



SCIENCE

STUDENT BOOK

► **6th Grade | Unit 4**

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SCIENCE 604

Molecular Genetics

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Molecular Genetics

Introduction

And God said, "Let the earth bring forth grass, the herb yielding seed, and the fruit tree yielding fruit after his kind, whose seed is in itself, upon the earth: and it was so.

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 God saw that it was good. (Genesis 1:11-12)

At the beginning of creation, God created living things according to their *kind* (Genesis 1:11-12, 21, 24-25). This included not only plants, but also animals. Thus, dogs have puppies according to the dog *kind*, cats have kittens according to the cat *kind*, and peach trees bear peaches according to the peach *kind*. Living things produce their own kind year after year.

For example, a farmer does not have to worry that he will get peas if he plants bean seeds. The farmer knows that he will get beans if he plants bean seeds. The beans will have physical and chemical characteristics like their parents. The new bean seedlings may not look exactly like their parents, but they will have similar characteristics. They will still be bean plants.

The same is true for human beings. Human beings get their characteristics or traits from their parents. Such things as eye color, hair color, and skin color are inherited from the parents. Animals also demonstrate inheritance of characteristics. For example, the trait for the spotted coat of a leopard is inherited from the parents. This characteristic is "written into" or "coded" within the cells of leopards. That is why leopard offspring have the same characteristics as the parents.

Why does this happen? In this LIFEPAK® you will find the answer! You will explore the world of genetics. *Genetics* is the scientific study of heredity, the passing on of the characteristics of living organisms from one generation to the next. You will learn more about genetics and heredity in this LIFEPAK. You will examine the relationship between reproduction in living things and how the offspring inherit the traits of parents. You will also examine the inheritance of these traits among living things and the way certain traits can be predicted. Finally, you will learn more about the way genes and the DNA molecule transmit the characteristics within living things that God has created.

Objectives

Read these objectives. These objectives tell what you should be able to do when you have completed this LIFEPAK. When you have finished this LIFEPAK, you should be able to:

1. Describe the reproductive structures of flowers in relation to inheritance in plants.
2. Describe male-female reproduction and how the reproductive cells undergo reduction division.
3. Distinguish between dominance and recessiveness.
4. Explain how many traits depend on multiple genes.
5. Introduce the work of Gregor Mendel on genetic traits.
6. Solve a Punnett Square and analyze the data.
7. Explain how genes and DNA transmit traits.
8. Give examples of the use of hybrids and mutations that humans have selected for food provision.
9. Give examples of the interaction between genes and the environment.

This image shows a single sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

1. REPRODUCTION

God has designed living things to reproduce and make other living things after their own kind. For example, flowers form seeds which will reproduce the same kind of flowering plant. In this section of the LIFEPAK, you will study the parts of a flower. This study of flowering plants will give you a better understanding of

the process of **reproduction** in all plants. It will also help you get a better background in preparation for the material to be covered in the next section of the LIFEPAK. Also, in this section, you will learn more about male-female reproduction, which is accomplished by means of special cells called sperm and egg.

Section Objectives

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

1. Describe the reproductive structures of flowers in relation to inheritance in plants.
2. Describe male-female reproduction and how the reproductive cells undergo reduction division.

Vocabulary

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

anther (an thər). The upper portion of a stamen which contains pollen grains.

chromosome (krō mə sōm). Rod-shaped parts of a reproductive cell that carry the genes (the hereditary material).

cross-pollination (krōs pol ə nā shən). The transfer of pollen from the anther of one flower to the stigma of another.

egg cell (eg sel). A female reproductive cell in a plant or animal.

embryo (em brē ō). The undeveloped stage of a plant or animal. Examples: a plant that has not germinated, or a baby chick that has not hatched.

fertilization (fēr tə lə zā shən). The union of a male reproductive cell (sperm) and a female reproductive cell (egg) to form a cell that results in a new individual.

filament (fil ə mən). The stalk of a stamen in a flower.

genes (jēnz). The unit of DNA which carries inherited traits.

