LIFEPAC®

SCIENCE

STUDENT BOOK

▶ **10th Grade** | Unit 7

Alpha Omega
PUBLICATIONS

SCIENCE 1007
Genetics and Inheritance

LIFEPAC Test is located in the center of the booklet. Please remove before starting the unit.

Alpha Omega
PUBLICATIONS

Genetics and Inheritance

In Genesis 1:1 we read, "In the beginning God created the heaven and the earth." Genesis 1:12 states, "And the earth brought forth grass, and herb yielding seed after his kind, and the tree yielding fruit, whose seed was in itself, after his kind ..." And again in Genesis 1:24 we read, "And God said, Let the earth bring forth the living creature after his kind, cattle, and creeping thing, and beast of the earth after his kind: and it was so."

How often have you seen a puppy or a kitten or a human baby that resembles its parents? Often we have made these observations without a second thought. As the Scripture indicates, offspring resemble their natural parents. A pig has never been known to give birth to a sheep or a snake to give birth to a pigeon. How beautiful and how significant are the laws of heredity that God provided at the Creation.

Up to the mid-nineteenth century heredity was thought to result from the flowing together of substances from all the parts of each parent's body and the blending of these substances to form a new individual. The new individual would not resemble either parent, but would have features of each. If this theory were true, however, how could two purple-flowered plants produce plants that bear white flowers? How could brown-eyed parents have a child with blue eyes? How could pure white and black goats produce spotted kids or white sheep have brown lambs or pure-colored cattle give birth to spotted calves? Read Genesis 30:30–31:12. We can conclude that some characteristics are common for a species, such as feathers, flying, and toothless beaks for grasping food, in birds; and yet other unique characteristics are found in the individual. The mechanism of heredity established by God at the Creation allows for change, and it provides for constancy from one generation to the next. Man was unaware of these principles until an Austrian monk, Gregor Mendel, discovered some of the pieces of the puzzle. Since that time, much progress has been made in completing the picture.

Objectives

Read the following objectives. The objectives tell you what you will be able to do when you have successfully completed this LIFEPAC®. Each section will list according to the numbers below what objectives will be met in that section. When you have finished this LIFEPAC, you should be able to:

1. Describe how the principles of scientific investigation apply to the history of the study of heredity.
2. Explain the pattern by which single traits are transmitted from parents to offspring.
3. Describe the mechanism of probability and how inheritance of a trait is due to "chances."
4. Predict the types and frequency of traits in offspring.
5. Describe procedures to determine genotypes of individuals with dominant phenotypes.
6. Explain why gene expression may differ with different allelic combinations.
7. Compare chromosomes and genes.
8. Describe why genes and chromosomes are paired.
9. Describe how chromosomes control the inheritance of sex.

1. GREGOR MENDEL'S EXPERIMENTS

Many historians have described Gregor Mendel as an obscure monk who stumbled onto the nature of hereditary mechanisms while tending his garden between morning and evening prayers. However, he was clearly an alert and practical scientist who entered the monastery as part of his academic training as well as in response to his religious convictions. During life prior to joining the monastery, Mendel exhibited an active interest in crop improvements as demonstrated by the many awards he received for developing new varieties of fruit and vegetables. Also, he established thirty-four "pure" strains of peas in his garden in preparation for **hybridization** experiments. In 1865 he published the results of his seven years of study on cross-breeding of his garden peas.

Why did Mendel select the garden pea? These plants were easy to grow and their pollen-producing stamen and egg-containing pistil were easy to reach. Normally, pea plants self-pollinate; but to selectively crossbreed his plants, Mendel would remove the stamen and cover the flower with a bag to prevent chance **pollination** from other pea plants in the garden. In his experiments Mendel would select flowers of plants with the desired **trait** and would dust the pollen from the stamen of one plant onto the pistil of the other plant. He observed the offspring of these plants for several generations.

Most of the plants studied were different only in a single trait or hereditary feature. For example, Mendel obtained tall plants that produced only tall plants when allowed to **self-fertilize**, and short plants that produced only short plants when self-fertilized. In total he studied seven traits:

seed shape: round versus wrinkled
internal seed color: yellow versus green plant pigmentation
seed coat color: pigmented versus unpigmented
height: tall (six to seven feet) versus short (nine to eighteen inches)
pod color: green versus yellow
pod shape: round and inflated versus constricted and wrinkled
flower position: flowers along stems (axial) versus flowers at the top only (terminal)

Hundreds of crosses between each of these pairs of traits were performed. Did the offspring resemble one or both of the parents, or did the characteristics blend?

