March 2003

SeaWorld/Busch Gardens

Genetics

9-12 Classroom Activities

Dihybrid Cross

OBJECTIVE

The student will calculate a dihybrid cross and interpret the results.

ACTION

1. Divide the class into groups of four.
2. Distribute one Case Study Funsheet to each group. (Each group should have a different Case Study Funsheet to calculate).
3. Instruct students to calculate a dihybrid cross based on the given information in the case study and answer the questions. Review how to calculate dihybrid crosses using the background information on page 2.
4. Instruct students to present their calculations to the class.
5. The answers may be checked with the Teacher's Guide.

MATERIALS

- copy of each Case Study Funsheet
- copy of Case Study Teacher Guide
- pencils

VOCABULARY

albinism: The inherited absence of pigment.
allele: Alternative form of a gene.
dihybrid Cross: A breeding experiment in which parental varieties differing in two traits are mated.
dominant: An allele that determines phenotype even when heterozygous.
gamete: Haploid egg or sperm cells that unite during sexual reproduction to produce a diploid zygote.
genetics: The science of heredity; the study of heritable information.
gene: One of many discrete units of hereditary information located on the chromosomes and consisting of DNA.
genotype: The genetic make-up of an organism.
heterozygous: Having two different alleles for a given trait.
homozygous: Having two identical alleles for a given trait.
prehensile: Capable of grasping or holding.
recessive: An allele that is not expressed in the heterozygous condition.
spicule: A pointed modified scale that various raptors use to grip prey.
tendon: A type of fibrous connective tissue that attaches muscle to bone.

HOW TO CALCULATE DIHYBRID CROSSES

1. To set up a dihybrid cross, draw a large square, and then divide it into 16 equal squares.

2. Determine the genotypes of the parent organisms. Sometimes the cross is already specified.For example: Cross two organisms with the following genotypes: PpTt & PpTt. However, many times genetic vocabulary must be understood to determine the genotypes of the cross. For example: Cross a short white flower with one that is heterozygous for purple flower color and homozygous for tallness. Purple is dominant and white is recessive and tall is dominant and short is recessive. Therefore, the only way to express a short white flower is to be homozygous recessive for both traits (color and height) and its genotype will be (pptt). Heterozygous always means one of each letter. Therefore a plant that is heterozygous for purple color would have the genotype Pp. A plant that is homozygous for tallness would have the genotype TT. Therefore, the flower will have a complete genotype of PpTT and the cross would be between pptt x PpTT.

3. Determine the possible gametes of each parent. For example, if a parent has a genotype of PpTt, then the gametes will receive one of each pair (Pp and Tt) of alleles. There will be four possible combinations of alleles and each have an equal probability of occurring. The four possible allele combinations from the parent PpTt are PT, Pt, pT, and pt.

4. Place the four possible allele combination for each parent outside the dihybrid cross square. One parent's allele combinations will be placed on top of the dihybrid cross square and the other will be split to the left of the dihybrid cross square.

5. Determine the possible genotypes of the offspring by filling in the dihybrid cross square. This step is accomplished by taking a letter from the left and matching it with a letter from the top. Repeat this step until all 16 boxes of the dihybrid cross square are complete.

6. Summarize the genotypes and phenotypes of the offspring.

	PT	Pt	pT	pt
PT				
Pt				
pT				
pt				

	PT	Pt	pT	pt
PT	PPTT	PPTt	PpTT	PpTt
Pt	PPTt	PPtt	PpTt	Pptt
pT	PpTT	PpTt	ppTT	ppTt
pt	PpTt	PpTt	ppTt	pptt

The possible genotypes from the parental cross of PpTt x PpTt are:
PPTT PPTt PpTT PpTt PPtt Pptt ppTT ppTt pptt
Tall (TT, Tt) purple (PP, Pp) flowers will be produced by the following genotypes
PPTT (1/16) PPTt (2/16) PpTT (2/16) PpTt (4/16) *the frequency is stated in ( )*
Therefore 9 out of 16 possibilities could be tall purple flowers.
Tall (TT, Tt) white (pp) flowers will be produced by the following genotypes.
ppTT (1/16) ppTt (2/16) Therefore 3 out of 16 possibilities could be tall white flowers.
Short (tt) purple (PP, Pp) flowers will be produced by the following genotypes.
PPtt (1/16) Pptt (2/16) Therefore 3 out of 16 possibilities could be short purple flowers.
Short (tt) white (pp) flowers will be produced by the following genotypes.
pptt (1/16) Therefore 1 out of 16 possibilities could be short white flowers.

