Exploring Animal Genetics and Probability

Unit: Demonstrate the Application of Biotechnology to Agriculture, Food, and Natural Resources (AFNR)

Problem Area: Applying Biotechnology to Animal Systems

Lesson: Exploring Animal Genetics and Probability

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

1. Explain the importance of 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.

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

E-unit(s) corresponding to this lesson plan. CAERT, Inc. <http://www.mycaert.com>.
Equipment, Tools, Supplies, and Facilities

- Overhead or PowerPoint projector
- Visual(s) from accompanying master(s)
- Copies of sample test, lab sheet(s), and/or other items designed for duplication
- Materials listed on duplicated items
- Computers with printers and Internet access
- Classroom resource and reference materials

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

- alleles
- autosomes
- chromosome
- crossover
- deoxyribonucleic acid
- dihybrid cross
- diploid
- dominant
- gamete
- gene
- genetic code
- genetics
- genome
- genotype
- haploid
- heredity
- heritability
- heritability estimate
- heterozygous
- homologous chromosomes
- homozygous
- linkage
- locus
- monohybrid cross
- 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 identify similar characteristics that they have with their parents, grandparents, and/or siblings. Have students make a spider web on paper linking their traits to those of other family members. Common characteristics they could identify are eye color, hair color, right- or left-hand dominance, ability to roll tongue, and attached earlobes. Discuss with students the relationship between their parents' traits and their traits.
```
Objective 1: Explain the importance of genetics.

Anticipated Problem: Why are genetics important?

I. The study of genetics is extremely valuable to several areas of science. From medical to agricultural applications, innovations in studying DNA have revolutionized genetics. They have allowed biologists to develop and discover new drugs, vaccines, gene technology used in the treatment of genetic diseases, crops resistant to pesticides and pests, and commercially superior animals. However, with new science discoveries, several ethical, legal, and social questions and issues have surfaced.

A. Genetics is the study of heredity. The appearance of an offspring is directly influenced by its parents. The study of genetics is concerned with the transfer of traits. Gregor Mendel and Robert Bakewell were the first two individuals who gave insight into the study of genetics.

1. Gregor Mendel discovered that traits are inherited through units called genes. A gene is any of the segments of a chromosome that contain the hereditary traits of an organism. Mendel further discovered that genes are found in pairs and that half the inherited traits come from the father and half from the mother. This passing of traits from parents to offspring is called heredity.

2. Robert Bakewell confirmed that an offspring will express a certain trait if both parents excel in and express the studied trait. He continued his research in breeding systems and became known as “the father of modern animal breeding.” However, not all differences in animals are caused by genetics. Some are caused by the environment, or the conditions under which an animal is raised.

B. Understanding chromosomes is fundamental to genetics. A chromosome is a tiny threadlike structure that contains the genetic material in a cell.

1. Chromosomes are found in the nucleus of a cell. The genetic material in the chromosomes is called the genome of the organism. When animals mate, the genome of the offspring is a combination of traits from the mother and the father. All the cells within the animal are genetically identical. Each cell contains the same number of chromosomes. Different species express different numbers of chromosomes (horse—64; cattle—60; swine—38; sheep—54). Humans have a total of 46 chromosomes, which form 23 pairs (a set from each parent). A pair of chromosomes is known as homologous chromosomes. Within normal individuals, the number of chromosomal pairs in body cells is constant. An animal has one pair of sex chromosomes. These are the X and Y chromosomes. In some species, the male is XY and the female is XX. Autosomes are all the chromosomes in body cells other than sex chromo-
somes. Therefore, humans have 1 pair of sex chromosomes and 22 pairs of autosomes, for a total of 23 pairs of chromosomes.

a. A cell that contains the normal two sets of chromosomes (one from each parent) is said to have a diploid number \(2n\) of chromosomes. A gamete, or sex cell, carries only a single set of chromosomes and is said to have a haploid number \(1n\) of chromosomes.

b. A diploid cell contains two versions of each chromosome: a maternal homologue contributed by the haploid egg of the mother and a paternal homologue contributed by the haploid sperm of the father.

2. Chromosomes are made of deoxyribonucleic acid (DNA), which is a protein-like nucleic acid that controls inheritance. Each offspring receives two genes that may code for the same trait or for two alternative traits. The particular location of a gene on a chromosome is referred to as the gene’s locus. When alternative forms of a gene occur, they are called alleles. Therefore, when two haploid gametes containing the same allele of a gene come together in fertilization to form a zygote (the zygote develops into an offspring), the zygote is said to be homozygous. When two haploid gametes containing different alleles come together, the zygote is said to be heterozygous.