Section Objectives

Review these objectives. When you have completed this section, you should be able to:

1. Describe how the principles of scientific investigation apply to the history of the study of heredity.
2. Explain the pattern by which single traits are transmitted from parents to offspring.
3. Describe the mechanisms of probability and how inheritance of a trait is due to "chances."
4. Predict the types and frequency of traits in offspring.
5. Describe procedures to determine genotypes of individuals with dominant phenotypes.
6. Explain why gene expression may differ with different allelic combinations.

Vocabulary

Study these following words to enhance your learning success in this section.

allele	chromosome	deviation
dihybrid cross	dominant	F_1 generation
F_2 generation	gametes	gene
genotype	heterozygous	homozygous
hybrid	incomplete dominance	meiosis
monohybrid cross	multiple alleles	P_1 generation
phenotype	pollination	
principle of independent assortment		principle of segregation
probability	Punnett square	recessive
self-fertilization	test cross	trait
true-breeding		

THE MONOHYBRID CROSS

When crossing a pair of "pure-breeding" plants that differed only in a single **trait**, Mendel dusted pollen from one strain on to the pistil of the opposite trait flower. In this and subsequent experiments in which he reversed the plant that provided stamen and pistil, he found that the results did not depend upon which was the male or female plant. From these observations he concluded that the male and female parents equally contribute hereditary material. In this section we will study Mendel's experiments, results, and conclusions. You will apply the results of Mendel's work to activities of your own to test your understanding of the Mendelian principles of heredity.

Mendel's results. The results observed when tall plants were crossed with short plants showed all the offspring to be tall. When yellow-seed plants were crossed with green-seed plants, only yellow seeds were produced. Furthermore, when the round-seeded variety were bred to the wrinkled-seeded variety, only round seeds were grown. Mendel found that for each of the seven pairs of traits, one of the characteristics present in the parent plants was apparently lost in the next generation. This observation led to the question, what would happen if these offspring were allowed to self-pollinate?

Since Mendel's experiments specific terms have been adopted to designate the original parental generation as the **P_1 generation**; the offspring of the P_1, **F_1 generation** (first filial generation); the offspring of the F_1, the **F_2 generation**; and so on.

The seeds produced by the cross-fertilization of the P_1 generation were collected and planted. The plants that grew are the F_1 or **hybrid**. The F_2 plants were grown from seeds collected from **self-fertilized** F_1 plants. A cross between plants that differs only in one characteristic is called a **monohybrid cross**.

Since traits of P_1 plants did not blend in producing the F_1 plants, Mendel called the trait that was apparent in the F_1 generation the **dominant** trait. He called the trait that disappeared the **recessive** trait. For example, when a plant with green pods was crossed with a plant with yellow pods, all of the F_1 plants produced green pods. Green pods were dominant and yellow pods were recessive.

Following self-fertilization, the F_1 generation plants gave rise to F_2 plants in which the recessive trait reappeared. Traits that had disappeared now resurfaced. Being trained in statistics, Mendel went a step further. He counted the individuals produced from several hundred F_1 crosses and tabulated the total number of plants with dominant traits and those with recessive traits. In the cross between plants with round and wrinkled seeds, he counted 7,324 peas in the F_2 generation. Of those peas, 5,474 were round-seeded and 1,850 were wrinkled. Mendel's mathematical mind did not miss the fact that these figures represent three round-seed plants being produced for every one wrinkled-seed plant (5,474 to 1,850), or a 3 to 1 ratio. When other monohybrid crosses were examined, all gave ratios of approximately 3:1 between dominant and recessive traits. (See Figure 1.)