Black Rhino Case Study (*Diceros bicornis*)

You are a wildlife biologist researching black rhinos. During your time in Africa, you have observed two particular traits that allow some black rhinos to be better adapted to their environment. The first trait is an extra long prehensile lip that enables the rhino to have more efficient browsing capability than the usual size prehensile lip. Second, some of the rhinos in the study have extra long ears that allow them to hear a potential predator earlier than rhinos with normal size ears. If you could breed black rhinos that have both these traits (extra long prehensile lip and bigger ears), it would increase their chance for survival in the wild.

You have chosen the following two rhinos to enter into a breeding program for the two desired phenotypic traits. It has been determined (based on your previous research) that both the desired traits are homozygous recessive.

Parent 1:

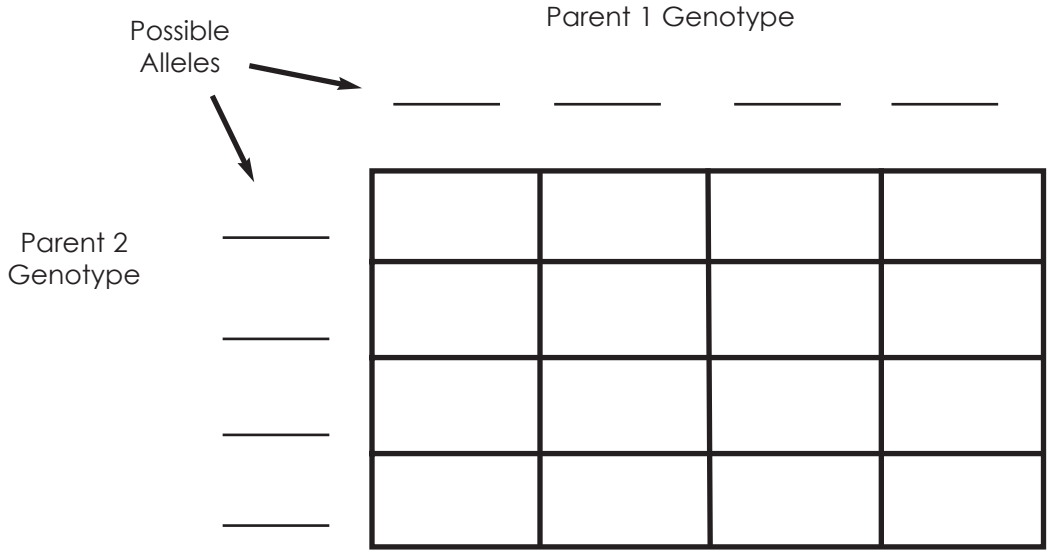
Homozygous dominant for the prehensile lip trait (PP). Therefore this parent does not express the extra long lip trait.

Heterozygous for the longer ear trait (Ee). Therefore this parent does not express the extra large ear trait.

Parent 2:

Heterozygous for the prehensile lip trait (Pp). Therefore this parent does not express the extra long lip trait.

Homozygous recessive for the large eared trait (ee). Therefore the parent does express the extra long ear trait.



Questions:

1. Determine the possible genotype (s) that will produce individuals without an extra long lip trait and do not express the extra large ear trait. What is the frequency that each of these genotype (s) occur in the dihybrid cross?
2. Determine the possible genotype (s) that will produce individuals that have a normal lip and the extra large ears? What is the frequency that each of these genotype (s) occur in the dihybrid cross?
3. How many rhinos can be produced with the extra long lip and large ear trait from the two parents crossed above? Explain your answer.
4. What is the ratio between rhinos that have normal prehensile lips and ears to those that have the normal lip but extra large ears? (Normal lip and ears: Normal lip and extra large ears).

