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## IV. SEXUAL REPRODUCTION: ANIMALS

Sexual reproduction is found in many different animal groups. Complex multicellular animals reproduce solely by sexual reproduction. The sum total of all the different stages of an animal's life and the sequence through which these occur is referred to as the animal's life cycle. In this section we will examine the life cycles of animals and how development occurs within the life cycle of the higher animals.

### SECTION OBJECTIVES

12. Distinguish between and explain the two different life cycles found in animals.
13. Describe some of the beginning events in embryo development.
14. Distinguish between and explain determination and differentiation.
15. Compare the various kinds of metamorphosis.

#### Greek and Latin root words:

**blastula** (Gr. *blastos* = sprout, Gr. *-ula* = little. Lit. "little sprout.")

**gastrula** (Gr. *gaster* = stomach, Gr. *-ula* = little. Lit. "little stomach.")

### VOCABULARY

blastulation

complete metamorphosis

conjugation

determination

differentiation

diplontic

embryo

gastrulation

haplontic

incomplete metamorphosis

juvenile stage

micronuclei

## TYPES OF LIFE CYCLES IN ANIMALS

There are two basic kinds of life cycles in animals. They are called the **haplontic** and the **diplontic** life cycles. The haplontic life cycle is most common among the protozoans and other groups of unicellular animals.

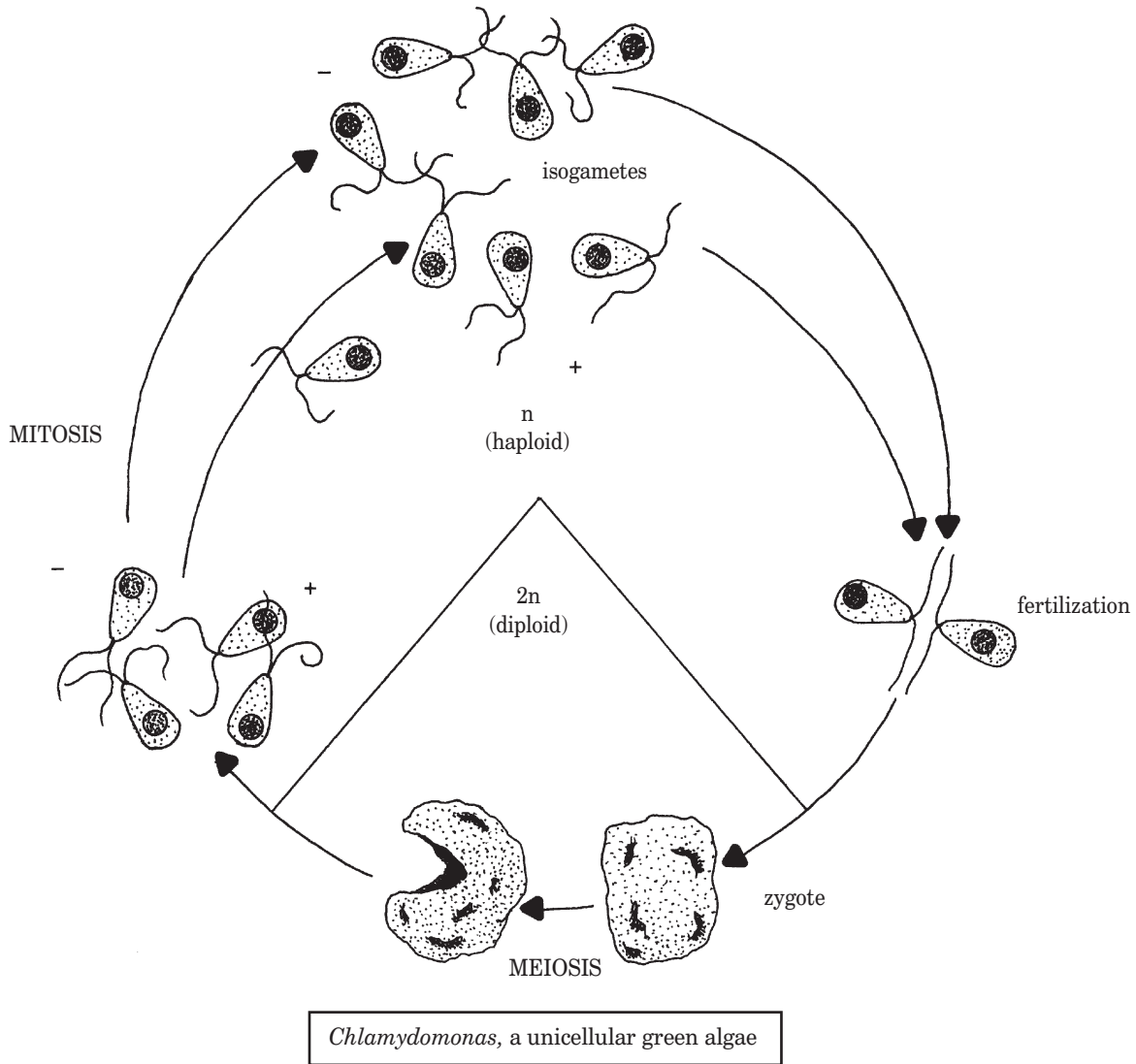
Species reproducing by a haplontic life cycle are usually isogamous or anisogamous. The diplontic life cycle is found among higher animals and involves oogamy.