genetics (jə net iks). The scientific study of heredity, the passing on of the characteristics of living organisms from one generation to the next.

germination (jēr mə nā shən). A starting to grow or develop; a sprouting.

mitosis (mī tō sis). A process of cell reproduction whereby a single cell splits apart to form two new cells.

nucleus (nü' klē əs). The command center that controls the life and activity of the cell. It is located within the cytoplasm of the cell.

ovary (ō vər ē). The female reproductive organ that produces egg cells.

ovule (ō vyūl). Part of a plant that develops into a seed.

pistil (pis təl). The entire female part of a flower.

pollen (pol ən). A powdery grain on the stamen that contains a sperm cell.

receptacle (ri sep tə kəl). The stalk which holds a flower.

reduction division (ri duk shən də vizh ən). Cell division which takes place in the reproductive cells and produces new cells with half the number of chromosomes.

reproduction (rē prə duk shən) The process by which cells make new cells like themselves.

self-pollination (self pol ə nā shən). The transfer of pollen from an anther of a flower to the stigma of the same flower.

sepal (sē pəl). One of the leaf-like parts which make up the calyx of a flower.

sperm cell (spèrm sel). A male reproductive cell.

stamen (stā mən). The male part of the flower where pollen is stored. It is made up of the anther and the filament.

stigma (stig mə). The part of the flower that takes in pollen. It is located at the top of the pistil.

style (stīl). The tube that connects the stigma to the ovary.

trait (trāt). A characteristic carried by a gene.

Note: All vocabulary words in this LIFEPAAC appear in **boldface** print the first time they are used. If you are not sure of the meaning when you are reading, study the definitions given.

Pronunciation Key: hat, āge, cāre, fār; let, ēqual, tèrm; it, īce; hot, ōpen, ōrder; oil; out; cup, pūit, rūle; child; long; thin; /ʒh/ for then; /zh/ for measure; /u/ or /ə/ represents /a/ in about, /e/ in taken, /i/ in pencil, /o/ in lemon, and /u/ in circus.

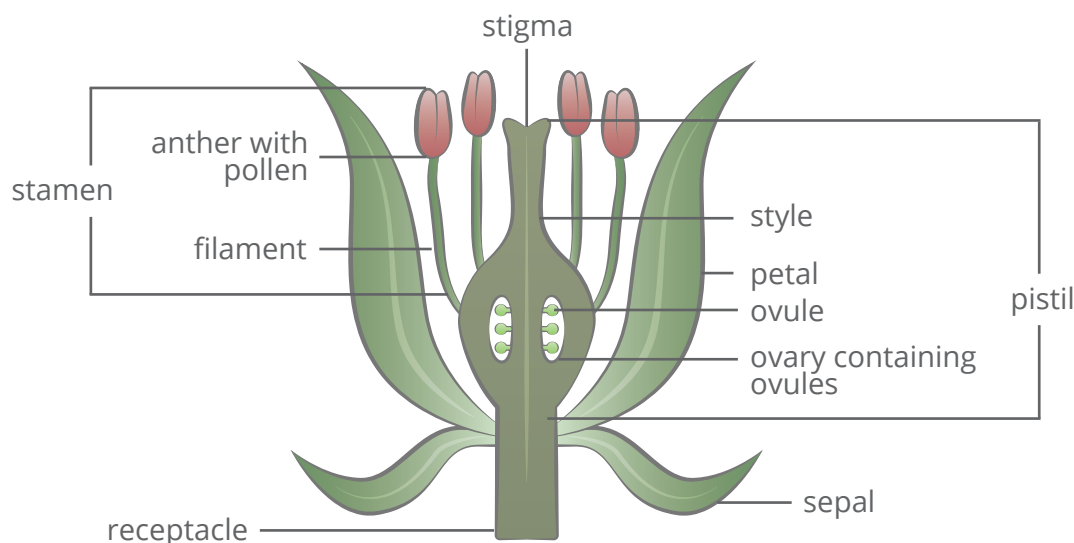


Figure 1 | “The parts of a flower”

REPRODUCTION IN FLOWERS

Flowers form seeds which will reproduce the flowering plant according to its own kind. The seed carries all of the information about the plant within the tiny plant embryo. When the tiny plant begins to germinate, it already carries the characteristics of its parent plants. This information is “coded” within the cells of the new plant. The tiny plant will grow into a new plant that resembles its parents in characteristics.