Burmese Python (*Python molurus bivittatus*)

You are a wildlife biologist researching Burmese pythons. During your time in Asia, you observed a particular trait that allows some Burmese pythons to be better adapted to their environment. Some snakes have extra large scales on their abdomen. This increases the surface area of their abdomen that is in contact with the ground, therefore, making locomotion easier. In addition, you noticed that albino Burmese pythons do not survive as long in the wild as those who have normal pigmentation because lack of camouflage ability (beige blotches on a dark brown background). If you could breed Burmese pythons that have normal pigmentation (avoiding albinism) and extra large abdominal scales, it would increase their chance for survival in the wild.

You have chosen the following two Burmese pythons to enter into a breeding program for the two desired phenotypic traits. It has been determined that the trait for the extra large abdominal scales is homozygous recessive. Albinism is also a homozygous recessive trait. The normal pigmentation trait is dominant and is expressed in homozygous dominant and heterozygous individuals.

Parent 1:

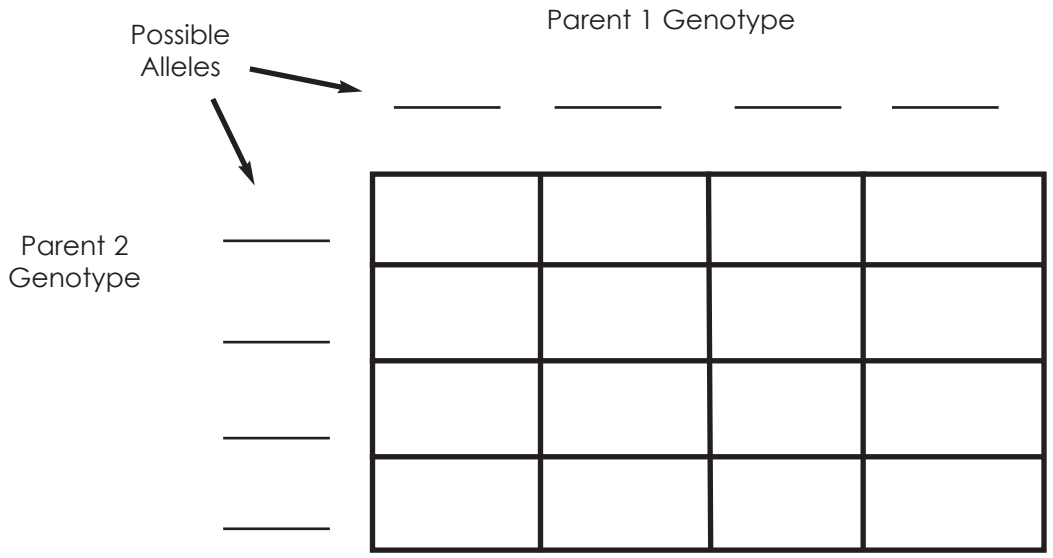
Heterozygous for the extra large ventral (abdomen) scales (Ss). Therefore this parent does not express the extra large scale trait.

Heterozygous for the pigmentation trait (Pp). Therefore this parent expresses the normal pigmentation.

Parent 2:

Heterozygous for the extra large ventral (abdomen) scales (Ss). Therefore this parent does not express the extra large scale trait.

Heterozygous for the pigmentation trait (Pp). Therefore this parent expresses the normal pigmentation.



Questions:

1. Determine the possible genotype (s) that will produce individuals that have normal sized scales (do not express the extra large abdominal scales) and have normal pigmentation (do not express albinism). What is the frequency that each of these genotype (s) occur in the dihybrid cross?
2. Determine the possible genotype (s) that will produce individuals that have normal scales and are albino? What is the frequency that each of these genotype(s) occur in the dihybrid cross?
3. Determine the possible genotype (s) that will produce individuals with extra large abdominal scales and have normal pigmentation. What is the frequency that each of these genotype (s) occur in the dihybrid cross?
4. Determine the possible genotypes that produce individuals with extra large scales and are albino? Which of these genotypes occur in the dihybrid cross?
5. What is the ratio between the four phenotypic traits (normal scales with normal pigment, albinism with normal scales, extra large scales with normal pigment, and albinism with extra large scales).

