SBI3U-C

Mendel's Laws of Inheritance

Introduction

Early geneticist Gregor Mendel (1822–1884), an Austrian monk, paved the way for modern geneticists. Mendel's laws of inheritance are still used today to form an understanding of how traits are passed on. In this lesson, you will learn about Mendel, his experiments, and resulting laws. You will apply Mendel's laws to problems involving various types of genetic inheritance using a tool called a Punnett square.

Planning Your Study

You may find this time grid helpful in planning when and how you will work through this lesson.

Suggested Timing for This Lesson (hours)	
Principles of Genetics	¼
Mendel's Law of Segregation	½
Mendel's Law of Independent Assortment	1
Activity: Solving Punnett Square Problems	1
More Complex Problems	½
Key Questions	1

What You Will Learn

After completing this lesson, you will be able to

- explain the concepts of DNA, genes, chromosomes, alleles, mitosis, and meiosis, and how they account for the transmission of hereditary characteristics according to Mendelian laws of inheritance
- use the Punnett square method to solve basic genetics problems involving monohybrid crosses, incomplete dominance, co-dominance, dihybrid crosses, and sex-linked genes
- investigate monohybrid and dihybrid crosses through computer simulation, and use the Punnett square method and probability rules to analyze the qualitative and quantitative data and determine the parent genotype
- explain the concepts of genotype, phenotype, dominance, incomplete dominance, co-dominance, recessiveness, and sex linkage according to Mendelian laws of inheritance

Principles of Genetics

The science of genetics began with the work of Gregor Mendel in the 1860s. Since then, there has been an explosion of research into genetics, especially since the discovery of DNA in 1953. For example, the Human Genome Project (HGP) was a thirteen-year collaborative effort of scientists around the world. Its goals were to identify all of the 20 000 to 25 000 genes in human DNA, and determine the sequences of the 3 billion chemical base pairs that make up human DNA.

Now that the human genetic code has been catalogued, the task of understanding what all our genes do has begun. The potential benefits to medicine and human health are enormous; for example, drugs can now be designed to target a patient's DNA in order to speed up recovery and reduce negative side effects.

In this lesson, you will study Mendel's genetic experiments on plants, and see how his discoveries created the foundation of genetics still in use today. But first, you need to learn a few more key terms relating to genetics. You will use these throughout the rest of this unit, in addition to the ones defined in Lesson 3.

Key Terms

Homozygous: Diploid organisms with two copies of the same allele of a given gene are called homozygous. Homozygous individuals are also referred to as pure-breeding individuals.

Heterozygous: Diploid organisms with two different alleles of a given gene are called heterozygous.

Dominant allele: The allele that takes precedence over another allele when both are present in a heterozygous individual, and will be expressed as the individual's phenotype for that trait.

Recessive allele: The allele that is overruled by another allele when both are present in a heterozygous individual, and will not be expressed as the individual's phenotype for that trait. Recessive alleles can still be passed on to offspring.

In genetic notation, dominant alleles are usually represented by a capital letter, and recessive alleles are usually represented by a lower-case letter. For a given trait, the same letter is always used for both the dominant and recessive alleles; it is usually the first letter of the dominant trait, with the recessive trait then using the same letter in lower case. For example, if the dominant allele for tallness were represented by 'T,' the recessive dwarf allele would be represented by 't' (not 'd'). There would be three possible genotypes for this combination: TT, tt and Tt. (Note that in the case of heterozygous genotypes the dominant allele is written first.)

Recommended Activity:

Watch this pencast video for an overview of homozygous and heterozygous organisms, and dominant and recessive alleles. (Make sure you have the latest version of Adobe Reader.)

Mendel's Experiments

Mendel performed a series of experiments using the common garden pea plant. Pea plants were an excellent choice for his studies because they were readily available and were fairly easy to grow. Most importantly, they had a number of traits that were expressed in only one of two ways. These readily observable traits are summarized in Figure 6.1, below. Note that the two forms of each trait are easily distinguished from each other.