Let’s examine the parts of a flower by looking closely at the illustration of a flower in Figure 1. You should also refer to the vocabulary list while examining Figure 1 in order to learn about each part of the flower. You should study the illustration and the vocabulary appropriate to the flower parts until you know them well. This knowledge of flowering parts of a plant will help you better understand reproduction in plants.

Some plants are **self-pollinated**, like the flowering plant shown in Figure 1. In self-pollinating plants, the **stigma** receives the **pollen** produced within its own flower. In some cases, plants receive pollen from other plants. This could happen when the wind or insects bring pollen from another plant. This situation is called **cross-pollination**.

Note in Figure 1 that the narrow **filaments** topped by the **anthers** form the **stamens** of the flower. When the pollen grain from an anther lands on the stigma, it usually sticks to it because of the sweet plant juices located there. The presence of sugar makes the pollen grains grow pollen tubes. Some kinds of pollen require weak sugar to make them grow; others require strong sugar before they will grow tubes. This requirement varies from one kind of plant to another.

When the pollen grain lands on the stigma and begins to grow a tube, the pollen tube grows down the **style** to the **ovary**. Each pollen grain contains a male reproductive cell known as the **sperm cell**. The sperm cell will go down the tube and unite with an **egg cell** in the ovary. When the egg cell and the sperm cell unite, **fertilization** occurs. This newly fertilized egg will make many new cells and will grow into a tiny plant embryo. The embryo is located in the **ovule** (note the location in Figure 1). The ovule grows into a seed. The plant embryo usually remains in the seed until it is planted in the soil. The stigma, style, ovule, and ovary all make up the female part of the flower called the **pistil**. Let’s examine a real flower in the following experiment!



Try this experiment to learn about flowers.

Overview. You will examine in detail the various parts of a flower. First, you will scrape grains of pollen off the flower and examine them with a magnifying glass. The magnifying glass will also enable you to examine the stigma, the **sepals**, the **receptacle**, the anthers, the filaments, the style, and the ovary. When the ovary is sliced open, the magnifying glass will enable you to count the ovules inside the ovary.

These supplies are needed:

- magnifying glass or dissection scope
- fresh flower
- toothpick
- plastic knife
- black paper or very dark material

Follow these directions. The first twelve questions of this LIFE PAC are related to this experiment and have been included as part of the experiment. Answer the questions as they are listed in this experiment. Place a check mark in the box as you complete each step.

- ☐ 1. Use the toothpick to scrape off some pollen.

1.1 What is the shape of the pollen? _____

1.2 What color is the pollen? _____

1.3 Does the pollen have any markings, creases, folding, etc.? _____

☐ 2. Examine the pollen using the magnifying equipment. (You might need to place the pollen on black or dark material for better viewing.)
- ☐ 3. Examine the sepals of the flower. (Check Figure 1 for location.)
- 1.4 How many sepals does the flower have? _____
- ☐ 4. Examine the petals of the flower. (Check Figure 1 for location.)
- 1.5 How many petals are there? _____

Experiment 604.A Flower Examination (continued on next page)

☐ 5. Examine the stigma.

1.6 Sketch the top of the stigma in the space below.

☐ 6. Locate the bottom part of the flowering plant below the sepals—the stalk.

1.7 The part of the stalk which holds the flower is called the _____. (Refer to Figure 1, if needed.)

☐ 7. Locate and examine the filament. (Refer to Figure 1, if needed.)

1.8 Does the filament with the anther rise above the stigma? _____

1.9 If the pollen is located above the stigma, the flower is generally self-pollinated. If the pollen is below the stigma, the flower is generally cross-pollinated. Based on this information, is your flower self-pollinated or cross-pollinated? _____

☐ 8. Locate and examine the style. (Refer to Figure 1, if needed.)