a. Each DNA molecule consists of two stands shaped as a double helix or spiral structure. These strands are nucleotides bonded 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.

b. The genetic code is the sequence of nitrogen bases in the DNA molecule. This sequence is for amino acids and proteins. The ability of DNA to replicate itself allows for a molecule to pass genetic information from one cell generation to the next. Each species has a different genetic code.

3. In October 1990, the Human Genome Project (HGP) started. Its goals were to determine the complete sequence of DNA subunits, identify all human genes, and allow for further study. The project came to completion in 2003. However, studies and further research have continued, not only with humans, but also with about 800 other organisms that have been sequenced in recent years. The importance of studying all DNA in every chromosome in humans will have numerous profound effects. Diseases usually have genetic components. Therefore, the knowledge of where specific genes are located will help in diagnosing, preventing, or treating diseases. In livestock, the location of genes will help in providing information for selecting superior breeding stock.

**Teaching Strategy:** Have students read appropriate sections in the E-unit and assist in providing information as the content is summarized on the writing surface. Use VM–A to summarize the number of chromosomes for selected animal species. Use VM–B to review the DNA molecule. Conduct LS–A to help students view DNA molecules.
Objective 2: Explain how genotype and phenotype are different.

Anticipated Problem: How do genotype and phenotype differ?

II. Just carrying a particular pair of alleles does not guarantee that the trait encoded by them will be expressed. Only the dominant allele (written as a capital letter) will express the trait. The corresponding recessive allele (written as a lowercase letter), though present, will not express the trait. For example, in Angus cattle, the black gene (B) is dominant to the red gene (b). Therefore, with two alleles (B and b), the possibility exists of having three genotypes (BB, Bb, and bb) and two phenotypes (two black and one red).

A. Genotype is the actual genetic code. Biologists often refer to the genotype as the totality of alleles that an individual contains. It controls physical and performance traits. The genotype of an organism cannot be changed by environmental factors.

B. Phenotype is an organism’s physical or outward appearance. This is the part of the genotype the organism expresses. Phenotype is dependent on the genes the individual inherits. In some instances, phenotype may be altered by the organism’s environment. For example, the color of coat may not be changed by the environment. However, a lamb may have a genotype to gain 1 pound per day. If the lamb receives a low-grade diet, then the lamb may gain only 1/2 pound per day. Therefore, the genetic potential of the lamb is hidden because of the environmental factor, the low-grade diet.

1. Qualitative traits are traits controlled by only 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. They can also be altered by environment. Examples are rate of gain, growth rate, and backfat depth.

Teaching Strategy: Have students read appropriate sections in the E-unit and assist in providing information as the content is summarized on the writing surface. Use VM–C to discuss dominant and recessive traits. Conduct a class discussion about the
Objective 3: Explain how to estimate the heritability of certain traits.

Anticipated Problem: How is the inheritance of certain traits estimated?

III. Estimating the inheritance of traits is based on probability. Probability is the likelihood or chance that a trait will occur. Mating animals that have 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 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 trait.

A. The Punnett square is a matrix that provides a technique for predicting genotype. It considers the dominant and recessive genes of both parents for one trait. The Punnett square is a useful tool to help determine both genotype and phenotype from animal crosses.

1. A Punnett square is created by drawing a 4-square (2 × 2) or a 16-square (4 × 4) box. Each parent is assigned a side of the box, and all possible offerings from that parent are written along the side, one offering per square.

2. Each parent is allowed to give one gene per trait. The dominant gene is represented by a capital letter, whereas the recessive gene is represented by a lowercase letter. By combining the gene from one parent with the corresponding gene from the other parent, the offspring is assigned a trait (e.g., eye color, polled or horned).

3. To determine the genotype and phenotype of the offspring, the parents’ offerings are combined and written in the corresponding inner squares. For the offspring, similar letters are written next to each other to help sort the results. For example, when finding black coat color, the letter B is used for the dominant black, and the letter b is used for the recessive red. Handling the letters in this way causes less confusion when reporting genotype and phenotype. Labeling traits to letters within the title of a Punnett square is also helpful.