| Dominant	P_1 Cross	Recessive	Frequency in F_2 Generation		Actual Ratio
1. round	x	wrinkled seeds	5474 <u>1850</u> 7324	round wrinkled total	2.96 : 1
2. yellow	x	green seeds	6022 <u>2001</u> 8023	yellow green total	3.01 : 1
3. colored	x	white seed coat	705 <u>224</u> 929	colored white total	3.15 : 1
4. inflated	x	constricted pods	882 <u>299</u> 1181	inflated constricted total	2.95 : 1
5. green	x	yellow pods	428 <u>152</u> 580	green yellow total	2.82 : 1
6. axial	x	terminal flowers	651 <u>207</u> 858	axial terminal total	3.14 : 1
7. long	x	short stems	787 <u>277</u> 1064	long short total	2.84 : 1

| Figure 1: Monohybrid-Cross Ratios

Mendel's conclusions. Having observed that traits which disappeared in the F_1 generation reappeared in the F_2 generation, Mendel reasoned that something must be present within the plant to control the characteristic. He called these unknown controls, *factors*. Today we call these unknown controls, **genes**. In addition, he reasoned that a given trait in peas is controlled by a pair of factors. What makes this conclusion impressive is that **chromosomes** and genes had not been discovered.

Mendel hypothesized that during gamete formation the pair of factors (genes) controlling a trait separated into single, individual gametes. Therefore, each gamete carried only one gene for the trait from each pair. This process of separation and gamete formation is referred to as Mendel's first principle, the **principle of segregation**.

A second conclusion Mendel developed is the *principle of dominance* and *recessiveness*. In explaining this principle he introduced the use of symbols such as Y and y to represent dominant and recessive traits, respectively. He suggested that each plant inherits two distinct hereditary factors for each trait, one from each parent. During **pollination** the plant passes one of the two factors in each reproductive cell (pollen grain or ovule).

Together Mendel's two conclusions can be used to explain how a trait can disappear in the F_1 generation and reappear later. Assign the letter Y for yellow seeds. A pure yellow-seeded plant would be written YY, which indicates that both factors (genes) for this trait are for yellowness. The dominant trait is assigned the capital letter. Similarly, the small letter y stands for the recessive trait, green seeds. Thus the pure green-seed producing plant would be represented as yy. When the genes of an organism are represented by pairs of symbols for a trait being studied, this pairing indicates the organism's **genotype**. By assigning the genotype in this manner, Mendel was able to make predictions as to the kinds and proportions of **gametes** or
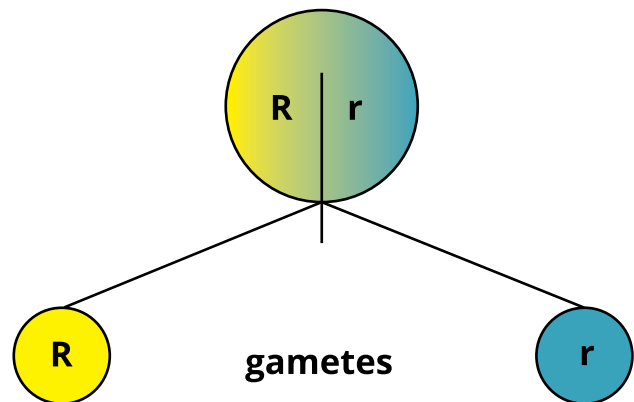
| Figure 2: Gamete Formation