1.10 The style is the structure that extends from the ovary to the stigma. Is the style long or short? _____

☐ 9. Locate and examine the ovary. Use a plastic knife to slice open the ovary. Slice small pieces of the ovary open one at a time.

1.11 a. Do you find ovules inside the ovary? _____

b. How many? _____

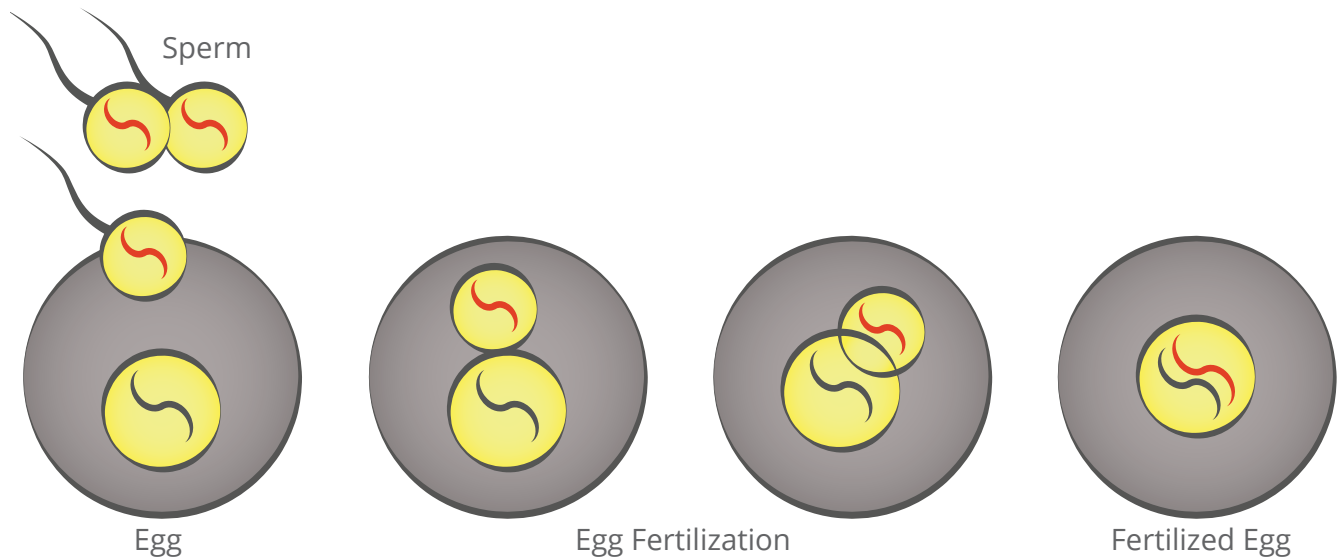


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Experiment 604.A Flower Examination



| Male-Female Reproduction

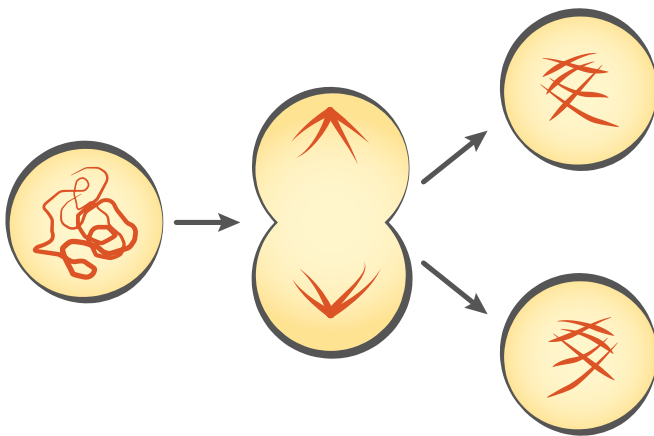
MALE-FEMALE REPRODUCTION

Most multicellular plants and animals reproduce themselves by a process called *male-female reproduction*. In male-female reproduction, there are special cells called sperm and egg. The sperm cell from a male parent and the egg cell from a female parent join together to form a new living thing. This process begins a new life. In the previous discussion on plants, the uniting of a sperm cell from the pollen grain with the egg cell of the ovary is an example of male-female reproduction. The resulting little

