TEXAS FARM BUREAU®

Texas Ag in the Classroom STEM Lessons

ANIMAL SCIENCE | VARIATION & PROBABILITY OF EXPRESSED TRAITS

AT A GLANCE

Grade Level/Subject
10th grade biology

Overview
Students will begin the lesson comparing and contrasting their traits to that of their parents. Through this introductory activity, they will begin to explore genotype and phenotype and how traits are expressed. Students will then predict trait probability for cattle using Punnett Squares. This lesson should be taught prior to the lesson, 'Survival of the Fittest: Adaption & Evolution.'

Phenomena Focus
Red cows can have black calves.

Major Concepts
- Genotype is the set of genes in our DNA responsible for a particular trait.
- Phenotype is the physical expression of a trait.
- Dominant trait produces a dominant phenotype in individuals who have one copy of the allele, which can come from just one parent.
- For a recessive trait to produce a recessive phenotype, the individual must have two copies, one from each parent.
- Punnett Squares reveal genotype probability of an offspring.
- Both genetic and environmental factors can affect expression of traits.

Objectives
At the end of this lesson, students will be able to:
- Differentiate genotype and phenotype and explain how traits are expressed.

- Explain the difference between dominant and recessive traits and why some are expressed and some are not.
- Predict the probability of traits using a Punnett Square given different pairs of traits.

TEKS Alignment

Science

- 112.34.c.6.D: Science concepts. The student knows the mechanisms of genetics such as the role of nucleic acids and the principles of Mendelian and non-Mendelian genetics. The student is expected to: recognize that gene expression is a regulated process.
- 112.34.c.6.F: Science concepts. The student knows the mechanisms of genetics such as the role of nucleic acids and the principles of Mendelian and non-Mendelian genetics. The student is expected to: predict possible outcomes of various genetic combinations such as monohybrid crosses, dihybrid crosses, and non-Mendelian inheritance.
- 112.34.c.7.E: Science concepts. The student knows evolutionary theory is a scientific explanation for the unity and diversity of life. The student is expected to: analyze and evaluate the relationship of natural selection to adaptation and to the development of diversity in and among species.

Math

- 111.47.c.5.A: Probability and random variables. The student applies the mathematical process standards to connect probability and statistics. The student is expected to: determine probabilities, including the use of a two-way table.

English Language Arts

- 110.36.c.1.A: Developing and sustaining foundational language skills: listening, speaking, discussion, and thinking—oral language. The student develops oral language through listening, speaking, and discussion. The student is expected to: engage in meaningful and respectful discourse by listening actively, responding appropriately, and adjusting communication to audiences and purposes.
- 110.36.c.1.B: Developing and sustaining foundational language skills: listening, speaking, discussion, and thinking—oral language. The student develops oral language through listening, speaking, and discussion. The student is expected to: follow and give complex oral instructions to perform specific tasks, answer questions, or solve problems and complex processes.
- 110.36.c.2.B: Developing and sustaining foundational language skills: listening, speaking, reading, writing, and thinking--vocabulary. The student uses newly acquired vocabulary expressively. The student is expected to: analyze context to distinguish between the denotative and connotative meanings of words.
- 110.36.c.4.G: Comprehension skills: listening, speaking, reading, writing, and thinking using multiple texts. The student uses metacognitive skills to both develop and deepen comprehension of increasingly complex texts. The student is expected to: evaluate details read to determine key ideas.

- 110.36.c.5.D: Response skills: listening, speaking, reading, writing, and thinking using multiple texts. The student responds to an increasingly challenging variety of sources that are read, heard, or viewed. The student is expected to: paraphrase and summarize texts in ways that maintain meaning and logical order.

Agricultural, Food, and Natural Resources

- 130.7.c.7.B: The student explains animal genetics and reproduction. The student is expected to: explain the use of genetics in animal agriculture such as Expected Progeny Differences (EPDs), phenotype, and genotype.
- 130.10.c.8.A: The student applies the principles of molecular genetics and heredity. The student is expected to: explain Mendel's laws of inheritance by predicting genotypes and phenotypes of offspring using the Punnett square.
- 130.10.c.8.B: The student applies the principles of molecular genetics and heredity. The student is expected to: predict genotypes and phenotypes of animal offspring using Mendelian or non-Mendelian patterns of inheritance in various forms of livestock and use Punnett Square and assign alleles to justify all predictions.