4. In calculating results, each possible offspring combination should be examined to determine both genotype and phenotype. A typical monohybrid heterozygous cross always yields a phenotype with a 3:1 ratio, whereas a typical dihybrid heterozygous cross always yields a phenotype with a 9:3:3:1 ratio.

B. A monohybrid cross takes into account a single trait and is represented by a single set of letters. For example, black coat color is dominant in cattle over red, and the trait would be represented by Bb. A Punnett square for a monohybrid heterozygous cross would have four inside squares.

C. A dihybrid cross takes into account two traits and would be represented by four letters instead of two. A dihybrid cross showing both eye color and hair color may
be represented by \( BbHh \). A Punnett square for a typical dihybrid heterozygous cross would have 16 inside squares.

**Teaching Strategy:** Have students read appropriate sections in the E-unit and assist in providing information as the content is summarized on the writing surface. Use VM–D to assist in describing a monohybrid cross and a dihybrid cross using Punnett squares. Use VM–E, VM–F, and VM–G to analyze heritability estimates in cattle, swine, and sheep.

Assign LS–B to practice and understand use of the Punnett square.

Hold a class discussion on the importance of heritability estimates. Ask how a producer can use this knowledge of heritability. (Answer: To improve animal characteristics, herd growth, and production.)

Have students conduct computer or library research on Punnett squares. The following calculators are worth viewing:


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

**Anticipated Problem:** What are sex determination, linkage, crossover, and mutation?

IV. Some characteristics carried on to the next generation are sex linked. The genes for these traits are on the sex chromosomes. Knowledge about these genes and their location can assist producers and biologists in determining desirable traits of selected animals.

A. **Sex chromosomes** determine the sex of a zygote. The process differs slightly among species.

1. Male sex chromosomes are either \( X \) or \( Y \) in mammals. 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 the egg from the female has an \( X \) chromosome. Therefore, a female zygote will have two \( X \) chromosomes (\( XX \)), whereas a male zygote will have one \( X \) chromosome and one \( Y \) chromosome (\( XY \)).

2. The female determines the sex of the offspring in poultry. The male carries two sex chromosomes (\( ZZ \)). The female carries only one sex chromosome (\(ZW \)). After meiosis, every sperm cell carries a \( Z \) chromosome. Only half the egg cells carry a \( Z \) chromosome; the other half carry a \( W \) chromosome.

B. 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.

C. **Crossover** is the formation of new chromosomes resulting from the splitting and rejoining of the original chromosomes. This explains why the predicted results of a mating do not always happen. During one stage of meiosis, the chromosomes line up. 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** is the appearance of a new trait in the offspring that did not exist in the genetic makeup of the parents. Mutations are of little value in improving livestock.

**Teaching Strategy:** Have students read appropriate sections in the E-unit and assist in providing information as the content is summarized on the writing surface. Use VM–H, VM–I, and VM–J to assist in understanding sex determination, linkage, and crossover.

Have students conduct library research on genes linked to the sex chromosomes. Assign reports or presentations based on their findings.

- **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. The anticipated problems can be used as review questions.

- **Application.** Use the included visual master(s) and lab sheet(s) to apply the information presented in the lesson.

- **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 activities. A sample written test is provided.

**Answers to Sample Test:**

**Part One: Matching**

1. f
2. c
3. h
4. g
5. d
6. a
7. b
8. e
Part Two: Completion

1. genome
2. locus
3. dominant
4. recessive
5. Probability
6. Heritability

Part Three: Multiple Choice

1. b
2. c
3. d
4. b
5. a
6. d
Exploring Animal Genetics and Probability

Part One: Matching

Instructions: Match the term with the correct definition.

a. phenotype  e. mutation  
b. crossover   f. gene       
c. autosomes  g. heterozygous 
d. genotype   h. homozygous 

_____1. Any of the segments of a chromosome that contain the hereditary traits of an organism
_____2. All the chromosomes in body cells other than sex chromosomes
_____3. Two haploid gametes containing the same allele
_____4. Two haploid gametes containing different alleles
_____5. The actual genetic code
_____6. The organism’s physical or outward appearance
_____7. The formation of new chromosomes resulting from the splitting and rejoining of the original chromosomes
_____8. The appearance of a new trait in the offspring that did not exist in the genetic makeup of the parents
Part Two: Completion

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

1. The genetic material in the chromosomes is called the _________________________ of the organism.

2. The particular location of a gene on a chromosome is referred to as the gene’s _________________________.

3. Only one allele, the _________________________ one, is expressed.

4. The _________________________ allele is present but not expressed.

5. _________________________ is the likelihood or chance that a trait will occur.