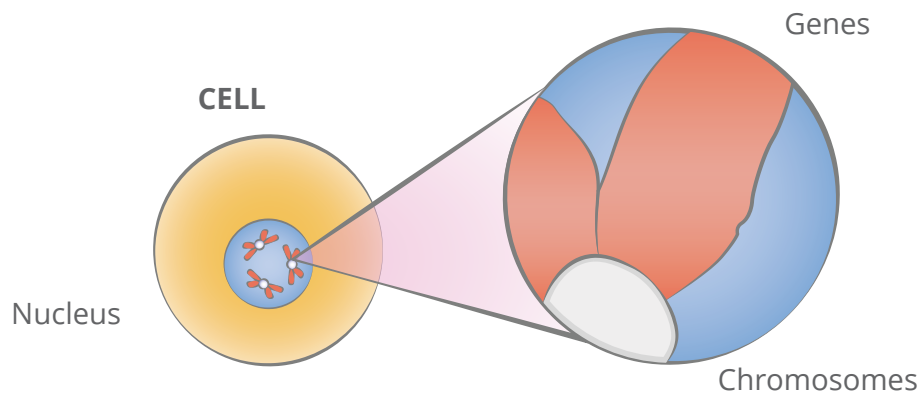
plant embryo will develop within the seed and will receive its traits from both the male and the female parent.

Mitosis. Most cells reproduce by splitting apart to form two new cells. This splitting apart to form new cells is called mitosis. This type of cell division occurs when organisms grow larger and when worn-out cells are replaced. The two new cells formed by mitosis are initially smaller than the one big cell from which they came. Yet, the two new cells are like the parent cell.

The **nucleus** of the cell controls cell activity, especially cell division. The nucleus contains the **chromosomes**. These are long strands of material, initially clumped together like a ball. Located on the chromosomes are **genes** that carry information about the traits of that particular living organism. When new cells are made by mitosis, the chromosomes unravel to form rod-like structures. As the new cells are formed, they receive the same number of chromosomes (with genes) as the original cell. Since the new little cells have the same number of chromosomes and genes, all of the traits are carried into the new cells that are made by mitosis.



| Cell mitosis



| Chromosomes and genes within the cell



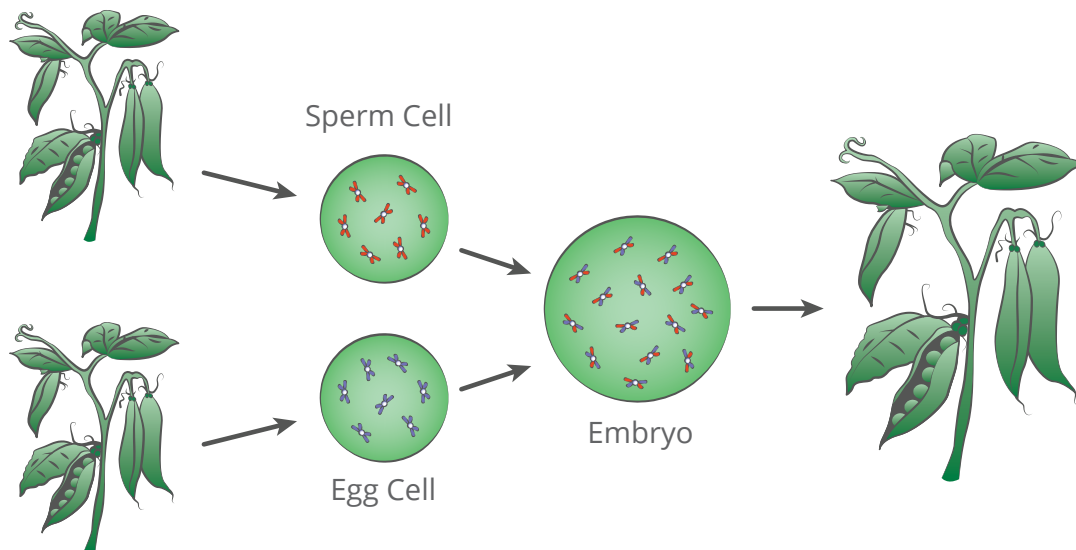
Write the correct answer on each blank line.