Materials/Preparation

- PowerPoint with information from Explain section (prepared by teacher)
- Copies of Words and Definitions cards (provided)
- Punnett Square worksheet (provided)
- Genetics Jeopardy PowerPoint (provided)

PROCEDURE

ENGAGE – Gets the students' minds focused on the topic

- *Describe how the teacher will capture students' interest.*
- *What kind of questions should the students ask themselves after the engagement?*

1. Begin lesson with having students list their key characteristics (eye color, hair color, face shape, height, etc.) and comparing them to that of their parents.
   - Solicit a few examples from students.
   - Give students two minutes to do a think-pair-share to discuss how it's possible for offspring to express different traits than that of their parents.
   - Explain to students that they'll be discovering the variation and probability of expressed traits among parents and offspring today.

EXPLORE – Provides students with a common experience; real world connection/personalization

- *Describe what hands-on/minds-on activities students will be doing.*
- *List "big idea" conceptual questions the teacher will use to encourage and/or focus students' exploration*

2. Ask students if it is possible for a red cow to give birth to a black calf.
    - If someone says 'yes,' ask why and the same if they say 'no.'
    - You will come back to this at the end, so don't correct students on their answers.

3. Pass out a stack of the 'Words' and 'Definitions' cards to each student (see attached document). Give them two minutes to match the word to the definition. Review correct answers with students and explain that there are three different types of gene combinations we'll be exploring: homozygous dominant, homozygous recessive, and heterozygous. The words are as follows:
    - **Homozygous** is two copies of the same allele at a given locus (i.e., YY or yy).
    - **Heterozygous** is two different alleles at a given locus (i.e., Yy).
    - A **dominant allele** is an allele that is expressed fully if there is at least one copy at a given locus.
    - A **recessive allele** is an allele that requires two copies at a given locus to be expressed phenotypically.
    - **Genotype** is the genetic constitution of an individual organism.
    - **Phenotype** is the set of observable characteristics of an individual resulting from the interaction of its genotype and the environment. (Example: A person's skin tone is genetic, but by sitting in the sun during the summer, it can be altered.)

EXPLAIN – Teaches the concept with interaction between the teacher and students

- *Student explanations should precede introduction of terms or explanations by the teacher. What questions or techniques will the teacher use to help students connect their exploration to the concept under examination?*
- *List higher order thinking questions, which teachers will use to solicit student explanations and help them to justify their explanations.*

3. Tell the students the following: "When I say, 'little professor,' you are to pair up with a classmate in an area large enough for you both to write in your notebooks. Throughout the course of this lesson, you will have the opportunity to be the student and the teacher. For the purpose of this lesson, B is the dominant gene in cattle that codes for a black coat; b is the recessive form of this allele that codes for a red coat. We will reference this throughout the lesson and in the activity later."
    - Once students have paired up, deliver the next set of instructions: "I now need one person in each group to raise your hand. Those of you with your hands up will be Little Professor 1 and your partners will be Little Professor 2. Little Professor 2s, for the next few minutes, you are not to listen to me. You may read, daydream, or put your head down. The only thing you may not do is leave your seats, talk, or be a disruption."
    - ***Homozygous Dominant***
        - Tell the Little Professor 1s that the information on the PowerPoint is what they will be teaching their partners.

- When two homozygous dominant individuals (BB + BB) are mated, each can produce only one kind of gamete.
- In our example, this gamete can only carry gene B. The union of gametes from two homozygous dominant parents results in a zygote that is homozygous dominant.
    - In other words, the only possible combinations is B x B = BB. Thus, homozygous parents produce only homozygous dominant offspring.
- Instruct the Little Professor 1s to take the next two minutes to instruct their partners on this information and explain the color cow they would get as a result of the example. Be sure they get the most important information into their notebooks. *(Teacher note: Instruction from student to student should take no more than two minutes. However, if they need less time, you may instruct them to only take 90 seconds or however long you see necessary throughout the rest of the lesson.)*
- Once the time is up, ask the students if any further clarification is needed on this content. Tell students the resulting cow color would be black.

