects. A ***heritability estimate*** expressed 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 Slide 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.
      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 13)

      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.

Use TM: 4-4 and TM: 4-5 to discuss Punnett Squares. LS:L4-1 also covers this information. TM: 4-6 lists the heritability of commonly selected cattle traits. Notice the trend in maternal and terminal traits – in general, maternal traits are less heritable than terminal (carcass-oriented) traits.

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

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

(PowerPoint Slide 14)

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 15)

1. Cattle—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 16)

B. 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 17)

C. 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 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.

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

Use TM: 4-7 to discuss sex chromosomes and the gender determination of offspring. TM: 4-8 diagrams gene linkage and crossover.

Review/Summary: Focus the review and summary of the lesson around the student learning objectives **(PowerPoint Slide 18)**. Call on students to explain the content associated with the objectives.

Application: Have students complete LS: 4-1: Punnett Square. Their success in completing this exercise will provide evidence of their understanding of heritability. If possible bring in a local cattle producer to explain how they use genetics to improve their cattle herd.

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

Answers to Sample Test:

Matching

1. E
2. F
3. D
4. C
5. G
6. B
7. H
8. A

Fill-in-the-blank

1. DNA
2. Different
3. Codominance
4. Mutation
5. Linkage
6. Replicate

Short Answer

1. Refer to Objective 4 in this lesson for scoring this question.
2.

	b	b
B	Bb	Bb
b	bb	bb

Sample Test

Understanding Genetics

Name: _____

Matching: *Match each word with the correct 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 chromosome.

_____ 2. The organism's physical or outward appearance.

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

_____ 4. Traits controlled by several pairs of genes. These traits are expressed across a range. These traits an 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 o genes and cannot be altered by the environment.

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

Fill-in-the-blank*: 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 for the molecule to pass genetic information from one cell generation to the next.

Short Answer*: Answer the following question*.