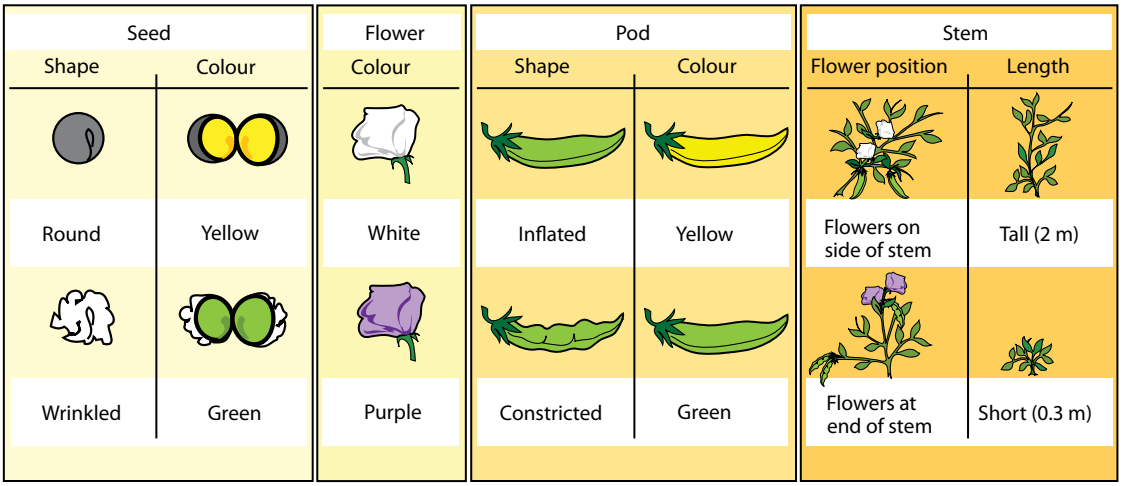

Figure 6.1: Mendel's seven pea plant characteristics. The dominant form of each trait is shown in the top row and the recessive form in the bottom row.

Source: Wikimedia Commons

Mendel understood the value of having controls in his experiments. For this reason, he began by studying crosses between pure-breeding plants that were different with respect to only one trait. These parent plants were called the parent generation or P generation.

When crossing a pure-breeding tall plant with a pure-breeding dwarf one, all the resulting plants were called hybrids. All of the hybrids in this generation, called the first filial or F_1 generation, were tall. Since the trait of tallness seemed to dominate the trait of dwarfness, Mendel called it the dominant trait. The trait that was not expressed in the F_1 generation he called the recessive trait.

Mendel then crossed his F_1 generation plants and found that the resulting generation, called the F_2 generation, yielded about three tall plants for each dwarf plant, a mathematical ratio of 3:1. Mendel was surprised; he had predicted that all of the offspring would be tall, so he began to infer that some of the tall plants from the F_1 generation must still carry the dwarf gene.

This led Mendel to his theories about how genes are passed on. Two of his theories are now known as Mendel's laws of inheritance:

1. Mendel's Law of Segregation
2. Mendel's Law of Independent Assortment

You will learn about these laws and their importance in the next sections.

Support Questions

Be sure to try the Support Questions on your own before looking at the suggested answers provided.

14. Match the term with its description. Suggested answer

Term	Description
1. Genotype	A. A genotype in which the alleles of a pair are different; for example, Bb
2. Phenotype	B. One of two or more alternate forms of a gene; for example, wrinkled or smooth pea pods
3. Heterozygous	C. Alleles of this type determine the expression of the genetic trait in offspring
4. Homozygous	D. All of an individual's allele combinations; often defined for a particular trait only. Can also refer to the entire genetic makeup of an individual
5. Allele	E. A genotype in which both alleles are identical; for example, bb
6. Gene	F. The offspring of two individuals of different genotypes
7. Dominant	G. The observable form of a trait; for example, blue eyes
8. Recessive	H. Alleles of this type are overruled by dominant alleles
9. Hybrid	I. Sections of a chromosome, each of which contains one set of instructions

Mendel's Law of Segregation

Mendel concluded that each genetic trait is determined by two alleles, one contributed from each parent. So, when you were conceived, you received one maternal allele and one paternal allele. The combination of these alleles determined your characteristics as an individual. This principle has become known as Mendel's Law of Segregation..

Mendel's Law of Segregation

During gamete formation, the pair of alleles responsible for each trait segregate (separate) so that each gamete contains only one allele for each trait.