- ***Homozygous Dominant + Heterozygous***
    - Tell Little Professor 1s that it is now their turn to take a break while you talk to the Little Professor 2s; tell Little Professor 2s that the content on the PowerPoint is what they will be teaching their partners.
    - The mating of a homozygous dominant individual (BB) with a heterozygous individual results (Bb) in an unexpected ration of homozygous dominant to one heterozygote.
    - The homozygous dominant parent (BB) produces only one kind of gamete, a dominant B.
    - The heterozygous parent (Bb) produces in equal proportion two kinds of gametes, one carrying the dominant gene (B) and one carrying the recessive gene (b).
    - The chances are equal that a gamete from the parent producing only the one kind of gamete will unite with each of the two kinds of gametes produced by the heterozygous parent; therefore, the number of homozygous dominant offspring and heterozygous offspring produced should be approximately equal.
    - Instruct the Little Professor 2s to take the next two minutes to instruct their partners on the new content and make sure they get the most important information into their notebooks.
    - Once the time is up, ask the students if any further clarification is needed on this content.

- ***Homozygous Recessive***
    - Instruct the Little Professor 2s to take a break while the Little Professor 1s listen to you.

- The homozygous dominant (BB) individual can produce only gametes carrying the dominant gene.
- The recessive individual (bb) must be homozygous recessive to express the recessive trait.
    - Therefore, the individual produces only gametes carrying the recessive gene (b).
- When the two types of gametes unite, all offspring produced receive both the dominant and the recessive gene and are thus heterozygous (Bb).
- Little Professor 1s, take the next two minutes to teach your partners.
- Once the time is up, ask the students if any further clarification is needed on this content.

- ***Ratios***
    - Instruct the Little Professor 1s to take a break while the Little Professor 2s listen to you.
    - Each of the two heterozygous parents (Bb) produces two kinds of gametes in approximately equal ratios.
        - One kind of gamete carries the dominant gene (B) and the other kind carries the recessive gene (b).
    - The two kinds of gametes produced by one parent each have an equal chance of uniting with each of the two types of gametes produced by the other parent.
        - Thus, four equal chance unions of gametes are possible.
    - If the gamete carrying the dominant gene (B) from one parent unites with the gamete carrying the dominant gene (B) from the other parent, the offspring produced are homozygous dominant (BB).
    - If the gamete carrying the dominant gene (B) from one parent unites with the gamete carrying the recessive gene (b) from the other parent, the offspring are heterozygous (Bb).
    - When the gametes carrying the recessive gene (b) from both parents unite, the offspring produced will be homozygous recessive (bb).
    - The total expected ratio among the offspring of two heterozygous (Bb) is one homozygous dominant (BB) to two heterozygous (Bb) to one homozygous recessive (bb).
        - This 1:2:1 is the genotypic ratio.
    - The appearance of the offspring is in the ratio of three dominant (B) to one recessive (b) because the homozygous dominant and the heterozygous animals are all black and cannot be genetically distinguished from one another visually.
        - This 3:1 ratio based on external appearance is called the phenotypic ratio.
    - Instruct Little Professor 2s to take the next two minutes to teach their partner this new information.
    - Once the time is up, ask the students if any further clarification is needed on this content.

