

THINKING AND ACTING LIKE A SCIENTIST

TEACHER'S GUIDE

Alien Invasion

How can Punnett squares be used to demonstrate the probability of traits in a population?

GRADES 9–12

Life Science





Alien Invasion

Grade Level/ Content	9–12/Life Science
Lesson Summary	In this lesson, students will use Punnett squares to determine the probability certain traits will be passed on from parents to offspring.
Estimated Time	2, 45-minute class periods
Materials (per team)	coin, construction paper, markers, crayons, craft materials (popsicle sticks, yarn, etc.), ruler, Investigation Plan , Assessment , journal
Secondary Resources	Probability of Inheritance Fun with Punnett Squares Punnett Square Calculator Using Punnett Squares to Show Mendel's Genetics Discoveries
NGSS Connection	HS-LS3-3 Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.
Learning Objectives	<ul style="list-style-type: none">• Students will determine the genotypes and phenotypes of the alien individuals.• Students will calculate the frequencies and probability of each allele selected in the alien species.• Students will predict what the offspring of the alien species will look like based on statistics and probability.

How can Punnett squares be used to demonstrate the probability of traits in a population?

An alien species has invaded Earth! You have been tasked by a top-secret government organization to collect genetic information about this species. You must determine what characteristics they possess and what the probabilities are of those traits being expressed in their offspring. You have been asked to create exemplar crosses of different traits and to illustrate what these possible offspring will look like.

You will use Punnett squares to show your crosses. This effort will give you an idea of how common different traits are. You will learn what the probabilities are that certain traits will be passed on from parents to offspring. By knowing the statistics surrounding their reproductive and genetic behaviors, humans will be better prepared in case this species turns out to be hostile!

Investigation is based on the Van Andel Education Institute (VAEI) Instructional Model for Inquiry-Based Science.

In all investigations:



Students don't know the "answer" they are supposed to get.



Students play a driving role in determining the process for learning.



Teachers and students construct meaning together by journaling.



Students are working as hard as the teacher.

Part 1

INVESTIGATION SETUP

Materials you will need:

- One coin per group
- [Investigation Plan](#)
- Construction paper, markers, crayons, craft materials (popsicle sticks, yarn, etc.)
- Ruler
- [Assessment](#)
- Journal

Part 2

INVESTIGATION FACILITATION



Question

Introduce the investigation question.

How can Punnett squares be used to demonstrate the probability of traits in a population?

OPENNESS TO NEW IDEAS

Discuss with students how a Punnett square can be used to predict the genotypes and phenotypes of offspring. Ask them to think about traits beyond the obvious ones of hair and eye color.



Personal Knowledge

Students capture what they already know about genetics, inheritance, genotypes, phenotypes, and monohybrid and dihybrid crosses.

- Find out what students already know about the terms “dominant” and “recessive.”
- Determine if they can distinguish between a genotype, phenotype, homozygous, and heterozygous.

DISCOURSE

Have students create a chart that lists each of the major vocabulary words listed above in one column. Have students use the second column to define them and provide an example. Have students discuss the vocabulary words, using them in context.



Prediction

Students communicate an expected outcome, based on prior knowledge.

- Students make a prediction as to what they think the frequencies of certain genes will be when the aliens reproduce. They should make this prediction before they do each of the crosses. They can write their predictions in their journal before each cross.
- Students present the prediction as *I predict _____ because _____.*



Secondary Knowledge

Students use secondary sources to understand how to perform monohybrid and dihybrid crosses using Punnett squares and use this data to determine genetic frequencies in a population.

- Use these resources (or your own) to better understand how to use a Punnett square to determine allele probabilities:

[Probability of Inheritance](#)

[Fun with Punnett Squares](#)

[Punnett Square Calculator](#)

[Using Punnett Squares to Show Mendel's Genetics Discoveries](#)

COLLABORATION AND CONSTRUCTION OF MEANING

You may wish to conduct a *Jigsaw* to help students work collaboratively. Place students in a “home” group and have each student choose a different article to read. After reading, the groups divide into new “expert” groups consisting of students who read the same article. The article is discussed and then students re-form into their home groups and share in the construction of meaning.



Investigation Plan

Students conduct trials to determine the genotypes and phenotypes of the various traits they selected.