- 1.12** The process by which most cells make new cells like themselves is called _____.
- 1.13** The male reproductive cell is the a. _____ and the female reproductive cell is the b. _____.
- 1.14** Cell activity is controlled in the _____.
- 1.15** The splitting apart of one cell to form two new cells is called _____.
- 1.16** The _____ are located on the chromosomes of a cell and contain information about traits.

Reduction division. In addition to mitosis, there is another kind of cell division known as reduction division. *Reduction division* is a special type of cell division that occurs in reproductive cells. **Reduction division** occurs in the cells of plants and animals which reproduce themselves by male-female reproduction.

When new reproductive cells are formed by reduction division, the chromosome material is reduced by half. Chromosomes normally occur in pairs. Thus, they are reduced so that the reproductive cell gets only one of each pair. When the sperm and egg are joined together, the new individual organism that results will be restored to the original number of chromosomes in the parent organisms. In the experiment that follows, you will find out more about how reduction division works.

The garden pea is an example of a plant that reproduces by reduction division. The garden pea has fourteen chromosomes. When the pollen is being formed, special reproductive cells become the sperm cells. The sperm cell will undergo reduction division and will only have seven chromosomes. Likewise, the egg cell will only have seven chromosomes. When the sperm from the pollen unites with the egg, the resulting fertilized egg will be restored to the original fourteen chromosomes. This is characteristic of the garden pea. The little embryo which will develop within the seed will have this constant number of fourteen chromosomes. The genes which are carried on the chromosomes are partially from the male parent and partially from the female parent.



| The garden pea reproduces by reduction division.



Complete the following activity.

1.17 Describe how flowers are fertilized when the flower is cross-pollinated. _____



Try this experiment to learn about reduction division.

Overview. You will examine a lima bean embryo to see an example of male-female reproduction by reduction division.

These supplies are needed:

- lima beans soaked overnight in water
- magnifying glass or dissection scope

Follow these directions. Put a check in the box as you complete each step.

- | | |
|---|---|
| <p><input type="checkbox"/> 1. Locate the point where the bean was attached to the pod. You will find the embryo on the same side that the bean was attached. DO NOT OPEN THIS SIDE OF THE SEED.</p> <p><input type="checkbox"/> 2. Take your thumbnail and open the opposite side from where the bean</p> | <p>has been attached to the pod. You can slip your thumbnail between the two halves. The bean opens readily if it has been soaked overnight.</p> <p><input type="checkbox"/> 3. Observe the open halves of the lima bean with the magnifying equipment. Note the tiny embryo.</p> |
|---|---|

1.18 Can you see the very small leaves on the embryo? _____

Notice also where the root will form. Did you find it? _____

1.19 Sketch the opened halves of the lima bean in the space below. Label the parts of the lima bean in your drawing.

1.20 On the basis of male-female reproduction, explain in your own words how the little lima bean embryo was formed.

Experiment 604.B Lima Bean Embryo

(continued on next page)



Answer the following questions.

- 1.21** If you were studying a seed that had fourteen chromosomes, what would be the number after reduction division? _____
- 1.22** What is the function of the sugary substance found on the stigma? _____

- 1.23** How are the cells of a leaf or stem replaced when they are damaged? _____

- 1.24** What is the difference between *self-pollination* and *cross-pollination*? _____

- 1.25** What is the definition of *mitosis*? _____

- 1.26** How would you define and describe *reduction division*? _____

- 1.27** In what particular cells does reduction division occur? _____

TEACHER CHECK

initials

date



Experiment 604.B Lima Bean Embryo



Review the material in this section in preparation for the Self Test. The Self Test will check your mastery of this particular section. The items missed on this Self Test will indicate specific areas where restudy is needed for mastery.

SELF TEST 1

Label the parts of a typical flower (each answer, 2 points).