Dominant alleles determine the expression of the genetic trait in the offspring, while recessive alleles are overruled by dominant alleles. For example, the gene for height in pea plants has two different alleles: a dominant tall allele, T, and a recessive dwarf allele, t. If a pea plant possesses two tall alleles (TT) or one of each of the alleles for height (Tt), it will be tall. The only way for a plant to develop as a dwarf is if both of its alleles are of the recessive type (tt).

Example

If the allele for brown eyes is dominant and the allele for blue eyes is recessive, what would be the genotype for

a) a homozygous brown-eyed male?

b) a heterozygous brown-eyed female?

Solution

Let B represent the dominant allele for brown eyes.

Let b represent the recessive allele for blue eyes.

a) Since the male is homozygous, with brown eyes, his genotype would be BB.

b) Since the female is heterozygous, her genotype would be Bb.

Recommended Activity:

Watch this pencast video, which works through the above example, to make sure you understand the concept.

Genetic Screening

Genetic screening can be used to determine the genotypes (and, therefore, the potential phenotypes or traits) of unborn children. Various techniques can be used to determine whether a child has a genetic disorder such as Down syndrome.

One interesting example is Huntington's disease. This disease develops later in life, and results in a deterioration of the nervous system, eventually resulting in death. What makes this disease frightening is the fact that the allele is dominant, so the odds of passing it on are greater. Fortunately, the frequency of this allele is not high within the general population, but it could be of concern if individuals with Huntington's disease do not undergo genetic screening.

Genetic screening raises some ethical issues for some people. Those against it express many concerns. Some feel it is immoral or unethical to prejudge the value of a human life based on its genetic makeup before birth. Others are concerned that people identified as having certain genetic traits may feel forced to choose to not marry or have children. They also worry about who else may get access to their genetic data and what might be done with it. For example, what if insurance companies or employers knew your genetic code and then acted to deny you insurance or employment because they thought you might be more likely to develop an expensive medical condition?

Those in favour of genetic screening argue that the benefits outweigh the drawbacks. They feel that if genetic screening can help prevent children from being born with conditions like Huntington's disease, then it is unethical to allow them to be born with this disease if we can prevent it. Also, genetic screening could help new parents prepare for the special needs of their child to ensure they have as rich a life as possible.

Support Questions

15. What would be the eye colour genotype of a blue-eyed female? Suggested answer

16. A woman over the age of 35 has an increased chance of having a child with chromosomal abnormalities. State a reason why a woman may choose to undergo genetic screening of the fetus, and state a reason why she may choose not to undergo the procedure.

Suggested answer

The Punnett Square

A Punnett square is a chart used to determine the possible combinations of characteristics among offspring. It tells us the genotype of the offspring and, by examining the genotype, we can determine the phenotype.

A sample Punnett square is illustrated below. It shows the cross that would occur between a homozygous brown-eyed male (BB) and a heterozygous brown-eyed female (Bb). The separation of the parental genotypes into single letters along the side and top of the table represents meiosis. Each single letter (B or b) represents a gamete (sperm or egg) and the double letters (BB or Bb) represent what is found in the zygote when the gametes join.

		Paternal alleles →	
		B	B
Maternal alleles ↓	B	BB	BB
	b	Bb	Bb

Recommended Activity:

Watch this pencast video, which works through the above example.

The shaded area represents the possible zygotes or offspring. In this example, there would be a 50% chance that their offspring would have the BB genotype (homozygous dominant), and a 50% chance that their offspring would have the Bb genotype (heterozygous). All possible offspring would have the brown-eyed phenotype.

In the next section, you will learn how to solve genetics problems using a Punnett square.

Monohybrid Crosses

The benefit of using Punnett squares to understand Mendel's Law of Segregation across one generation is most easily demonstrated for one trait. A monohybrid cross is a cross that involves only one trait; for example, eye colour, plant height, or flower colour.

Example

A pea plant that has yellow seeds is cross-pollinated with a pea plant that has green seeds. Yellow seeds are dominant over green seeds. If the yellow-seeded pea plant is homozygous, what are the genotypes and phenotypes of the F_1 generation?

Solution

There are a series of steps you need to follow in order to solve a monohybrid cross problem using the Punnett square method:

1. Write "let" statements for the symbols to be used. Remember that you can choose any letter to represent the gene, but the same letter (in upper and lower case) is used for both alleles.