1. Explain how sex of offspring is determined in cattle.

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: 4-1

NUMBER OF CHROMOSOMES FOR CATTLE COMPARED WITH OTHER SPECIES

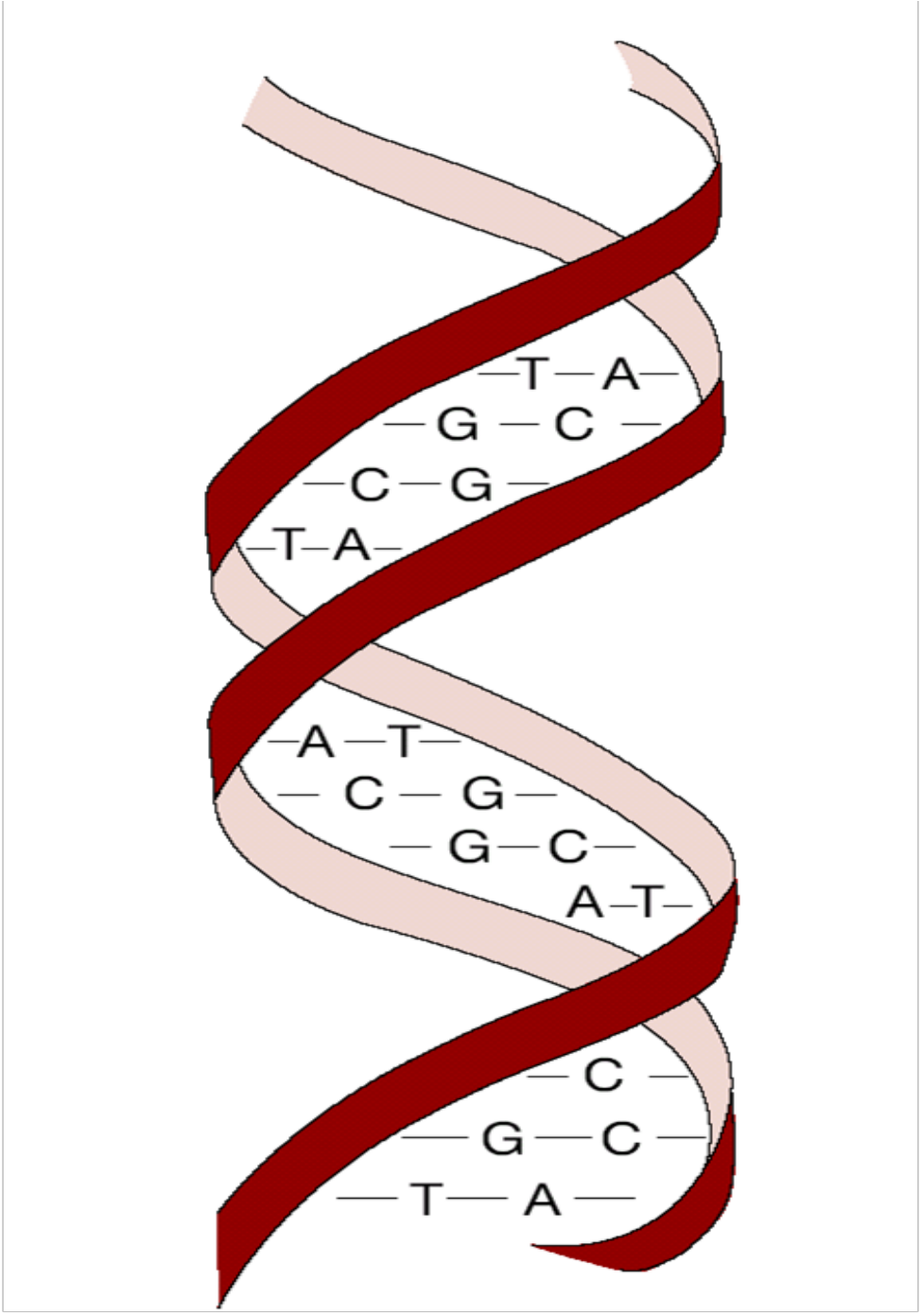
Cattle: 60

Other species:

- Cat: 38
- Chicken: 78
- Dog: 78
- Donkey: 62
- Horse: 64
- Human: 46
- Mule: 63
- Sheep: 54
- Swine: 38

TM: 4-2

DNA STRUCTURE



TM: 4-3

GENOTYPE AND PHENOTYPE

- ***Genotype***
  - Actual genetic code.
  - Controls physical and performance traits.
  - Cannot be changed by environmental factors.

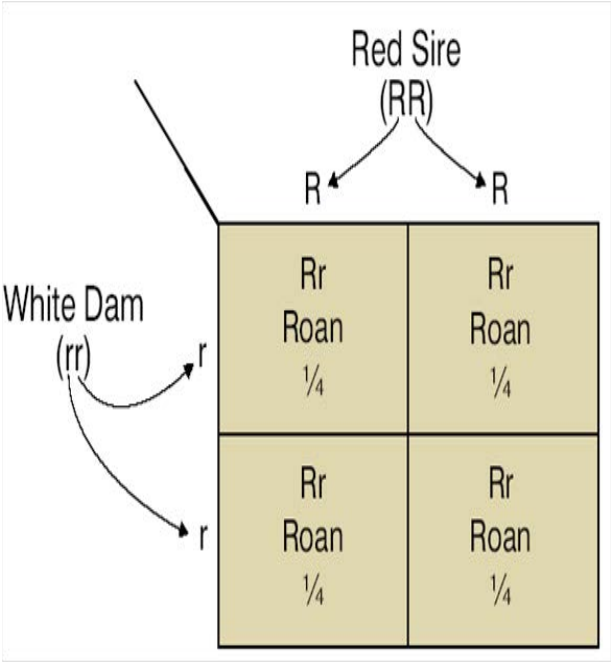
- ***Phenotype***
  - Organism's physical or outward appearance.
  - The organism expresses or shows
  - May be altered by the organism's environment.