1.01 Write the following parts of a flower on the correct lines in the illustration:

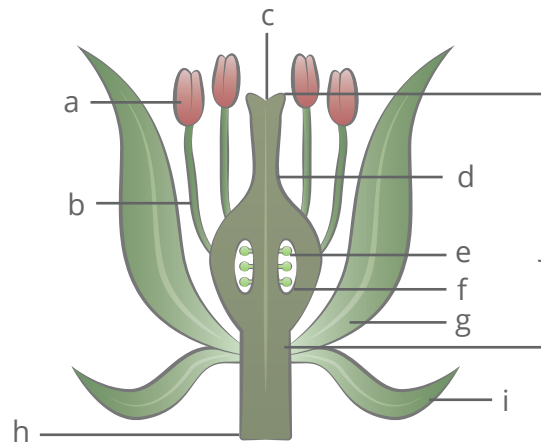
anther with pollen
petal
stigma

filament
pistil
style

ovary
receptacle

ovule
sepal

- a. _____
- b. _____
- c. _____
- d. _____
- e. _____
- f. _____
- g. _____
- h. _____
- i. _____
- j. _____



Match the following items (each answer, 2 points).

- 1.02** _____ the transfer of pollen from the anther of a flower to the stigma of another flower
- 1.03** _____ the male part of a flower that contains pollen
- 1.04** _____ the stalk of the flower on which the entire flower rests
- 1.05** _____ the kind of cell division which replaces worn out cells
- 1.06** _____ the kind of cell division which reduces the chromosome number
- 1.07** _____ the part of the flower that has a sugary substance for receiving pollen grains
- 1.08** _____ the name of the undeveloped plant or animal
- 1.09** _____ a female reproductive cell
- 1.010** _____ a male reproductive cell
- 1.011** _____ the powdery substance found on the anthers

- a. pollen grains
- b. sperm cell
- c. embryo
- d. anther
- e. mitosis
- f. receptacle
- g. reduction division
- h. stigma
- i. cross-pollination
- j. egg cell
- k. self-pollination

Complete the following activities (each answer, 5 points)

1.012 Describe the manner in which a flower receives pollen. _____

1.013 What is the meaning of male-female reproduction in relation to chromosome numbers?

1.014 When reproductive cells are formed, they undergo a type of cell division.

What chromosome numbers are expected from this division? _____

1.015 Describe the structure of a flower that would most likely be cross-pollinated.

Write the correct answer in each blank space (each answer, 3 points).

1.016 A garden pea, whose chromosome number is fourteen, has _____ chromosomes within the egg cell.

1.017 A garden bean, whose chromosome number is twenty, has _____ chromosomes within the sperm cell.

1.018 If a leaf of a garden pea with fourteen chromosomes is damaged, the new leaf cells will have _____ chromosomes.

1.019 The pistil of a flower is the _____ part of the flower.

1.020 An embryo is an _____ plant or animal.

1.021 The powdery or grainy substance found on the anthers is _____ .

1.022 When a pollen grain lands on the stigma, it usually sticks because of the presence of _____ .

1.023 When a plant receives pollen from within the same flower, it is said to be _____ .

1.024 When a sperm and egg are united, the chromosome number is restored to the _____ number.

1.025 Reduction division occurs in _____ cells.

Write true or false (each answer, 1 point).

- 1.026 _____ Reduction division results in half the number of chromosomes as the original.
- 1.027 _____ The receptacle holds only the male part of the flower.
- 1.028 _____ The anther is a female part of the flower.
- 1.029 _____ The pistil is the entire female part of the flower.
- 1.030 _____ The stigma produces a sugary substance.
- 1.031 _____ Mitosis results in cells with half the number of chromosomes.
- 1.032 _____ The embryo is an undeveloped plant or animal.
- 1.033 _____ The style of the flower contains pollen.
- 1.034 _____ An organism makes more cells as it gets larger.
- 1.035 _____ An organism makes more cells by mitosis in order to grow and get larger.

80
100

SCORE _____

TEACHER _____

initials

date



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