Prehensile-tailed Porcupine (*Coendou prehensilis*)

You are a wildlife biologist researching prehensile-tailed porcupines. During your time in South America, you have observed two particular traits that allow some porcupines to be better adapted to their environment. The first trait is an extra long prehensile tail that enables the porcupine to have more efficient grasping capabilities than the usual length prehensile tail. Second, some of the porcupines in the study have extra long whiskers on their face and feet that allow them to sense their environment better than those that have normal size whiskers. If you could breed prehensile-tailed porcupines that have both these traits (extra long prehensile tail and whiskers), it would increase their chance for survival in the wild. You have chosen the following two porcupines to enter into a breeding program for the two desired phenotypic traits. It has been determined (based on your previous research) that both the desired traits are homozygous recessive.

Parent 1:

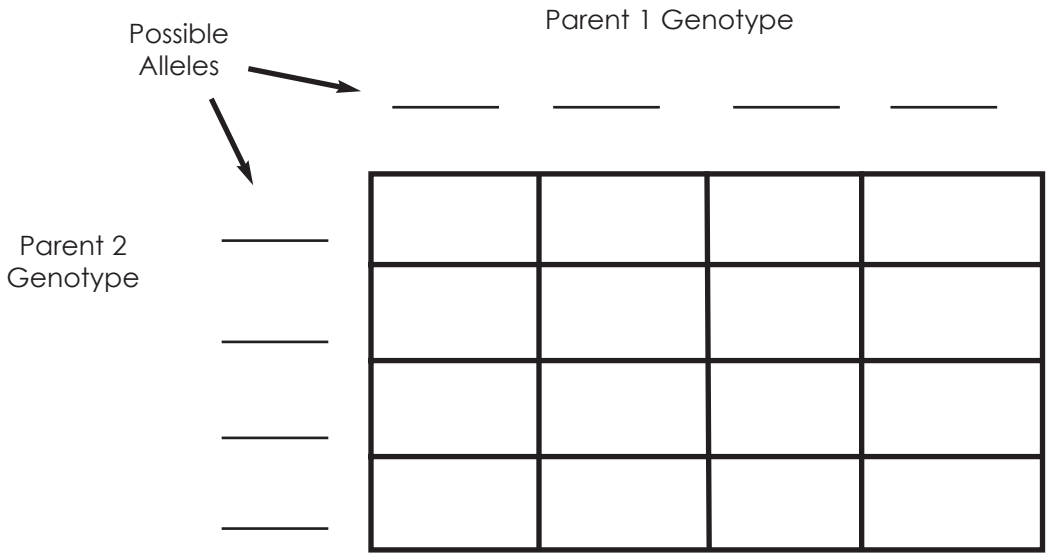
Heterozygous for the extra long prehensile tail trait (Tt). Therefore this parent does not express the extra long tail trait.

Heterozygous for the extra long whisker trait (Ww). Therefore this parent does not express the extra long whisker trait.

Parent 2:

Heterozygous for the extra long prehensile tail trait (Tt). Therefore this parent does not express the extra long tail trait.

Heterozygous for the extra long whisker trait (Ww). Therefore this parent does not express the extra long whisker trait.



Questions:

1. Determine the possible genotype(s) that will produce individuals that have normal sized prehensile tails (do not express the extra long prehensile tail) and have normal sized whiskers (do not express the extra long whisker trait). What is the frequency that each of these genotype (s) occur in the dihybrid cross?
2. Determine the possible genotype(s) that will produce individuals that have normal sized prehensile tails and extra long whiskers? What is the frequency that each of these genotype (s) occur in the dihybrid cross?
3. Determine the possible genotype(s) that will produce individuals with extra long prehensile tails and have normal whiskers. What is the frequency that each of these genotype (s) occur in the dihybrid cross?
4. Determine the possible genotype(s) that produce individuals with extra long prehensile tails and whiskers. What is the frequency that each of these genotype(s) occur in the dihybrid cross?
5. What is the ratio between the four phenotypic traits (normal tails with normal whiskers, normal tails with extra long whiskers, extra long tail with normal whiskers, and extra long tails with extra long whiskers)?