6. _________________________ is the proportion of the total variation that is due to additive gene effects.

Part Three: Multiple Choice

Instructions: Circle the letter of the correct answer.

_____1. A(n) _____ is a tiny threadlike structure that contains the genetic material in a cell.
   a. allele
   b. chromosome
   c. gene
   d. locus

_____2. A cell that contains the normal two sets of chromosomes (one from each parent) is called a(n) _____.
   a. allele
   b. gene
   c. diploid cell
   d. haploid cell

_____3. Gametes are _____.
   a. alternative forms of a gene
   b. all the chromosomes in body cells other than sex chromosomes
   c. locations of genes
   d. sex cells
4. A technique used for predicting genotype is _____.
   a. the Pearson square
   b. the Punnett square
   c. the Mendel triangle
   d. dominance

5. A monohybrid cross takes _____ into account.
   a. a single trait
   b. two identical traits
   c. two different traits
   d. four traits

6. The tendency for certain traits to appear in groups in the offspring is called _____.
   a. crossover
   b. determination
   c. heritability
   d. linkage
# NUMBER OF CHROMOSOMES FOR SELECTED ANIMALS

<table>
<thead>
<tr>
<th>Species</th>
<th>Number of Chromosomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cat</td>
<td>38</td>
</tr>
<tr>
<td>Cattle</td>
<td>60</td>
</tr>
<tr>
<td>Chicken</td>
<td>78</td>
</tr>
<tr>
<td>Dog</td>
<td>78</td>
</tr>
<tr>
<td>Donkey</td>
<td>62</td>
</tr>
<tr>
<td>Horse</td>
<td>64</td>
</tr>
<tr>
<td>Human</td>
<td>46</td>
</tr>
<tr>
<td>Mule</td>
<td>63</td>
</tr>
<tr>
<td>Sheep</td>
<td>54</td>
</tr>
<tr>
<td>Swine</td>
<td>38</td>
</tr>
</tbody>
</table>
# Dominant and Recessive Traits

<table>
<thead>
<tr>
<th>Dominant</th>
<th>Recessive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black in cattle</td>
<td>red</td>
</tr>
<tr>
<td>White face in cattle</td>
<td>colored face</td>
</tr>
<tr>
<td>Black in horses</td>
<td>brown</td>
</tr>
<tr>
<td>Color in animals</td>
<td>albinism (lack of all color)</td>
</tr>
<tr>
<td>Rose comb in chickens</td>
<td>single comb</td>
</tr>
<tr>
<td>Pea comb in chickens</td>
<td>single comb</td>
</tr>
<tr>
<td>Normal size in cattle</td>
<td>dwarfism (Hereford cattle)</td>
</tr>
</tbody>
</table>
**PUNNETT SQUARES**

**MONOHYBRID**

Red Sire (RR)

<table>
<thead>
<tr>
<th>Rr</th>
<th>Roan ¼</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rr</td>
<td>Roan ¼</td>
</tr>
</tbody>
</table>

White Dam (rr)

<table>
<thead>
<tr>
<th>Rr</th>
<th>Roan ¼</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rr</td>
<td>Roan ¼</td>
</tr>
</tbody>
</table>

**DIHYBRID**

Guinea Pig — Female

- BS: black, short
- Bs: black, short
- bS: black, short
- bs: black, short

Guinea Pig — Male

- BS: black, short
- Bs: black, long
- bS: black, short
- bs: black, long

9 dominant (black), dominant (short)
3 dominant (black), recessive (long)
3 recessive (brown), dominant (short)
1 recessive (brown), recessive (long)
### EXAMPLES OF HERITABILITY ESTIMATES FOR CATTLE

<table>
<thead>
<tr>
<th>Trait</th>
<th>Heritability (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number born</td>
<td>5</td>
</tr>
<tr>
<td>Calving interval (fertility)</td>
<td>10</td>
</tr>
<tr>
<td>Percent calf crop</td>
<td>10</td>
</tr>
<tr>
<td>Services per conception</td>
<td>10</td>
</tr>
<tr>
<td>Conformation score at weaning</td>
<td>25</td>
</tr>
<tr>
<td>Cancer eye susceptibility</td>
<td>30</td>
</tr>
<tr>