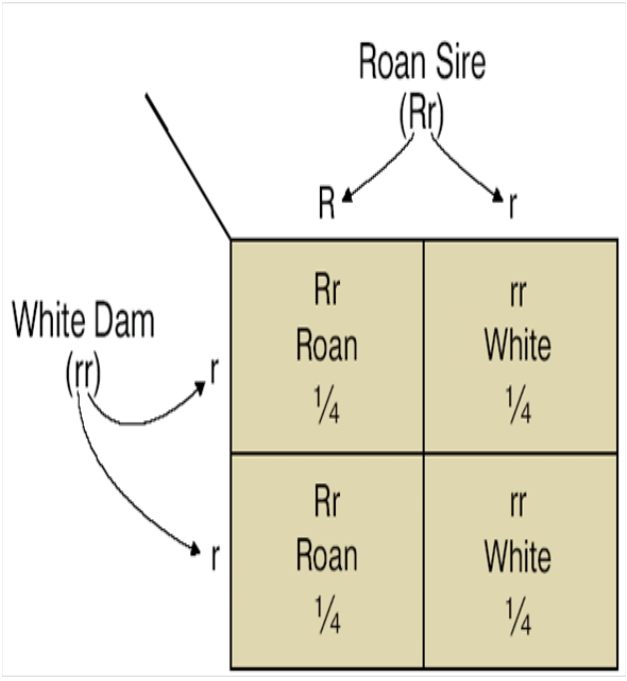
- A ***homozygous*** organism is one having similar ***alleles*** or genes in the DNA molecule for a particular trait.

- While a ***heterozygous*** organism is one having different alleles for a particular trait.

TM: 4-4

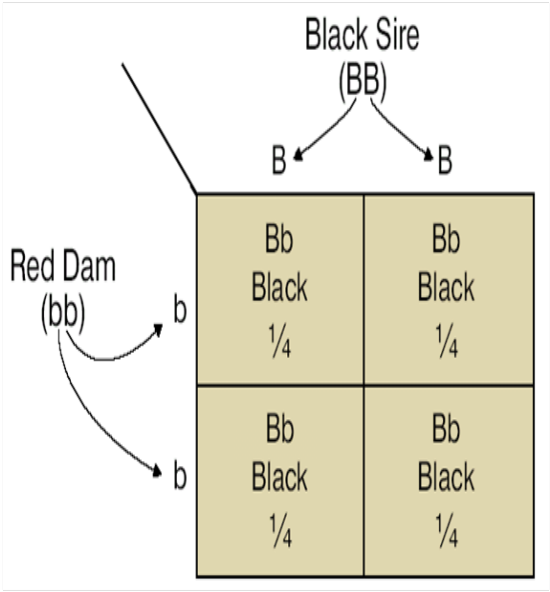
ESTIMATING THE HERITABILITY OF CERTAIN TRAITS