Leaf-Nosed Bat (*Carollia perspicillata*)

You are a wildlife biologist researching leaf-nosed bats. During your time in South America, you have observed two particular traits that allow some leaf-nosed bats to be better adapted to their environment. The first trait is an extra large leaf nose that enables the bat to echolocate and find food more effectively than the usual size leaf nose. Second, some of the bats in the study have stronger tendons in their feet than others. The bats that have stronger tendons are able to hang upside from branches longer than those who do not have as strong of tendons. If you could breed leaf-nosed bats that have both these traits (stronger tendons and larger leaf nose), it would increase their chance for survival in the wild.

You have chosen the following two bats to enter into a breeding program for the two desired phenotypic traits. It has been determined (based on your previous research) that both the desired traits are homozygous recessive.

Parent 1:

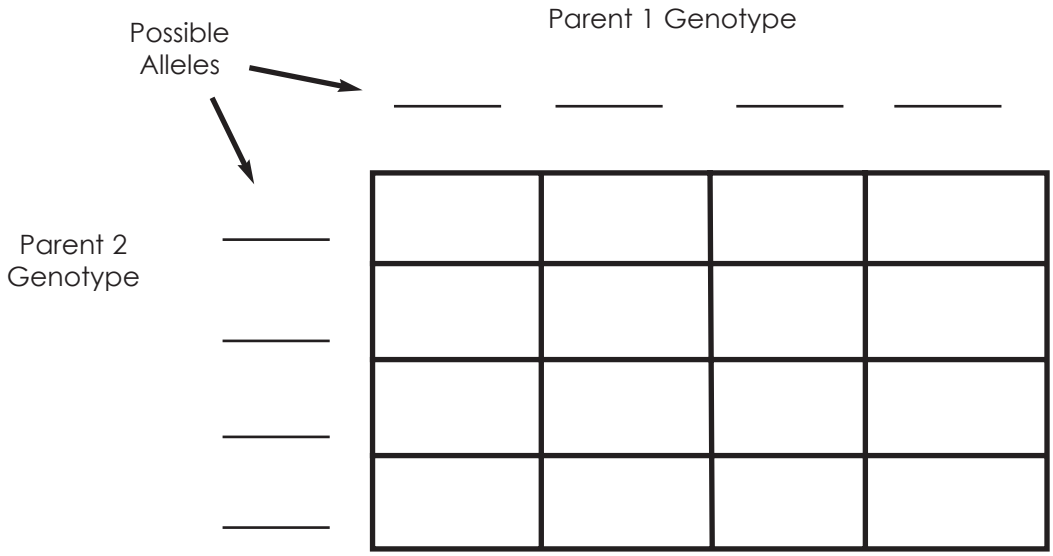
Heterozygous dominant for the leaf-nose trait (Nn). Therefore this parent does not express the extra large leaf-nose trait.

Homozygous recessive for the extra strong tendon trait (tt). Therefore this parent does express the extra strong tendon trait.

Parent 2:

Homozygous recessive for the leaf-nose trait (nn). Therefore this parent does express the extra large leaf-nose trait.

Homozygous recessive for the extra strong tendon trait (tt). Therefore the parent does express the extra strong tendon trait.



Questions:

1. Determine the possible genotype(s) that will produce individuals that have a normal size leaf-nose (do not express the extra large leaf-nose trait) and have normal claw curvature (do not express the extra claw curvature trait). What is the frequency that each of these genotype (s) occur in the dihybrid cross?
2. Determine the possible genotype (s) that will produce individuals that have a normal size leaf-nose and the extra claw curvature? What is the frequency that each of these genotype (s) occur in the dihybrid cross?
3. Determine the possible genotype(s) that will produce individuals that have the extra large leaf-nose and extra claw curvature. What is the frequency that each of these genotype (s) occur in the dihybrid cross?
4. What is the ratio between rhinos that have normal a leaf-nose and extra claw curvature to those that have extra claw curvature and larger leaf-nose? (Normal leaf-nose and extra claw curvature to larger leaf-nose and extra claw curvature).