sex cells each parent could produce. Genes are located on chromosomes. During your study of cells in Science LIFEPAC 1003, you learned that chromosomes exist in pairs and that when gametes are produced, one member of each pair of chromosomes is found in a gamete and the other member of the chromosome pair is found in another gamete. That is, genes are passed to the offspring from the parents, one from each parent so that in the offspring a pair of chromosomes also exists. If one of the chromosomes has the dominant gene for a given trait and the other chromosome has the recessive gene for that trait, the dominant gene masks or hides the recessive trait. A recessive trait does not alter the outward appearance (**phenotype**) of the organism controlled by that dominant gene. Using Mendel's symbols, a cross between **true-breeding** round-seeded pea plants (RR) with wrinkled-seeded pea plants (rr) produced only round-seeded pea plants (Rr). This plant, having received a factor from each parent, possesses a dominant gene for round seeds and a recessive gene for wrinkled seeds. Since the two factors are different (Rr) the plant is said to be **heterozygous**. Each parent (RR and rr) having both genes alike is called **homozygous**. The different forms of genes associated with the same trait, but giving different effects (R and r), are called **alleles**. An allele is an alternative form of a gene.
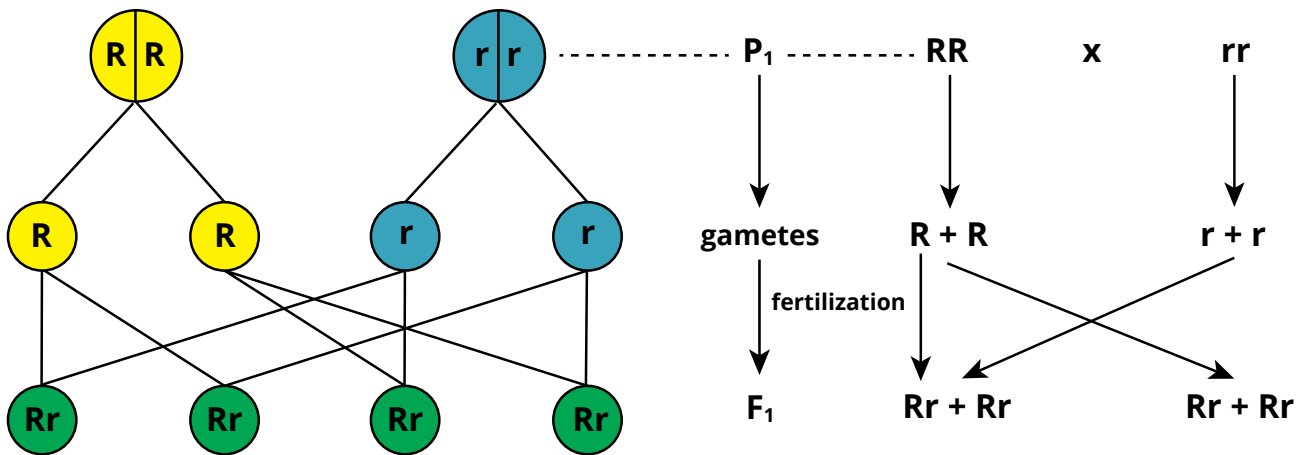
| Figure 3: Cross of Homozygous Dominant and Homozygous Recessive

Complete the following sentences.

1.1 The Austrian monk, a. _____ , stated that unknown structures called

b. _____ were responsible for controlling hereditary traits.

1.2 The name later given to these structures was _____ .

1.3 Mendel claimed that these structures could be a. _____ or

b. _____ with respect to one another.

1.4 A a. _____ trait completely hides or masks the presence of its counterpart,

the b. _____ trait.

1.5 Mendel's first principle, the principle of a. _____ states that in the process

of forming b. _____ , the two inheritance factors for any trait always

c. _____ and are distributed to different d. _____ .

1.6 The difference between appearance and genetic makeup has led to the development of

two terms to distinguish the two conditions. The appearance of the organism for the trait is

called a. _____ ; the actual genetic makeup is called b. _____ .

1.7 Consider the following cell information.

a. The cells of a pea plant are all derived from a single cell formed by the fusion of two

_____ , one from each parent.

b. Each sex cell contains _____ the normal number of chromosomes.

c. The process that restores the normal chromosome number in the offspring is _____ .

d. Any gene can occur in two or more different forms called _____ .

Match the following items.

1.8	_____	heterozygous, dominant cell	a.	Rr
1.9	_____	homozygous, recessive cell	b.	RR
1.10	_____	homozygous definition	c.	rr
1.11	_____	heterozygous definition	d.	identical alleles
1.12	_____	homozygous, dominant cell	e.	unlike alleles
			f.	RY

Answer the following questions.

1.13 Using height in pea plants, what is meant by each of the following terms?

a. allele _____

b. homozygous _____

c. heterozygous _____

1.14 Why will a cross involving true-breeding tall pea plants and true-breeding small pea plants

produce offspring that are all tall? In your answer give a definition of dominance. _____

_____

_____

_____

PROBABILITIES

The field of mathematics that deals with "chances" that a certain event may happen is the field of **probabilities**. This mathematical tool is useful only in chance or random occurring events. In this section you will study how the occurrence of specific events can be predicted.

Random events. Games of chance are excellent examples of probabilities of an event occurring. When flipping a coin or a marked disc, how often will the coin fall tails? What is the probability of it landing heads? Note that chance events ask the question, "How often will, or should, the event occur?"