<td>Gain on pasture</td>
<td>30</td>
</tr>
<tr>
<td>Weaning weight</td>
<td>30</td>
</tr>
<tr>
<td>Yield grade</td>
<td>30</td>
</tr>
<tr>
<td>Carcass grade</td>
<td>35</td>
</tr>
<tr>
<td>Age at puberty</td>
<td>40</td>
</tr>
<tr>
<td>Trait</td>
<td>Heritability (%)</td>
</tr>
<tr>
<td>-------------------------------------</td>
<td>------------------</td>
</tr>
<tr>
<td>Birth weight</td>
<td>40</td>
</tr>
<tr>
<td>Body condition score</td>
<td>40</td>
</tr>
<tr>
<td>Carcass—percent lean cuts</td>
<td>40</td>
</tr>
<tr>
<td>Conformation score at harvest</td>
<td>40</td>
</tr>
<tr>
<td>Cow maternal ability</td>
<td>40</td>
</tr>
<tr>
<td>Efficiency of gain</td>
<td>40</td>
</tr>
<tr>
<td>Preweaning gain</td>
<td>40</td>
</tr>
<tr>
<td>Yearling frame size</td>
<td>40</td>
</tr>
<tr>
<td>Yearling weight</td>
<td>40</td>
</tr>
<tr>
<td>Fat thickness</td>
<td>45</td>
</tr>
<tr>
<td>Feedlot gain</td>
<td>45</td>
</tr>
<tr>
<td>Dressing percent</td>
<td>46</td>
</tr>
<tr>
<td>Marbling score</td>
<td>50</td>
</tr>
<tr>
<td>Mature weight</td>
<td>50</td>
</tr>
<tr>
<td>Scrotal circumference</td>
<td>50</td>
</tr>
<tr>
<td>Tenderness</td>
<td>50</td>
</tr>
<tr>
<td>Final feedlot weight</td>
<td>60</td>
</tr>
<tr>
<td>Retail yield</td>
<td>60</td>
</tr>
<tr>
<td>Rib-eye area</td>
<td>70</td>
</tr>
</tbody>
</table>
# EXAMPLES OF HERITABILITY ESTIMATES FOR SWINE

<table>
<thead>
<tr>
<th>Trait</th>
<th>Heritability (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Litter survival to weaning</td>
<td>5</td>
</tr>
<tr>
<td>Litter size</td>
<td>10</td>
</tr>
<tr>
<td>Number farrowed</td>
<td>10</td>
</tr>
<tr>
<td>Number of pigs weaned</td>
<td>12</td>
</tr>
<tr>
<td>Weaning weight (3 weeks)</td>
<td>15</td>
</tr>
<tr>
<td>Birth weight</td>
<td>20</td>
</tr>
<tr>
<td>Five-month weight</td>
<td>25</td>
</tr>
<tr>
<td>Number of nipples</td>
<td>25</td>
</tr>
<tr>
<td>Conformation</td>
<td>30</td>
</tr>
<tr>
<td>Feed efficiency</td>
<td>30</td>
</tr>
<tr>
<td>Age at puberty</td>
<td>35</td>
</tr>
<tr>
<td>Percent lean cuts</td>
<td>45</td>
</tr>
<tr>
<td>Probe backfat (live at 200 lb. [99.8 kg])</td>
<td>45</td>
</tr>
<tr>
<td>Carcass length</td>
<td>50</td>
</tr>
<tr>
<td>Loin muscle area</td>
<td>50</td>
</tr>
<tr>
<td>Percent of shoulder</td>
<td>50</td>
</tr>
<tr>
<td>Percent carcass muscle</td>
<td>50</td>
</tr>
<tr>
<td>Percent ham</td>
<td>55</td>
</tr>
<tr>
<td>Percent fat cuts</td>
<td>60</td>
</tr>
</tbody>
</table>
# Examples of Heritability Estimates for Sheep

<table>
<thead>
<tr>
<th>Trait</th>
<th>Heritability (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number born</td>
<td>13</td>
</tr>
<tr>
<td>Conformation score</td>
<td>15</td>
</tr>
<tr>
<td>Feed efficiency</td>
<td>20</td>
</tr>
<tr>
<td>Fat thickness</td>
<td>25</td>
</tr>
<tr>
<td>Milking ability</td>
<td>25</td>
</tr>
<tr>
<td>Birth weight</td>
<td>30</td>
</tr>
<tr>
<td>Weaning weight</td>
<td>30</td>
</tr>
<tr>
<td>Carcass—percent lean cuts</td>
<td>35</td>
</tr>
<tr>
<td>Fleece weight</td>
<td>40</td>
</tr>
<tr>
<td>Post-weaning daily gain</td>
<td>40</td>
</tr>
<tr>
<td>Skin folds</td>
<td>40</td>
</tr>
<tr>
<td>Weight of retail cuts</td>
<td>40</td>
</tr>
<tr>
<td>Yearling weight</td>
<td>40</td>
</tr>
<tr>
<td>Rib-eye area</td>
<td>45</td>
</tr>
<tr>
<td>Face covering</td>
<td>50</td>
</tr>
<tr>
<td>Mature weight</td>
<td>50</td>
</tr>
<tr>
<td>Staple length</td>
<td>50</td>
</tr>
</tbody>
</table>
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.