Osprey (*Pandion haliaetus*)

You are a wildlife biologist researching ospreys. During your time in North America, you have observed two particular traits that allow some ospreys to be better adapted to their environment. The first trait is extra pigmentation in the dark band that extends from the beak through the eye. The extra dark band enables the osprey to reduce glare from the sun more than ospreys that do not have the extra dark pigmentation. Second, some of the ospreys in the study have extra long spicules than others. The ospreys that have these extra long spicules are able to capture prey more efficiently than those who do not have the extra long spicules. If you could breed ospreys that have both these traits (extra pigmentation and longer spicules), it would increase their chance for survival in the wild.

You have chosen the following two ospreys to enter into a breeding program for the two desired phenotypic traits. It has been determined (based on your previous research) that both the desired traits are homozygous recessive.

Parent 1:

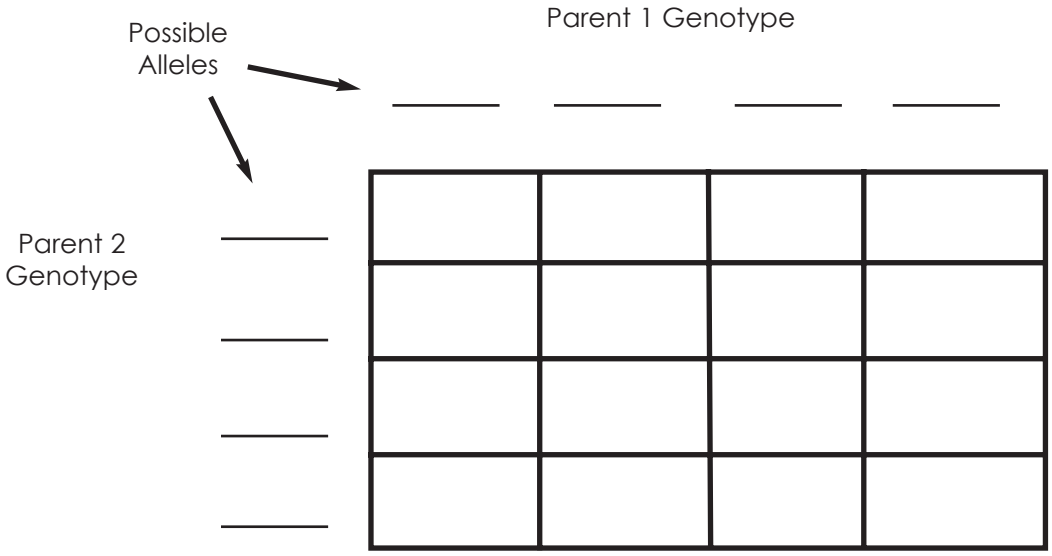
Heterozygous dominant for the extra pigmentation trait (Pp). Therefore this parent does not express the extra pigmentation trait.

Homozygous recessive for the extra long spicule trait (ss). Therefore this parent does express the extra long spicule trait.

Parent 2:

Homozygous recessive for the extra pigmentation trait (pp). Therefore this parent does express the extra pigmentation trait.

Heterozygous dominant for the extra long spicule trait (Ss). Therefore the parent does not express the extra long spicule trait.



Questions:

1. Determine the possible genotype (s) that will produce individuals that have normal pigment (do not express the extra dark pigment in the band that extends from the beak through the eye) and have normal length spicules (do not express the extra long spicule trait). What is the frequency that each of these genotype (s) occur in the dihybrid cross?
2. Determine the possible genotype (s) that will produce individuals that have normal pigment and extra long spicules? What is the frequency that each of these genotype (s) occur in the dihybrid cross?
3. Determine the possible genotype (s) that will produce individuals with extra dark pigment in their eye band and have normal spicules. What is the frequency that each of these genotype (s) occur in the dihybrid cross?
4. Determine the possible genotype (s) that produce individuals with extra pigment in the eye band and extra long spicules. What is the frequency that each of these genotype(s) occur in the dihybrid cross?
5. What is the ratio between the four phenotypic traits (normal pigment with normal spicules, extra pigment with normal spicules, normal pigment with extra long spicules, and extra pigment with extra long spicules)?