The answer to these questions is usually expressed as a fraction or a percentage. If heads will appear 500 out of 1,000 times the coin is flipped, the chance for a head is 500/1000 or one-half. The alternative to a head is a tail. Therefore, the rest of the coin flips will result in tails, also a 50 percent chance.

Suppose that you have a group of color cards divided equally into four colors (red, black, yellow, and green) and that each color has fourteen cards, numbered from 1 to 14. The chance or probability of drawing a red card from the group is 14/56 or 1/4. The chance for drawing a 5 of any color from the group is 4/56 or 1/14.

Complete the following activities.

1.15 Calculate this probability.

a. What is the probability of drawing a red five from the group of cards described in the

reading? _____

b. Explain. _____

1.16 Determine this probability.

a. What is the probability of a yellow-seed plant (YY) forming a Y gamete?_____

b. Explain. _____

1.17 Determine this probability.

a. What is the chance of a green-seed plant (yy) forming a y gamete? _____

b. Explain. _____

1.18 Make the following prediction.

a. If you have a heterozygous yellow-seed plant (Yy) what is the probability of forming a

Y gamete? _____

b. A y gamete? _____

c. Explain. _____

_____

Independent events. An important principle in probabilities is that the occurrence of a chance event during one trial does not influence the results of later trials. If you flip a coin and it comes up a head, what is the chance that the next flip will be a head? The chance for a head to occur on *any* flip is 1/2. A preceding event does not alter the probability of the next flip also being a head. If you toss the coin fifty times and all fifty turn up heads, the next toss still has a 50 percent chance of being a head.

This fact leads to the second important principle of probabilities; that is, if two trials are performed at the same time, the chance that the two independent events will occur together is the product of the chance for each occurring separately. For example, if you flip two coins at the same time, what is the chance for both coins turning up heads? The probability that a single coin will be heads is 1/2; therefore, the chance of having both heads is 1/2 x 1/2 or 1/4.

What is the chance of having both coins turn up tails? The answer is 1/2 x 1/2 = 1/4. This answer is due to the fact that the probability of two events occurring together is the product of each of their probabilities.

What is the chance of having the combination of one head and one tail? It is not 1/4, because two different ways exist to obtain this occurrence. You could have coin #1 turn up heads and coin #2 turn up tails (a probability of 1/2 x 1/2 = 1/4), or you could have coin #1 turn up tails and coin #2 turn up heads (a probability of 1/2 x 1/2 = 1/4). Each of these events follows the second principle; however, since this combination can occur in two ways, you add the probability of the two ways: 1/4 = 1/4 = 1/2.

Suppose you have a cube with each side numbered, from one to six. What is the chance of rolling that cube and having the side numbered 5 appear on top? Since the cube has six sides, the chance for any given side to appear on top is one out of six. If two cubes are rolled, what is the chance for both cubes to have the number 5 face up? The answer is 1/6 x 1/6 = 1/ 36, the product of the probability for each of the events.

Do the following investigation.

The following supplies are needed.

- ■ 2 coins
- ■ box (cardboard shoebox is good)

Follow the following directions and complete the activities.
Place a check in the box when each step is completed.

☐ 1. Do the following activity with another student. One person should toss a penny and the other serve as the recorder. The tosser should flip the penny in a cardboard box (shoebox) to prevent it from rolling away.

1.19 What are your chances for tossing a. a head? _____ b. a tail? _____

☐ 2. Toss the penny 10 times and record the number of times a head appears and the number of times a tail occurs.

Deviation Experiment

1.20   Results obtained: a. heads _____ b. tails _____

How many times did you expect to get c. heads? _____ d. tails? _____

☐ 3.   Calculate the **deviation** observed from the expected, using the following formula:

Difference between expected heads and observed heads _____

+

Difference between expected tails and observed tails _____

=

Deviation _____
total number of tosses

The more the experimental results deviate from the expected results, the more the deviation value will approach the value of 1.0. As your results get closer to the expected results, the deviation is smaller and nears the value of 0.0.

1.21   The deviation for your 10 tosses is _____ .

1.22   Interpret the meaning of the deviation value you obtained. _____

_____

☐ 4.   Now continue tossing the coin and record your results until you have tossed the coin 100 times.