- ***Heterozygous + Homozygous Recessive***
    - Instruct Little Professor 1s to listen while Little Professor 2s take a break.
    - The heterozygous individual (Bb) produces two kinds of gametes, one carrying the dominant gene and the other carrying the recessive gene, in approximately equal numbers.
    - The recessive individual (bb) produces only the gametes carrying the recessive gene (b).
    - There is an equal chance that the two kinds of gametes produced by the heterozygous parent (Bb) will unite with the one kind of gamete produced by the homozygous recessive parent (bb).
    - The offspring produced when these gametes unite occur in an expected ratio of two heterozygotes (Bb) to two homozygous recessive (bb).
    - Instruct Little Professor 1s to take the next two minutes to teach their partner the new content.
    - Once the time is up, ask the students if any further clarification is needed on this content.
- ***Breeding for Desired Traits in Cattle***
    - Explain to students that we are now going to review the desired traits that cattle producers will breed for in their herds. A producer's preferences are dependent upon their environment, market, and other factors.
    - Instruct Little Professor 2s to listen while Little Professor 1s take a break.
    - **Polled vs. horned:** Polled means naturally hornless and is the dominant trait. This is generally seen as a positive trait, because if animals are not polled, they are likely to be de-horned. De-horning is not a glamourous process but is seen as necessary because of safety issues to ranchers and the other animals.
    - **Black vs. red hide:** In areas with high heat, ranchers may want non-black hided animals so they can withstand higher heat.
    - **Solid vs. spotted coat:** How the spots are arranged may depend on the composition of breeds in the animal.
    - **White face vs. colored face:** This trait is gaining more attention, as there has been a correlation of animals with pinkeye and animals with white faces. Some producers are breeding for animals with a ring of color around their eyes, dark faces, or even for the way their eyelashes turn out. Pinkeye costs money to treat and takes time for the antibiotics to leave the animal's system before it can be taken to market. Therefore, it is much more profitable to breed for animals that don't get pinkeye.
        - Animals with white faces are often referred to as "baldies."
    - **Solid legs vs. stocking legs:** This trait has little production value, but "stocking" legs will essentially look like socks.
    - Instruct Little Professor 2s to take the next two minutes to teach their partners the new content.
    - Once the time is up, ask the students if any further clarification is needed on this content.

- Instruct Little Professor 2s to take one final break while Little Professor 1s listen.
- **Large REA vs. Small REA:** Rib Eye Area is definitely a profitable category. Just like you would pay more money for a large loin eye steak, meat packers will, too.
- **High birthweight vs. Low birthweight:** This trait is deceptive, in that most ranchers look for low birthweights. Cattle are finicky in that they don't always calve (or give birth) easily. One large factor in difficulty calving (also called dystocia) is birthweight. Depending on breed, an average birthweight may be around 75-85 pounds. As a rule of thumb, any calf over 100 pounds is very large, and the cow will generally need assistance in calving. As you would expect, it's not fun to help pull a calf, so ranchers try to avoid this as much as possible by breeding for easy calving females and low birthweights. This helps all animals be born more safely and comfortably and lets the farmer get more sleep!
- **Heat tolerant vs. heat susceptible:** This trait isn't critical in Iowa, but in areas like Arizona, New Mexico, and Texas, it's very important. In these areas, they will even cross more heat resistant types of cattle (like the Brahman of India) to European breeds (like the Angus) to create a heat-resistant and hardy animal with better meat quality (like the Brangus – part Brahman, part Angus).
- **Docile vs. rowdy:** As you might imagine, ranchers don't necessarily want to keep wild or dangerous animals around very long. Generally, they will only keep animals with calm demeanors for their breeding stock. The unpredictable ones will get sent to the sale barn.
- **Male vs. female:** The dairy sector relies heavily on females; therefore, this trait is very important to them. In the beef sector, there are uses for both males and females, so this is monitored less overall among ranchers.
    - Though the inheritance of gender is different than the others in the list, it is an important part of genetics.
    - Mothers can only give an X chromosome; therefore, fathers will always decide gender of offspring.
- Instruct Little Professor 1s to take two minutes to teach new content to partners.
- Once the time is up, ask the students if any further clarification is needed on this content.

4. End this section with leading classroom discussion on what traits are likely desirable for Texas cattle producers
    - Heat tolerance
    - Disease and parasite resistant
    - Polled
    - Calving ease
    - Adaptability and browse utilization

ELABORATE – Provides opportunity for students to apply the concept in a new situation

- *Describe how students will develop a more sophisticated understanding of the concept.*
- *What vocabulary will be introduced and how will it connect to students' observations?*
- *How is this knowledge applied in our daily lives?*

5. Students will be given a worksheet (provided) with blank Punnett squares and different pairs of traits of cattle. Students will predict probability of traits in the offspring. The worksheet also includes other questioning and analyses to ensure understanding of concepts.
    - Process this worksheet by going back to the phenomena presented at the beginning of the lesson (red cow giving birth to a black cow). Lead a discussion by asking students to explain the phenomena and how it's possible.