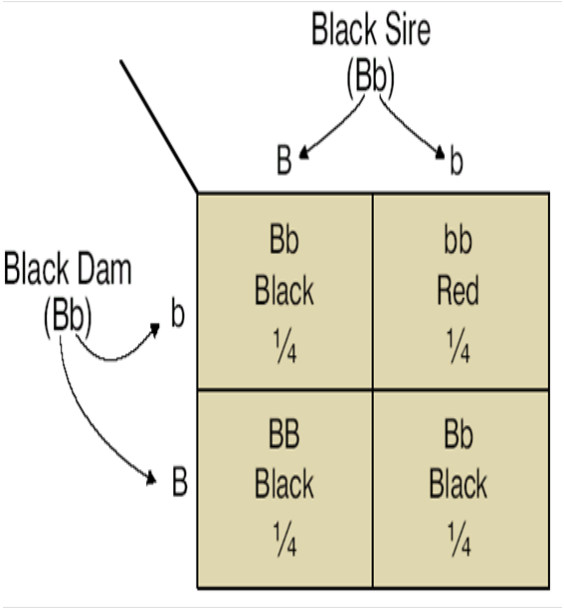




TM: 4-5

ESTIMATING THE HERITABILITY OF CERTAIN TRAITS





TM: 4-6

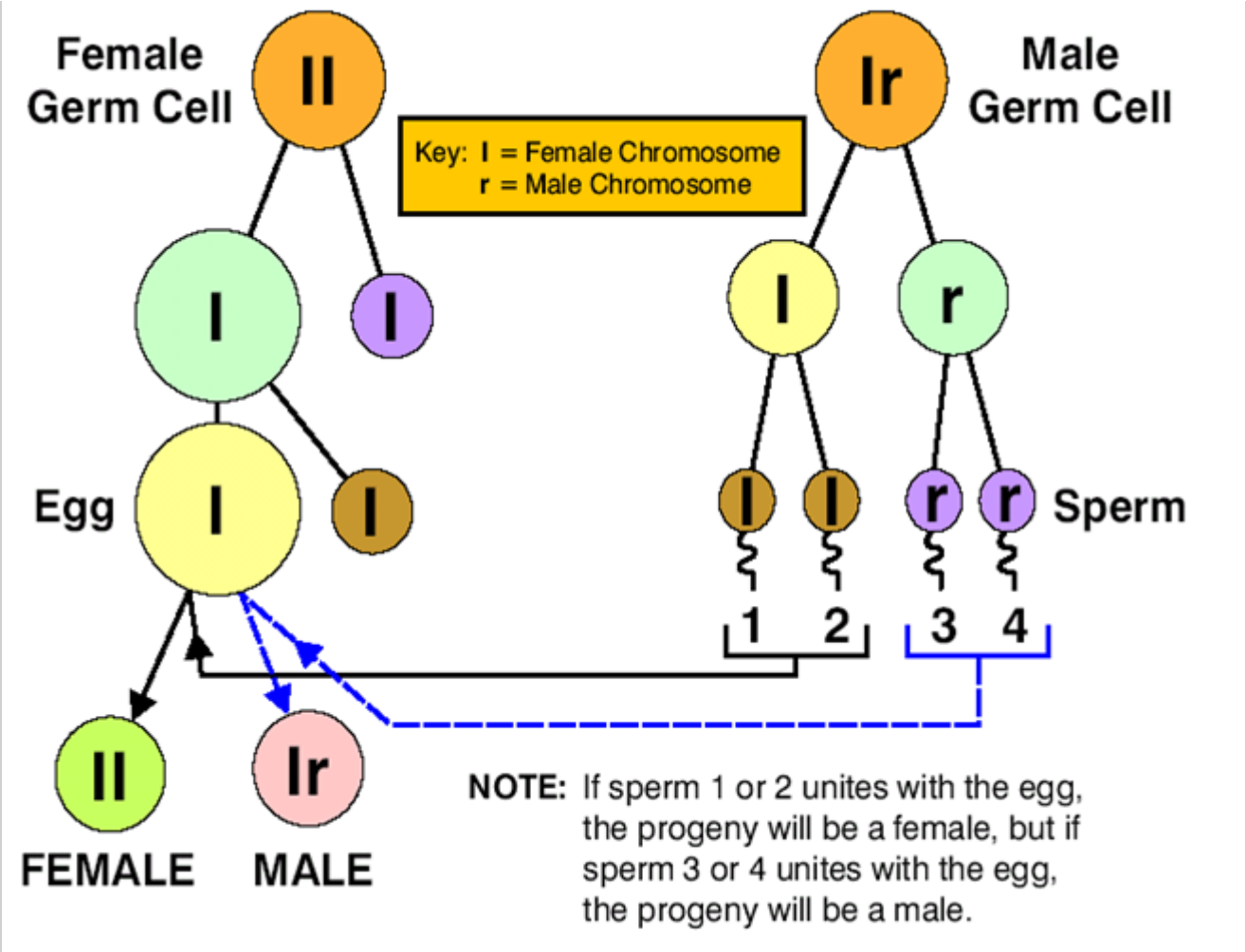
HERITABILITY ESTIMATES FOR BEEF CATTLE

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
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
Ribeye area	70