- Divide the class into groups. Give each group an [Investigation Plan](#) to follow.
- Have each group select which traits they are going to observe in the aliens. These could include antennae, wings, scales, red eyes, etc. Be creative!
- Have students establish the genotypes for each trait, flipping the coin to determine if a particular trait is dominant or recessive (heads = dominant, tails = recessive).
- Guide them as they perform several crosses (both monohybrid and dihybrid) using Punnett squares to show the possible patterns of inheritance of the traits.

INVESTIGATION PLAN
ALIEN INVASION

- In your group, select which traits you are going to observe in the aliens. These could include antennae, wings, scales, red eyes, etc. Be creative!
- Establish the genotypes for each trait, flipping the coin to determine if a particular trait is dominant or recessive (heads = dominant, tails = recessive).
- Perform several crosses (both monohybrid and dihybrid) using Punnett squares (see below) in your journal to show the possible patterns of inheritance of the traits. Use the different traits you have selected and run different scenarios (homozygous x homozygous, heterozygous x homozygous, etc.). You may also choose to have one or more of the traits be codominant or incompletely dominant.

Monohybrid Punnett Square

Dihybrid Punnett Square

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Investigation Plan

CRITICAL AND CREATIVE THINKING

Once students collect all of their data using the Punnett squares, they should use it to create the illustrations that show what their aliens look like. Students need to think critically how their data is represented in their illustration, and they need to think creatively to represent it in an original way.

CRITICAL THINKING

Use the [Fair Test](#) checklist to help students think critically about the investigation plan. Help them understand that a good investigation plan must include a test that is repeatable, generates quality data, and minimizes error. The more critically students think about their investigation plan, the more confident they can be in their results.



Observation

Students record the genotypes of the various traits they have selected and then perform crosses to see what the possible outcomes will be.

- Students should draw Punnett squares in their journals to complete their sample genetic crosses. They should collect both monohybrid and dihybrid data (perform crosses with one trait and with two traits being inherited at the same time).

Part 3

INVESTIGATION ANALYSIS AND DEVELOPMENT OF CLAIM



Data Analysis

Students make sense of their data by organizing it and representing it visually.

Have students analyze their data. They may wish to use the [Data Analysis](#) prompt as a guide.

- Have students **evaluate** their data for trustworthiness.
- Then, have them analyze their data to find patterns and trends. They may **organize** the data and/or **represent** it visually to construct meaning. After the crosses have been completed, students may draw an illustration of what the alien they chose looks like, including all of the traits they selected. They may wish to construct a model using the craft materials.
- Students should calculate ratios of both genotypes and phenotypes for each cross they do (monohybrid and dihybrid), and then plot which traits are more likely to appear in the alien population.
- Have students **interpret** what the identified patterns or trends mean.
- Ensure they have enough data that it can be used as evidence to support a claim.

INTEGRITY

Each team should fill out its own Punnett squares using the traits they have selected. Check the setups and make sure students have recorded their data correctly and ethically.



Explanation

Students write a claim and provide evidence and reasoning to support it.

- Have students use what they've discovered from their analyzed data about Punnett squares to write an explanation that answers their investigation question. Students may wish to use the [Explanation](#) prompt as a guide. Have them write their explanation in their journal.
- Have students develop a **Claim** to answer the question: How can Punnett squares be used to demonstrate the probability of traits in a population?
- Then, have them add **Evidence** (the analyzed data) to support their claim.
- Finally, have them add **Reasoning** to their claim. Reasoning should include the information obtained from this investigation as well as science principles they have learned.

Continued

Claim

By performing both monohybrid and dihybrid crosses, it is predicted that the frequencies and probabilities of alleles will follow the patterns put forth by Mendel and show normal inheritance. It is also possible there may be a codominant or incomplete dominant pattern of inheritance.

Evidence

If normal inheritance patterns are seen, the evidence to support them would include a ratio of 1:2:1 if both parents are heterozygous genotype in a monohybrid cross, and 9:3:3:1 phenotype if both parents are heterozygous for a dihybrid cross. If incomplete dominance is present, then intermediate phenotypes should be present.

Reasoning

Investigation: The Punnett squares showed all of the possible genotypes and phenotypes of the alien offspring that were possible depending upon the genotypes of the parents.