EVALUATE – Allows students to demonstrate understanding of the concepts and facts

- *How will students demonstrate that they have achieved the lesson objective?*
- *This should be embedded throughout the lesson as well as at the end of the lesson.*

6. Students will play Genetics Jeopardy (provided). Divide the classroom into two teams. Each team will send one person per turn who CANNOT receive help from their team.
    NOTE: The answers for Jeopardy are in the notes of the Genetics Jeopardy PowerPoint.

TEXAS FARM BUREAU®

_____

Name

VARIATION & PROBABLITY OF EXPRESSED TRAITS

Complete the following Punnett squares and the analysis questions that follow.

1. Polled (P) vs. Horned (p):
   Pp x Pp

Number of polled calves? _____
Number of horned calves? _____
Genotype Ratio: _____
Phenotype Ratio: _____

2. Black Hide (B) vs. Red Hide (b):
   BB x bb

Number of black calves? _____
Number of red calves? _____
Genotype Ratio: _____
Phenotype Ratio: _____

3. Solid (S) vs. Spotted Coat (s):
   SS x Ss

Number of solid calves? _____
Number of spotted calves? _____
Genotype Ratio: _____
Phenotype Ratio: _____

4. White Face (F) vs. Black Face (f):
   Ff x ff

Number of white face calves? _____
Number of black face calves? _____
Genotype Ratio: _____
Phenotype Ratio: _____

5. Heat Tolerant (T) vs. Heat Susceptible (t):

TT x tt

Number of heat tolerant calves? _____
Number of heat susceptible calves? _____
Genotype Ratio: _____
Phenotype Ratio: _____

6. High birthweight (H) vs. Low birthweight (h):
   HH x Hh

Number of high birthweight calves? _____
Number of low birthweight calves? _____
Genotype Ratio: _____
Phenotype Ratio: _____

7. Imagine you have your own cattle herd.
   a. Taking into consideration your environment, what are some traits you would want to have in your herd? Explain your answer.

   b. How would you attain these genetics in your herd?

c. How might the environment impact the traits you want in your herd? (Remember the example of skin tone. Skin tone is genetic, but it can be altered by sitting in the sun.)

Homozygous

TEXAS FARM BUREAU®

Two copies of the same allele at a given locus (i.e., YY or yy)

TEXAS FARM BUREAU®

Heterozygous

TEXAS FARM BUREAU®

Two different alleles at a given locus (i.e., Yy)

TEXAS FARM BUREAU®

Dominant Allele

TEXAS FARM BUREAU®

An allele that is expressed fully if there is at least one copy at a given locus

TEXAS FARM BUREAU®

Recessive Allele

TEXAS FARM BUREAU®

An allele that requires two copies at a given locus to be expressed phenotypically

TEXAS FARM BUREAU®

Genotype

TEXAS FARM BUREAU®

The genetic constitution of an individual organism

TEXAS FARM BUREAU®

Phenotype

TEXAS FARM BUREAU®

The set of observable characteristics of an individual resulting from the interaction of its genotype and the environment. A person's skin tone is genetic, but by sitting in the sun, it can be altered.

TEXAS FARM BUREAU®

GENETICS JEOPARDY

TEXAS FARM BUREAU®

RULES

- Each team sends one person per turn. They *cannot* get help from their team
- First to "buzz" in gets 15 seconds to answer.
- If the first person to buzz cannot get the answer, the second team can buzz in. Once they buzz in, they too have 15 seconds. They also cannot get help.
- You either gain or lose points on each turn.
- If no team buzzes within 10 seconds, the question ends and the answer is given.
- All answers must be given in question form (What is…)

Termin-ology	Cattle Traits	Future Babies	Fill in the Punnet	Ratios	Misc
$100	$100	$100	$100	$100	$100
$200	$200	$200	$200	$200	$200
$300	$300	$300	$300	$300	$300
$400	$400	$400	$400	$400	$400
$500	$500	$500	$500	$500	$500

TERMINOLOGY

- This is the term for an animal that has both recessive alleles.