### HAPLONTIC

The distinguishing feature of the haplontic cycle is that the diploid zygote divides immediately by meiosis to produce a new generation of haploid isogametes which function as the dominant adult organism. (see Figure 25). The exception is that in some groups the zygote may not divide immediately but enter a state of dormancy to survive periods of environmental stress like drying out, food shortage, or seasonal changes. Under normal conditions,

though, the diploid stage in the haplontic life cycle is very short-lived and neither moves nor feeds, but simply divides by meiosis to form daughter cells (isogametes). Despite the short life of the zygote, its division by meiosis does produce genetic variability in the population. These isogametes usually grow and divide asexually for a few generations before combining to produce another diploid zygote. Almost the full life cycle is passed in the haploid

**Figure 25: Haplontic Life Cycle**



isogamete stage. These haploid isogametes usually occur as strains, like plus or minus.

Note that the organism we used in Figure 25 as an example of the haplontic life cycle is the *Chlamydomonas*, a unicellular green algae. While this organism is characterized as a plant

in our two-kingdom classification scheme, it also has many animal-like characteristics. For example, it moves about through water and can swim away from danger. This type of hard-to-classify organism is typical of the unicellular organisms.



**Answer the following questions.**

- 4.1 Is the dominant stage of the haplontic cycle haploid or diploid? \_\_\_\_\_
- 4.2 Is the dominant stage motile or immotile? \_\_\_\_\_
- 4.3 In the haplontic life cycle, does meiosis occur just after or just before fertilization?  
\_\_\_\_\_
- 4.4 Can the haplontic life cycle provide genetic variation? \_\_\_\_\_
- 4.5 What type of gametes are usually involved in the haplontic life cycle? \_\_\_\_\_

## DIPLONTIC

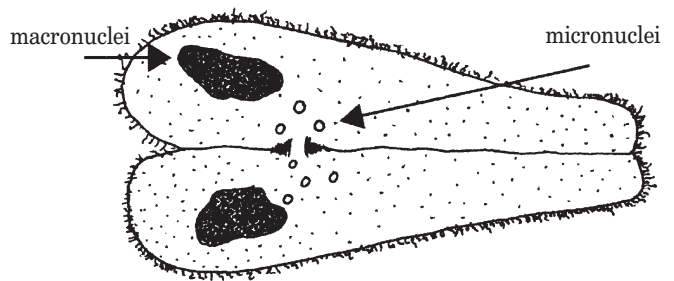
Structurally complex multicellular animals are diploid, but their unicellular gametes are haploid. These gametes unite in fertilization to form a zygote which develops into either a male or female multicellular adult, that will then produce haploid gametes in its gonads. These gametes then combine with those of another individual of the opposite sex to form another diploid zygote (see Figure 26). This is the diplontic life cycle, and it is in some ways the opposite of the haplontic life cycle. In the haplontic cycle, meiosis occurs in the zygote just after fertilization; in the diplontic, meiosis directly precedes fertilization. Perhaps the most obvious difference is that the motile dominant stage of the diplontic life cycle is a multicellular diploid adult. In fact, the question of whether the adult form is haploid or diploid is one of the key questions asked when assigning an animal to a specific life cycle group. Also, the gametes involved in the diplontic life cycle