Bongo Antelope (*Tragelaphus eurycerus*)

You are a wildlife biologist researching bongo antelope. During your time in Africa, you have observed two particular traits that allow some bongos to be better adapted to their environment. The first trait is that some bongos have thicker horns than others. The thick horns enable the bongo to defend itself better than bongos that do not have the thicker horns. Second, some of the bongos in the study have longer prehensile tongues than others. The bongos that have this extra long prehensile tongue are able to browse for food more efficiently than those who do not have this trait. If you could breed bongos that have both these traits (thicker horns and longer prehensile tongues), it would increase their chance for survival in the wild.

You have chosen the following two bongos to enter into a breeding program for the two desired phenotypic traits. It has been determined (based on your previous research) that both the desired traits are homozygous recessive.

Parent 1:

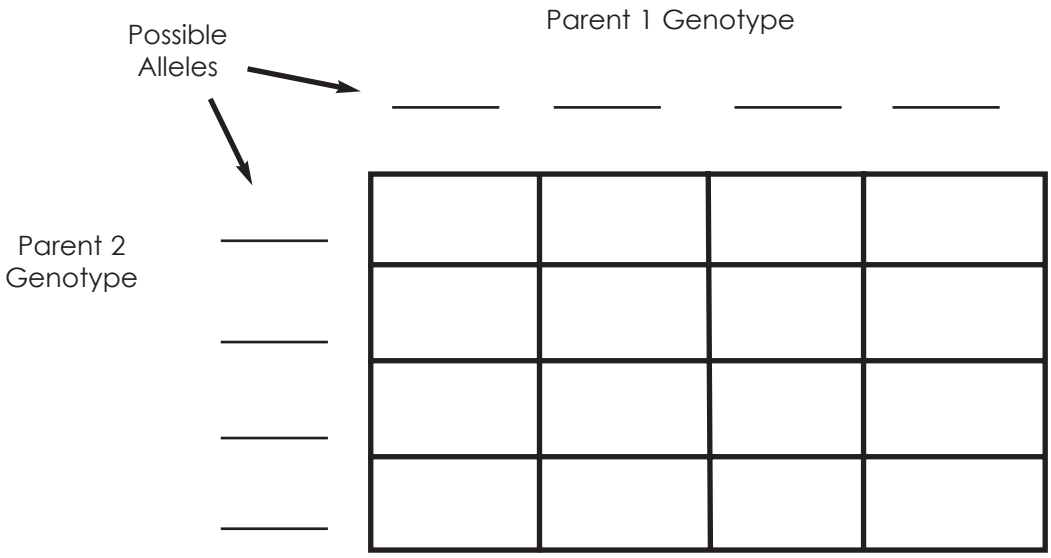
Heterozygous dominant for the horn trait (Hh). Therefore this parent does not express the extra thick horn trait.

Heterozygous dominant for the prehensile tongue trait (Ll). Therefore this parent does not express the extra long prehensile lip trait.

Parent 2:

Heterozygous dominant for the horn trait (Hh). Therefore this parent does not express the extra thick horn trait.

Heterozygous dominant for the prehensile tongue trait (Ll). Therefore the parent does not express the extra long prehensile tongue trait.



Questions:

1. Determine the possible genotype (s) that will produce individuals that have normal horns (do not express the extra thick horns) and have a normal prehensile tongue (do not express the extra long prehensile tongue trait). What is the frequency that each of these genotype (s) occur in the dihybrid cross?
2. Determine the possible genotype (s) that will produce individuals that have normal horns and the extra long prehensile tongue trait? What is the frequency that each of these genotype (s) occur in the dihybrid cross?
3. Determine the possible genotype (s) that will produce individuals with extra thick horns and have a normal prehensile tongue. What is the frequency that each of these genotype (s) occur in the dihybrid cross?
4. Determine the possible genotype (s) that produce individuals with extra thick horns and extra long prehensile tongue. What is the frequency that each of these genotype(s) occur in the dihybrid cross?
5. What is the ratio between the four phenotypic traits (normal horns with normal prehensile tongue, normal horns with extra long prehensile tongue, thick horns with normal prehensile tongues, and extra thick horns with extra long prehensile tongues)?