Science: Mendel's genetic theories state that dominant alleles mask recessive ones; therefore, if an individual has two dominant alleles, the dominant trait will be expressed. If two recessive alleles are present, the recessive trait will be expressed. If one dominant and one recessive allele are present, then the dominant trait will be expressed, unless the organism shows codominance or incomplete dominance.

- Once the explanation is written, have students discuss their results using a [Present and Defend](#). They may present their claims along with their alien illustrations to the rest of the class, explaining which traits they used and whether each is dominant or recessive. They may also present a few of their Punnett squares to show data collected.

DISCOURSE

Have students conduct a [Present and Defend](#) to develop presentation skills as well as audience participation. Research teams present a summary of their investigation to the class. The class analyzes the information presented and asks clarifying questions, challenges and/or supports the arguments made, and even presents alternative explanations as appropriate. Research teams defend their explanation with evidence and reasoning.



Evaluation

Students reflect on the investigation.

Have students discuss:

- How confident am I in my results?
- What would I do differently?
- What alternative explanations might be responsible for my results?

Part 4

INVESTIGATION ASSESSMENT AND EXTENSION



Application

Students demonstrate understanding of probability and frequency of inheritance by using Punnett squares to map out genetic traits of an alien species.

- Have students apply their learning by answering this question: What other patterns of inheritance are there that can impact the frequencies and probabilities of traits being expressed? (*Sex-linked traits are an example because they are carried on the x chromosome. This means females either have the trait and express it, do not have it, or have it and do not express it. They are carriers of the trait.*)
- Now that students have an understanding of how to use Punnett squares to calculate probabilities and frequencies of inheritance, they can use this knowledge to complete the practice problems found here: <https://kaskaskia.edu/BCambron/Biology%20101/Biol%20101%20Genetics%20Problems.htm>

SELF-DIRECTION

If students are showing high proficiency with the sample problems they have been given, look for harder items in a college level text. Students should expand their knowledge by investigating opportunities, making an enrichment plan, and presenting to the teacher for approval.

Assessment

To assess understanding, have students complete the **Assessment**. Also, have students present their illustrations of their aliens to the rest of the class. They should describe which traits they examined and if the alien was homozygous or heterozygous. They should also discuss what phenotypes their aliens expressed.

PUNNETT SQUARES ASSESSMENT

ALIEN INVASION

NAME: _____
DATE: _____

1. Two people are both carriers of a recessive genetic disorder. Given that the recessive gene is t, create a Punnett square for the following scenario. What is the chance for one of their children to be completely clear of the disorder? 25% or 1 in 4 What is the chance that one of their children will also be a carrier? 50% or 2 in 4

	T	t
T	TT	Tt
t	Tt	tt

2. Two parent plants are short stemmed. The plants both have purple blooms. In this plant species, short stems are recessive and purple blooms are dominant. In a second generation of plants, about half the plants produce white blooms, which is the result of a recessive. Complete the rest of these Punnett squares.

	Short stems			Purple blooms	
	s	S		P	p
s	ss	Ss	P	PP	Pp
S	Ss	SS	p	Pp	pp

3. In squirrels, the allele for dark gray hair (G) is dominant to the allele for light gray hair (g). Fluffy tail alleles (F) are dominant to thin, skimp tail alleles (f). What type of squirrel would each combination of alleles produce?

GgFf dark gray, fluffy-tailed squirrel ggFf light gray, fluffy-tailed squirrel
 ggff light gray, skimp-tailed squirrel Ggff dark gray, skimp-tailed squirrel

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Assessment with Answers

INVESTIGATION PLAN

ALIEN INVASION

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2. Establish the genotypes for each trait, flipping the coin to determine if a particular trait is dominant or recessive (heads = dominant, tails = recessive).
3. Perform several crosses (both monohybrid and dihybrid) using Punnett squares (see below) in your journal to show the possible patterns of inheritance of the traits. Use the different traits you have selected and run different scenarios (homozygous x homozygous, heterozygous x homozygous, etc.). You may also choose to have one or more of the traits be codominant or incompletely dominant.

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Purple blooms

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Short stems

s

s

Purple blooms

	pp

3. In squirrels, the allele for dark gray hair (G) is dominant to the allele for light gray hair (g). Fluffy tail alleles (F) are dominant to thin, skimpy tail alleles (f). What type of squirrel would each combination of alleles produce?

GgFf _____

ggFf _____

ggff _____

Ggff _____