are highly specialized in form and function. They serve solely for the task of reproduction. Contrast this with the dominant stage of the haplontic life cycle where the haploid gametes are also involved in the task of ingesting food and avoiding danger.

Here is a learning help. When trying to remember which life cycle is which, keep in mind that the life cycle is named after the adult (dominant) organism. Thus the haplontic life cycle has a haploid adult, and the diplontic has a diploid adult.

## CONJUGATION

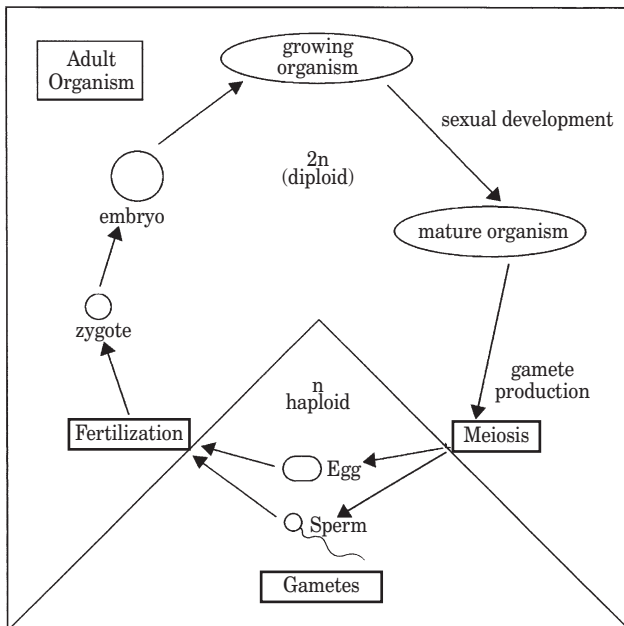
Figure 27: Conjugation



Conjugation in *Paramecium*, a common freshwater protozoan.

The process called **conjugation** is found in the group of protozoans called Ciliates. This group includes the well-known *Paramecium*. Conjugation is a process whereby two ciliates come together in physical contact and then, through pores that open in the cell membrane, exchange **micronuclei** (see Figure 27). This process may take several hours. Because there is an exchange of genetic material and the micronuclei are the daughter cells of meiosis, conjugation is considered a form of sexual reproduction.

Figure 26: Diplontic Life Cycle



### Complete the following statements.

- 4.6 In the diplontic life cycle, the dominant life cycle stage of the organism is \_\_\_\_\_ .  
 a. very large    b. diploid    c. unicellular    d. haploid
- 4.7 In the diplontic life cycle, meiosis \_\_\_\_\_ .  
 a. occurs during fertilization    b. occurs just after fertilization  
 c. occurs just before fertilization    d. doesn't occur

- 4.8 The diplontic life cycle is usually found among \_\_\_\_\_ organisms.  
 a. more complex multicellular                      b. unicellular  
 c. simple multicellular                                d. complex unicellular
- 4.9 The gametes found in the diplontic life cycle are \_\_\_\_\_ .  
 a. diploid      b. anisogamous      c. haploid      d. isogamous