TEXAS FARM BUREAU®

TERMINOLOGY

- This is the term for an animal who has both dominant alleles

TEXAS FARM BUREAU®

TERMINOLOGY

- This is the term for an animal that has both dominant and recessive alleles

TEXAS FARM BUREAU®

TERMINOLOGY

- This is the genetic constitution of an individual organism

TEXAS FARM BUREAU®

TERMINOLOGY

- This is the set of observable characteristics of an individual resulting from the interaction of its genotype and the environment.

TEXAS FARM BUREAU®

CATTLE TRAITS

- This trait is generally seen as a positive trait in cattle because of safety issues to producers and other animals.

CATTLE TRAITS

- This trait is gaining more attention as there has been a correlation of animals with pinkeye and animals with the opposite trait.

TEXAS FARM BUREAU®

CATTLE TRAITS

- This trait isn't critical in the north or midwest, but is very important in states like Arkansas, Texas, and New Mexico.

CATTLE TRAITS

- This trait is deceptive because you think cattle producers would want the opposite.

CATTLE TRAITS

- This trait has little production value, but will essentially look like socks.

FUTURE BABIES

- What would a cross between this bull and cow look like?

- Mother – RR
- Father – rr

- R – Large rib eye area; r – Small rib eye area

TEXAS FARM BUREAU®

FUTURE BABIES

- What would the offspring of a cross between this bull and cow look like?

- Mother – Pp
- Father – Pp

- P – Polled; p – horned

TEXAS FARM BUREAU®

FUTURE BABIES

- A dog is heterozygous for curly hair and is mated with a dog homozygous for straight hair (straight hair is recessive). How many curly haired dogs will there be?

TEXAS FARM BUREAU®

FUTURE BABIES

- A chicken homozygous for white feathers is mated with a chicken homozygous for red feathers (red is recessive). How many red chicks and white chicks will there be?

FUTURE BABIES

- A daisy is heterozygous for gold flowers and is bred with a daisy homozygous for yellow flowers (yellow is recessive). How many gold flowers will there be?

FILL IN THE PUNNET

	R	R
r	?	
r		

TEXAS FARM BUREAU®

FILL IN THE PUNNET

	?	?
	RR	Rr
	Rr	rr

TEXAS FARM BUREAU®

FILL IN THE PUNNET

	?	?
	Rr	Rr
	rr	rr

TEXAS FARM BUREAU®

FILL IN THE PUNNET

	?	?
	RR	RR
	Rr	Rr

TEXAS FARM BUREAU®

FILL IN THE PUNNET

	?	?
	Rr	rr
	Rr	rr

TEXAS FARM BUREAU®

RATIOS

- A 3:1 ration of dominant to recessive traits indicates that the parents have what genotypes?
- Bb and Bb

TEXAS FARM BUREAU®

RATIOS

- If the offspring are half dominant phenotypes and half recessive phenotypes, what must the parents' genotypes be?
- Bb : bb

TEXAS FARM BUREAU®

RATIOS

- If all of the offspring have the recessive phenotype, what must be the genotypes of the parents?
- bb and bb

RATIOS

- What are the possible genotype combinations that would enable the offspring to have all dominant phenotypes?
- Hint – there are 3
- BB:BB
- BB:Bb
- BB:bb

TEXAS FARM BUREAU®

RATIOS

- A cow and a bull are heterozygous for color
- Black is dominant; red is recessive
- They have had 3 calves, all of which are black
- What are the odds that they will have a red calf the fourth time?

MISCELLANEOUS

- In areas with high heat, cattle producers may want non-_____ hided cattle.

TEXAS FARM BUREAU®

MISCELLANEOUS

- This is the term for a gene that is always expressed if it is possessed by the individual

TEXAS FARM BUREAU®

MISCELLANEOUS

- This is the term for a gene that is only expressed under certain circumstances

MISCELLANEOUS

- This is the term for the circumstance in which an individual may have a gene but will not express it because of a different gene

MISCELLANEOUS

- This is the term for naturally hornless cattle.

FINAL JEOPARDY

- This trait is a profitable category, particularly when you sell the animal to market.

TEXAS FARM BUREAU®