1.23   Results obtained:

heads obtained a. _____ tails obtained b. _____

heads expected c. _____ tails expected d. _____

1.24   What is the deviation for the 100 tosses?   _____

_____

☐ 5.   Record the total number of heads and tails you obtained on the chalkboard. After the whole class has completed the coin tossing and recorded their results on the board, total the results for the class. If the class is small you may repeat the 100-toss trial several times and total the results.

1.25   Total tosses for the class _____

1.26   Results of tosses:

heads obtained a. _____ tails obtained b. _____

Deviation Experiment

1.27 Calculate the deviation.

Class deviation = _____

1.28 How does increasing the total number of coin tosses from 10 to 100 affect the deviation?

_____

_____

1.29 How does increasing the total number of tosses from 100 to the total for the class (or

added tosses) affect the deviation? _____

_____

1.30 What two important probability principles were established in this exercise?

a. _____

b. _____

☐ 6. Now obtain two pennies.   ☐ 7. Toss the coins 100 times and record
your results.

1.31 How many times did two heads occur, two tails occur, and one head and one tail occur?

HH obtained a. _____

TT obtained b. _____

HT obtained c. _____

1.32 The percent of occurrence is the obtained results divided by the total tosses and

multiplied by 100. Calculate the percent occurrence for each combination.

percent HH occurrence a. _____

percent TT occurrence b. _____

percent HT occurrence c. _____

TEACHER CHECK _____ _____
                                                initials   date

Deviation Experiment

SELF TEST 1

Write the letter for the correct answer (each answer, 2 points).

1.01   Gene individuals that carry contrasting inheritance factors are called _____ .
a. heterozygotes   b. homozygotes   c. alleles

1.02   In the cross BB x bb the percent of offspring in the F_1 generation that will have the same

genotype as their parents is _____ .

a. 100%   b. 50%   c. 25%   d. 0%

1.03   The total of all genes carried by an organism is referred to as the _____ .
a. genotype   b. phenotype   c. prototype

1.04   Mendel's principle of segregation implies that the two members of an allelic pair of

genes _____ .
a. are distributed to separate gametes
b. may contaminate one another
c. are associated dependently depending on all other genes
d. are segregated pairwise

1.05   A (TT) genotype is said to be _____ .
a. homozygous   b. heterozygous   c. dihybrid

1.06   If the parent genotypes are Aa and Aa, the offspring are expected to be _____ .
a. 1⁄2 AA and 1⁄2 aa   b   all Aa
c. 1⁄4 AA, 1⁄2 Aa, 1⁄4 aa   d. 3⁄4 AA and 1⁄4 aa

1.07   A family has seven sons. The chance that their eighth child will be a daughter is _____ .
a. one chance in seven   b. one chance in eight
c. one chance in two   d. practically none

1.08   The probability that both of two tossed coins will come down heads (or tails) is _____ .
a. 1⁄2 x 1⁄2 or 1⁄4   b. 1⁄4 x 1⁄4 or 1⁄2   c. 1⁄4 x 1⁄4 or 1⁄8

1.09   This cross will yield four phenotypes in the 1:1:1:1 ratio: _____ .
a. rryy x rryy   b. RrYy x rryy   c. RrYy x RrYy   d. RRYY x rryy

1.010   Different forms of a given gene are known as _____ .
a. alleles   b. chromosomes   c. recessives   d. dominants

1.011   For a recessive gene to appear in an individual, he must inherit _____ .
a. two genes for that trait   b. one gene for that trait
c. three genes for that trait   d. no genes for that trait

1.012 When neither of the genes of a pair is dominant or recessive, the genes are said to be

_____ .

a. multiple alleles
b. incomplete dominant alleles
c. incomplete alleles

Define the following terms (each answer, 3 points).

1.013 allele _____

1.014 heterozygous _____

1.015 monohybrid cross _____

1.016 phenotype _____

1.017 multiple alleles _____

1.018 test cross _____

Complete these items (each answer, 5 points).

1.019 Complete the Punnett square for a cross between YyRr and YyRr showing number and genotype of the gametes, genotype and phenotype ratios of the F_2 generation, and the ratio of traits.

M   F

1.020 How can knowledge of genetics be used to improve the agricultural production of food?

_____

_____

_____

42 / 52   SCORE _____   TEACHER _____ _____
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