**Do the following activities.**

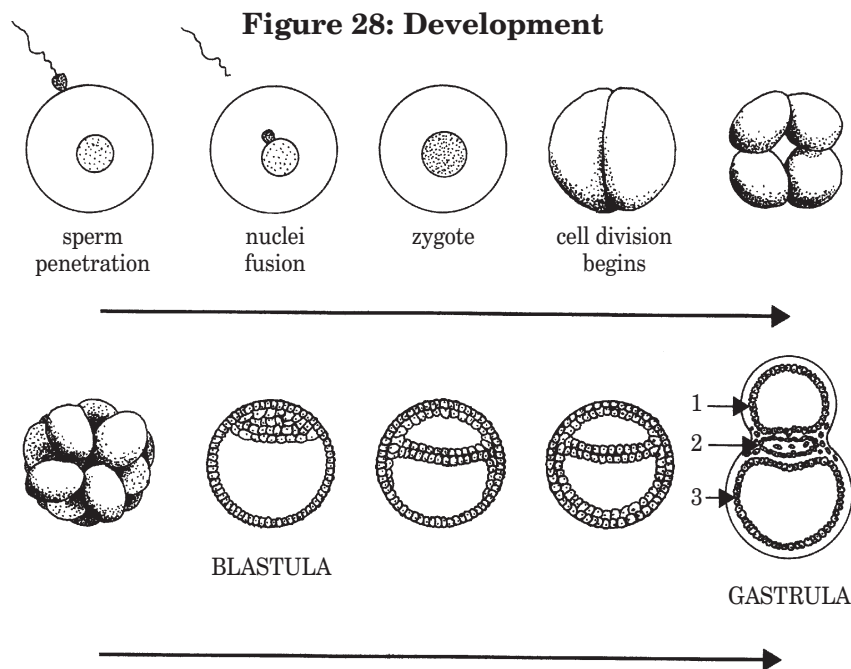
- 4.10 Why is conjugation considered a form of sexual reproduction? \_\_\_\_\_  
 \_\_\_\_\_
- 4.11 Explain the steps of conjugation in your own words. \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

## DEVELOPMENT

In Section II, we studied the general process by which organisms grow: cell division by mitosis. There are many specialized aspects to this growth in the higher animals. Here we will briefly examine the general development of the zygote into an **embryo**, the determination of embryonic cells' future specialization and the final differentiation of these cells into the specific cell types. These developments bring the organism to its adult form. In some organisms, the development from embryo to adult occurs in just a few weeks or months (as with many insects),

whereas larger, more complex animals require many years of development to reach adulthood. Usually those organisms that develop quickly require little, if any, care from the parents. Those that develop more slowly tend to require much more parental care. How about you? How many years have you been growing? How much care have you required from your parents?

Finally, we will look at the unusual type of growth and development called metamorphosis, which occurs in many of the insects and in some other groups of organisms.



## GENERAL DEVELOPMENT

When a sperm and an egg have united in fertilization, the new diploid cell produced is called a zygote. This term applies only to the single cell stage. Once the cell begins to divide, it is referred to as an embryo. (refer to Figure 28 for this section).

The zygote grows by mitosis into an embryo. Within an hour of fertilization, the cell begins dividing. These initial cell divisions do not increase the size of the embryo. Recall the very large size of the egg and its abundant food reserves. The cell divisions involved at this stage simply partition the zygote's cytoplasm, food stores, and organelles into new and smaller cells. After about twelve divisions, the divisions slow down to allow the complex series of genetic events that cause cell determination and differentiation which we will examine next.

During the division process, the outer cells form tough bonds between themselves, cutting off the inner cells of the embryo from direct

contact with the surrounding fluid environment. Then the cells inside the embryo draw water into the inner layers of the embryo, forming a hollow space inside the embryo. The embryo with its hollow space inside is now called a blastula. Its formation is referred to as **blastulation**.

The next major stage in the development of the embryo involves the division of the inner cells into three layers. This process is referred to as **gastrulation**, and the embryo is now referred to as a gastrula. These three cell layers will then themselves develop into specific organs and structures. Following gastrulation, the outer of the three layers, the ectoderm, will develop into the nervous system. The mesoderm (middle layer) becomes muscle, bone, blood, lymph vessels, and reproductive organs while the digestive tract and respiratory system are formed by the endoderm (inner layer).