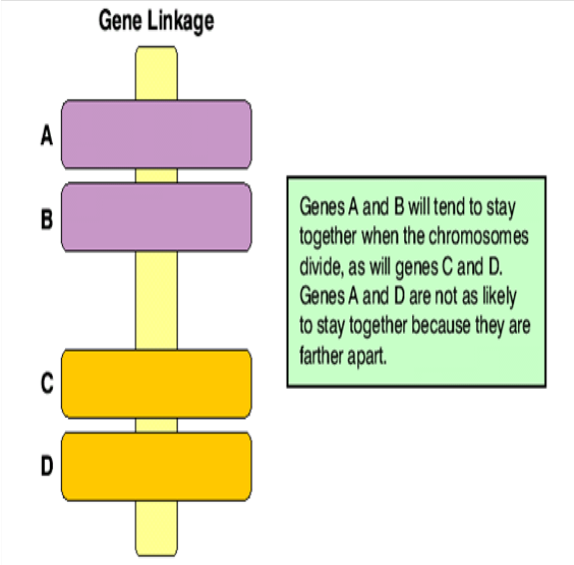
TM: 4-7

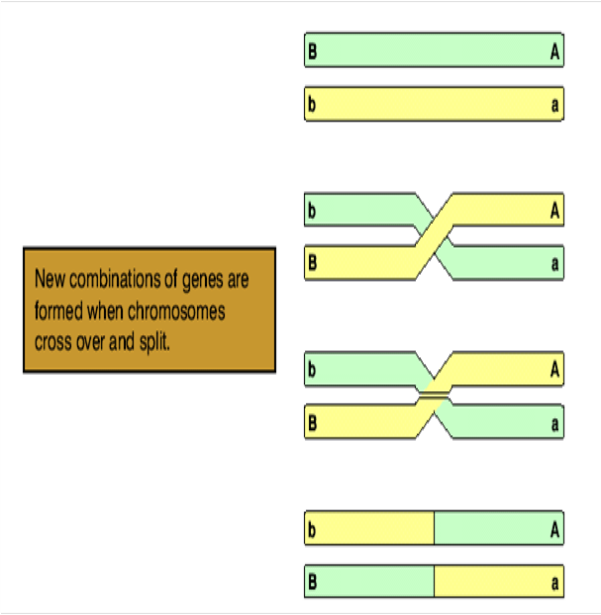
CHROMOSOME COMBINATIONS DETERMINE SEX



TM: 4-8

GENE LINKAGE AND CHROMOSOME DIVISION, CROSSOVER, AND SPLIT





LS: 4-1

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 female that is heterozygous for black coat color (Bb) with a male that is homozygous for the recessive red coat color (bb).

   a. What would be the genotype ratio?

   b. What would be the phenotype ratio?

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

a. What would be the genotype ratio?

b. 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.

LS KEY: 4-1

PUNNENT 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).

Pp	**Pp**
pp	**pp**

   a. What would be the genotype ratio? **2:2**

   b. What would be the phenotype ratio? **2:2**

2. Mating a female that is heterozygous for black coat color (Bb) with a male that is homozygous for the recessive red coat color (bb).

Gg	**gg**
Gg	**gg**

   a. What would be the genotype ratio? **2:2**

   b. What would be the phenotype ratio? **2:2**

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

TT	**Tt**
Tt	**tt**

   a. What would be the genotype ratio? **1:2:1**

   b. What would be the phenotype ratio? **3:1**

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

PPBB	**PPBb**	**PpBB**	**PpBb**
PPBb	**PPbb**	**PpBb**	**Ppbb**
PpBB	**PpBb**	**ppBB**	**ppBb**
PpBb	**Ppbb**	**ppBb**	**ppbb**

   a. How many phenotypes are possible? **4**

   b. List each phenotype and the number of offspring with that phenotype. **PB: 9; Pb: 3; pB: 3; pb: 1**