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.
Extracting DNA

Purpose

The purpose of this activity is to extract DNA from cells.

Objective

Examine DNA structure.

Materials

- disposable plastic transfer pipettes
- ethanol (needs to be cold)
- lab sheet
- salt/detergent mixture (2 L distilled water, 100 mL Palmolive® dishwashing liquid, 15 g salt)
- small disposable cup
- sports drink (clear)
- test tube (15 mL) with cap
- test tubes smaller than 15 mL
- test tube rack
- writing utensil

Procedure

1. Obtain a test tube, and label with your initials.
2. Obtain a small disposable drinking cup with some sports drink.
3. Swish the sports drink around in your mouth for one minute. While swishing, try to scrape the sides of your cheeks to get cheek cells to release. Then, spit the drink back into the cup.

4. Pour 8 mL of cheek cells into the labeled test tube.

5. Then add 2 mL of the salt/detergent mixture.

6. Seal or cap the test tube. Invert the test tube six to eight times.

7. Let the test tube stand for two minutes.

8. Use a disposable plastic transfer pipette to add the cold ethanol. Add only enough alcohol to bring the volume in the test tube to 12 to 13 mL. When adding alcohol, allow it to run down the side of the test tube.

9. Do not mix the two separate layers.

10. Observe how the strands of DNA begin to come together where the layers meet.

11. Let the test tube sit in the rack undisturbed for 15 minutes. DNA will continue to precipitate out.

12. Observe strands of DNA.

13. Try to transfer DNA strands into smaller test tubes. Place a transfer pipette close to the DNA, and draw it up into the pipette.

Student Questions:

1. What are the elements that make up DNA?

2. Why is there a need to use a salt/detergent mixture in this lab?

3. How can DNA become visible once the alcohol is added?

4. Why is it important to be able to extract DNA?
Principles of the Punnett Square

Purpose

The purpose of this activity is to apply the principles of the Punnett square to inheritance of traits.

Objective

Determine genotype and phenotype outcomes of offspring by using the Punnett square.

Materials

♦ lab sheet
♦ writing utensil

Procedure

Use the Punnett square method to estimate the possible gene combination.

1. Mating a homozygous black Angus bull to a heterozygous black Angus heifer.
   (Black coat color = B; red coat color = b)
   a. How many genotypes are possible? _____
   b. How many phenotypes are possible? _____

2. Mating a heterozygous black Angus bull to a heterozygous black Angus cow.
   (Black coat color = B; red coat color = b)
   a. What would be the genotype ratio? _____
   b. What would be the phenotype ratio? _____
3. Mating a white-face heifer (WW) to a black-face bull (ww).
   (White face = W; black face = w)
   a. What would be the genotype ratio? _____
   b. What would be the phenotype ratio? _____

4. Mating a polled black cow (PpBb) to a polled black bull (PpBb).
   (Polled = P; horned = p)
   (Black = B; red = b)
   a. What would be the genotype ratio? _____
   b. What would be the phenotype ratio? _____

5. Mating a polled red cow (PPbb) to a horned black bull (ppBb).
   (Polled = P; horned = p)
   (Black = B; red = b)
   a. What would be the genotype ratio? _____
   b. What would be the phenotype ratio? _____