   Let Y represent the dominant allele (yellow seeds).

   Let y represent the recessive allele (green seeds).

2. Write down the description of the parents involved, including their genotypes, using the correct symbols. Join them with the symbol for cross-breeding (which is the same as the multiplication symbol, ×).

Parents

Yellow seeds (YY) × Green seeds (yy)

3. List all possible gametes that could be produced by each parent.

   Gametes

   Y Y × y y

4. Set up the Punnett square by drawing a square divided into four smaller squares. Place the letters for one set of gametes along the left side of the square, and the letters for the other set of gametes along the top of the square, as shown below. It doesn't matter whether you put the maternal or paternal gametes along the side or the top, because the answer will be the same.

	Y	Y
y		
y		

5. Cross the gametes with each other to establish the genotypes of the offspring. To do this, simply fill in each square with the two letters that line up with that square (down and across).

	Y	Y
y	Yy	Yy
y	Yy	Yy

6. Based on the information in the Punnett square, state the resulting genotypes and phenotypes of the F_1 offspring, including the chance they will occur, expressed as a percentage.

   F_1 genotype

   4 out of 4 or 100% are Yy

   F_1 phenotype

   4 out of 4 or 100% are yellow seeds (because the heterozygote Yy is always yellow)

Recommended Activity:

Watch this pencast video, which works through the above example.

Support Questions

17. For each of the monohybrid crosses of pea plants listed below (a to e), create a Punnett square and determine the following information:

- parent phenotypes and genotypes
- parent gametes
- The number of F_1 genotypes and the chance they will occur
- The number of F_1 phenotypes and the chance they will occur

a) Two heterozygous tall parents are crossed. Suggested answer

b) A heterozygous tall plant is crossed with a dwarf plant. Suggested answer

c) Two plants that are heterozygous for purple flowers are crossed. Suggested answer

d) A plant that is heterozygous for green pods is crossed with a plant that has yellow pods. Suggested answer

e) A plant that is homozygous for green pods is crossed with a plant that has yellow pods. Suggested answer

Use the table of Mendel's experiments included below to help you work through the problems.

Mendel's experiments

Trait	Alleles (DOMINANT/ recessive)	Possible genotypes
Plant height	TALL dwarf	TT or Tt tt
Flower colour	PURPLE white	PP or Pp pp
Flower position on stem	AXIAL (side) end	AA or Aa aa
Pod colour	GREEN yellow	GG or Gg gg
Pod shape	INFLATED constricted	II or Ii ii
Seed colour	YELLOW green	YY or Yy yy
Seed shape	ROUND wrinkled	RR or Rr rr

Mendel's Law of Independent Assortment

As you just learned, Mendel's Law of Segregation states that the alleles for a single trait separate when gametes are formed. These allele pairs are then randomly united at fertilization. Mendel arrived at this conclusion by performing cross-pollination experiments with pea plants that differed in only one trait (for example pod colour).

Mendel began to wonder what would happen if he studied plants that differed in two traits. Would both traits be transmitted to the offspring together, or would each trait be transmitted independently of the other? From his experiments, Mendel developed the principle now known as the Law of Independent Assortment:

Mendel's Law of Independent Assortment

During gamete formation, alleles segregate independently of each other.

In the next section you will apply Mendel's Law of Independent Assortment by examining crosses that involve two traits.

Dihybrid Crosses

A dihybrid cross is a cross that involves two separate traits; for example, eye and hair colour, or plant height and flower colour.

Example

In pea plants, tall plants are dominant over dwarf plants, and purple flowers are dominant over white flowers. If two heterozygous plants for these traits are crossed, what are the genotypes and phenotypes of the F_1 generation?

Solution

The steps used to solve this problem using the Punnett square method are similar to the steps used earlier to solve a monohybrid cross.

1. Write "let" statements for the symbols to be used.

   Let T represent the dominant allele for height (tall) and t represent the recessive allele (dwarf).

   Let P represent the dominant allele for flower colour (purple) and p represent the recessive allele (white).

   Remember, the choice of letter used to represent a trait is up to you, but the dominant and recessive allele of the same trait must be represented by the same letter (in upper and lower case).