### Answer the following questions.

- 4.12 When does the developing organism take on the name “embryo”? \_\_\_\_\_  
\_\_\_\_\_
- 4.13 What is a zygote? \_\_\_\_\_  
\_\_\_\_\_
- 4.14 What is blastulation? \_\_\_\_\_  
\_\_\_\_\_
- 4.15 What occurs during gastrulation? \_\_\_\_\_  
\_\_\_\_\_

## DETERMINATION AND DIFFERENTIATION

The two terms, determination and differentiation might sound alike, but the processes they describe are very different. **Determination** involves the giving of a specific set of instructions to each cell. Determination causes different proteins to be manufactured in the developing cells and these proteins direct the future destinies of the cells. They tell the cell exactly what its future specialization is to be, such as nerve, muscle, or blood vessel cells. Although they have been given the primary commands concerning their future specialty, they don't display their specialized roles until later. These cells appear

unchanged. The genetic events causing determination begin in the eight-cell stage and are basically complete by the point the gastrula begins to develop nerve tissue. These instructions are irreversible in nature, although scientists have recently succeeded in artificially “deprogramming” a late-stage cell so that it behaves as if it were undetermined.

**Differentiation** occurs later in the embryo's development, when the cell actually carries out the instructions it received during determination. The cells specialize and become the different parts needed to make a complete organism.

Both of these processes are the outworking of activities at the gene level. During the growth of the embryo, tremendously complex systems of gene regulation are in action. The many biochemical reactions that direct the determination and differentiation of cells in the embryo are the result of enzyme activity. Enzymes are produced by the transcription and translation of genes, and must occur at just the right time, for the right length of time, and at the right speed. Scientists are only beginning to understand these tremendously complex and divinely-created systems of gene control. Note that the developmental gene control system works during both determination and again at differentiation. Some genes are expressed at determination, but do not start the cell's developmental specialization. Later, at differentiation, the proteins produced during determina-

tion interact with other genes and proteins to bring about the cell's differentiation!

As this differentiation continues, the resulting cell specializations produce tissues and organs. A tissue is a mass of the same kind of specialized cells working together for a common purpose. Examples of tissues are muscle, nerve, tendon, membrane, and bone. Organs are structures composed of numerous kinds of tissues working together for one purpose. Examples of organs are the heart, brain, lungs, kidneys, and liver. The many complex functions seen in the higher animals and especially in man are the result of many complex types of interactions between tissues and organs. The human brain is the most complex organ of all God's creation. It has to be — it is the organ by which we express some of the characteristics of God's Image, such as reason, thought, and self-awareness.



**Complete the following statements.**

- 4.16 The process of giving a specific set of instructions to each cell is known as \_\_\_\_\_ .
- 4.17 These instructions cause the cell to produce different \_\_\_\_\_ .
- 4.18 The actual carrying out of these instructions is known as \_\_\_\_\_ .
- 4.19 A specialized group of cells working together is known as a(n) (a) \_\_\_\_\_ and groups of them working together form a (n) (b) \_\_\_\_\_ .
- 4.20 Both processes start at the \_\_\_\_\_ level.
- 4.21 Most of the biochemical reactions involved in the above processes result from the activity of (a) \_\_\_\_\_ which are produced by transcription and translation of (b) \_\_\_\_\_ .

**Thought exercise.**

John was sitting in his desk at school, when, to his surprise, his mother appeared at the door of the classroom. John's teacher, Sister Loreen, got up and whispered quietly back and forth with John's mother. Then Sister Loreen sat down and John's mother motioned for him to come to her. He walked quietly out to her, and she said, "John, Amanda's fever is much higher and she seems to be getting worse. I'm going to take her to the doctor. I won't be home by the time you get home from school, so you'll need to fix yourself a snack and then go check whether Grandpa needs help to finish his mowing. Can you do that? Once you've finished, check the job list on the refrigerator. There's a short list of jobs for you to do."

John nodded soberly and said, "Yes, Mother." John carried out the commands exactly; on arriving home he helped himself to some cookies and juice and then went to check on Grandpa's mowing progress. Afterwards, he came home and quickly took care of the jobs on the list.

1. After his mother's visit to the schoolhouse, John had been given instructions but was not yet free to carry them out. He was like a cell that had undergone \_\_\_\_\_ .
2. After John arrived home, he could go about following his mother's instructions and did so diligently. He was now like a cell that had undergone \_\_\_\_\_ .