2. Write down the description of the parents involved, including their genotypes, using the correct symbols.

   Parents

   Tall with purple flowers (TtPp) × Tall with purple flowers (TtPp)

3. List all possible gametes that could be produced by each parent. Remember that one allele from each pair is passed on to its offspring. Thus, for a parent that is heterozygous for two separate traits, there are four possible allele combinations in the gametes (Figure 6.2).

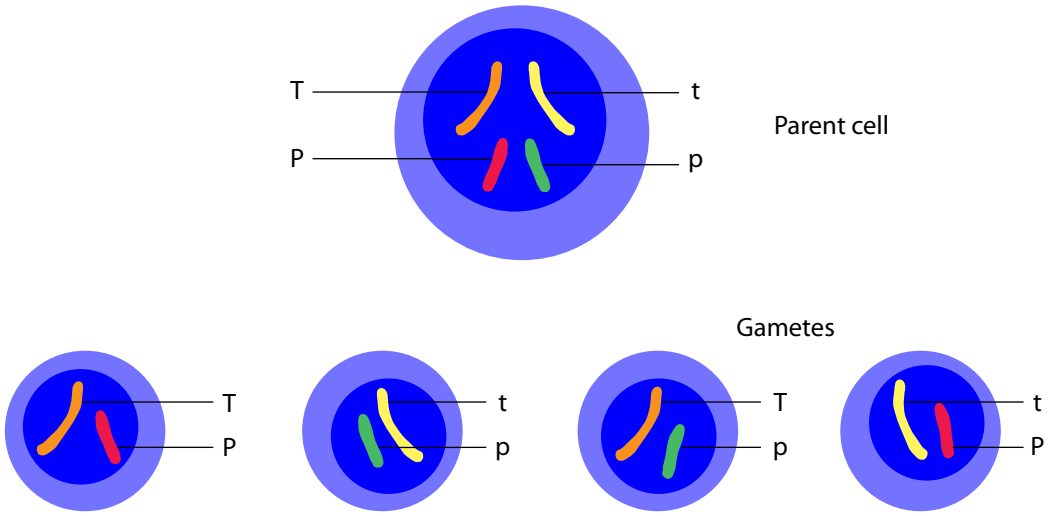

Figure 6.2: A heterozygous parent cell and its gametes

In this example, the genotypes of both parents are identical (TtPp), so you only have to work out the set of possible gametes once.

Working out the list of possible gametes for a parent can be confusing, so you may want to use the FOIL method (First, Outer, Inner, Last). For a parent with the genotype TtPp, the FOIL method works to produce four gametes as follows:

F: take the **first** two alleles for each trait

T t P p

= TP

O: take the **outer** two alleles for each trait

T t P p

= Tp

I: take the **inner** two alleles for each trait

T **t** **P** p

= tP

L: take the **last** two alleles of each trait

T **t** P **p**

= tp

Gametes

TP Tp tP tp (same for both parents)

Remember: Each gamete must contain one allele for each trait.

4. Set up the Punnett square as shown below, and cross the gametes with each other to establish the genotypes of the offspring (called the F_1 generation).

	TP	Tp	tP	tp
TP	TTPP	TTPp	TtPP	TtPp
Tp	TTPp	TTpp	TtPp	Ttpp
tP	TtPP	TtPp	ttPP	ttPp
tp	TtPp	Ttpp	ttPp	ttpp

Notice that the alleles of the same trait are still listed beside each other, as they were in the monohybrid cross. That is why the first gamete in the square is shown as TTPP instead of TPTP.

5. Based on the information in the Punnett square, state the resulting genotypes and phenotypes of the offspring. Note: When dealing with dihybrid crosses, the frequency of genotypes and phenotypes are often stated as ratios instead of percentages. In this format, each type of offspring is preceded by a number indicating its quantity, and is separated from the next type by a colon. The ratios for the genotypes in the F_1 generation are shown below.

F_1 genotypes

1TTPP : 2TTPp : 2TtPP : 4TtPp : 1TTpp : 2Ttpp : 1ttPP : 2ttPp : 1ttpp

F_1 phenotypes

Tall/purple = 1TTPP + 2TTPp + 2 TtPP + 4TtPp = 9

Tall/white = 1TTpp + 2Ttpp = 3

Short/purple = 1ttPP + 2ttPp = 3

Short/white = 1 ttpp = 1

The phenotype ratios are:

9 tall/purple : 3 tall/white : 3 short/purple : 1 short/white

Recommended Activity:

Watch this pencast video, which works through the above example.

Activity: Solving Punnett Square Problems

The best way to learn how to solve Punnett square problems is through practice. The following two activities will give you some experience at solving problems involving monohybrid and dihybrid crosses.

Start with this activity called Monohybrid Genetics. When you have completed it, try the more challenging Dihybrid Genetics activity.

The tutorials use traits found in fruit flies. Fruit flies are often chosen for genetic experiments because they have short life cycles, breed easily in lab conditions, and are easily handled. They also have some easily seen traits like eye colour and wing shape that are determined by single genes. This makes them ideal subjects for genetic research.

Support Questions

18. In guinea pigs, black coat colour (B) is dominant over white (b), and short hair length (H) is dominant over long (h). Indicate the genotypes and phenotypes from the following crosses:

a) A guinea pig that is homozygous for black coat and heterozygous for short hair is crossed with a white, long-haired guinea pig. Suggested answer

b) A guinea pig that is homozygous for black coat and long hair is crossed with a guinea pig that is heterozygous for black coat and short hair. Suggested answer

More Complex Problems

For most traits, the genetics are not as simple as in the cases you have dealt with so far. There are three situations where solving the genetics becomes more difficult:

- incomplete dominance
- co-dominance
- multiple alleles

You will solve problems of each type in the sections below.

Incomplete Dominance

Mendel observed instances in nature where strict dominance did not apply. Usually, the dominant allele overrules the expression of the recessive allele in a heterozygous individual. However, in the determination of some traits, the different alleles of a gene may both be expressed in a heterozygous individual, producing an intermediate phenotype.

When neither allele is completely dominant over the other, we say that there is incomplete dominance. With incomplete dominance, a cross between organisms with two different phenotypes produces offspring with a third phenotype that is a blending of the parental traits.

A good example of incomplete dominance occurs in flowers called four o'clock flowers. They come in a variety of colours determined by two alleles (red and white) that show incomplete dominance. The heterozygous condition (pink) is a blend of the other two alleles (red and white).

You can still use a Punnett square to solve problems involving incomplete dominance. The only difference is that now you don't use upper- and lower-case letters to describe the traits because one is not dominant over the other. There are several ways to represent the different alleles. One way is to use one letter for the trait and indicate the second allele using the prime symbol (′), for example R for red and R′ for white. An easier way is to represent each allele using a different capital letter, for example R for red and W for white. You won't confuse this with a dihybrid trait because each gamete only has two letters in it, not four.

Example

Using a Punnett square, show the cross between a red four o'clock flower and a white one. State the resulting genotypes and phenotypes as percentages.

Solution

Let R represent the red flower allele.

Let W represent the white flower allele.

Parents

Red flower (RR) × white flower (WW)

Gametes

R R × W W

	R	R
W	RW	RW
W	RW	RW

F_1 geznotype

100% RW

F_1 phenotype

100% pink flowers

Notice that all the offspring are pink because they are heterozygotes, containing one red allele and one white allele. The way to recognize when you are dealing with a problem involving incomplete dominance is to notice that the offspring is showing a third phenotype that is a blending of the parental traits.

Recommended Activity:

Watch this pencast video, which works through the above example.

Co-dominance

A slightly different form of inheritance can occur where two alleles are expressed at the same time, but instead of blending together as they do in incomplete dominance, both traits appear together in the offspring. This type of inheritance is called co-dominance. A common example of co-dominance is found in the hair colour of cattle and horses. These animals have two alleles for hair colour: red and white. If one parent is homozygous red and the other is homozygous white, then the offspring will be heterozygous, with a pinkish colour called "roan," which is a blend of red and white. However, unlike the case of incomplete dominance, in this instance, each hair in the coat of the heterozygous animal is either completely red or completely white. This mix of red and white hairs gives the heterozygous animal a pinkish colour even though none of its hairs are actually pink.

Just like in the case of incomplete dominance, the two alleles are not represented by upper- and lower-case letters. One common approach is to use two capital letters to describe the two alleles. A Punnett square can be used to solve problems of co-dominance in the same way it was used to solve problems involving incomplete dominance.

Example

Using a Punnett square, show the cross between a roan bull and a red cow. State the resulting genotypes and phenotypes as a ratio.

Solution

Let R represent the red allele.

Let W represent the white allele.

Parents

Roan bull (RW) × Red cow (RR)

Gametes

R R × R W

Paternal alleles →

Maternal alleles ↓		R	W
	R	RR	RW
	R	RR	RW

F_1 genotypes

2RR : 2RW

This can be simplified to the ratio 1RR : 1 RW.

F_1 phenotypes

2 red and 2 roan, so the phenotype ratio is 1 red : 1 roan

Therefore, there is a 50% chance of red offspring and a 50% chance of roan offspring.

Recommended Activity:

Watch this pencast video, which works through the above example.

Support Questions

19. Explain the meaning of dominance, co-dominance, and incomplete dominance.

Suggested answer

20. Determine the percentage of the different phenotypes in the F_1 generation of a cross between a pink and a white snapdragon. Snapdragons exhibit incomplete dominance in the same manner as four o'clock flowers. A pink flower is a heterozygous individual.

Suggested answer

Multiple Alleles

An individual can only have two alleles for a given gene (one from their mother and one from their father), but many alleles for a trait can be present in a population. When there are more than two alleles possible for a given gene in a population, the condition is termed multiple allelism.

For example, there are three alleles that contribute to blood type in humans: A, B, and O. If someone is blood type A, they produce the A blood protein; if someone is blood type B, they produce the B blood protein; someone who is type O produces no blood protein. The blood types A, B, AB, and O result from the pairings of these alleles.

Alleles A and B are dominant over allele O, but neither A or B is dominant over the other—they are co-dominant. This means they will both express themselves if they are present. For example, someone with blood type AB produces both A and B proteins. Blood type phenotypes and genotypes are summarized in the table shown below.

Phenotype	Genotype
A	AA or AO
B	BB or BO
AB	AB
O	OO

Matching compatible blood types is critical for blood transfusions. If the donor's blood has a substance (proteins A or B) that is foreign to the recipient, specific proteins called antibodies produced by the recipient bind to the foreign molecules and cause the donor's blood cells to agglutinate (clump together). This agglutination can cause the recipient to die.

A universal donor is a person with type O blood. They can give blood to anyone, but can only receive type O blood. A universal recipient is a person with type AB blood. They can receive any blood type, but can only give blood to people with type AB blood.

Recommended Activity:

Watch this pencast video about blood types.

Example

Using a Punnett square, show the cross between a type AB male and a heterozygous type B female. State the resulting genotypes and phenotypes as a ratio.

Solution

Let A represent the co-dominant A allele.

Let B represent the co-dominant B allele.

Let O represent the recessive O allele.

Parents

Type AB (AB) × type B heterozygous (BO)

Gametes

A B × B O

Paternal alleles →

Maternal alleles ↓		A	B
	B	AB	BB
	O	AO	BO

F_1 genotypes

1AB : 1BB : 1AO : 1BO

F_1 phenotypes

1 type AB: 2 type B: 1 type A

Recommended Activity:

Watch this pencast video, which works through the above example.

Support Questions

21. Show the cross between a mother who is heterozygous for type B blood and a father who is heterozygous for type A blood. What is the chance of producing a child with type O blood?

Suggested answer

Key Questions

Now work on your Key Questions in the online submission tool. You may continue to work at this task over several sessions, but be sure to save your work each time. When you have answered all the unit's Key Questions, submit your work to the ILC.

(15 marks)

19. Consider a cross between a pea plant that is heterozygous for round seeds and a pea plant that has wrinkled seeds. The allele for round seeds (R) is dominant over that for wrinkled seeds (r). Using a Punnett square, determine the genotypes of the offspring. **(8 marks)**

20. In guinea pigs, the black coat (B) is dominant over the white coat (b), and straight hair (H) is dominant over curly hair (h). Using a Punnett square, complete the cross between a heterozygous black, curly-haired individual and a homozygous straight-haired, white individual. State the parent genotypes, gametes, and the F1 phenotypes and genotypes. **(7 marks)**

Now go on to Lesson 7. Send your answers to the Key Questions to the ILC when you have completed Unit 2 (Lessons 5 to 8).