Contents

CHAPTER

22

Parthenogenesis

In spring and early summer, when food is abundant, aphid females reproduce parthenogenetically.

Usually an unfertilized ovum develops into a new individual only after the fertilization but in certain cases the development of the egg takes place without the fertilization. This peculiar mode of sexual reproduction in which egg development occurs without the fertilization is known as the **parthenogenesis** (Gr., *parthenos*=virgin; *genesis*=origin). An organism that has developed parthenogenetically is called a **parthenogenone** or **parthenote**. The phenomenon of the parthenogenesis occurs in different groups of the animals as in certain insects (Hymenoptera, Homoptera, Coleoptera), crustaceans, rotifers and also in some vertebrates such as several desert lizards, turkeys and some mammals.

There are certain conditions which are intermediate between parthenogenesis and fertilization, *e.g.*, partial fertilization, gynogenesis, androgenesis and merogony. 1. In **partial parthenogenesis**, the egg may be fertilized by only a part of sperm. For example, according to **Boveri** in sea urchin egg the fertilization of the egg (activation) takes place by the sperm aster. The sperm nucleus gets fused with the egg nucleus only in two cell stage. 2. In **gynogenesis**, the sperm penetrates the egg but takes no part in development. It degenerates in the egg without fusion with the egg nucleus, *e.g.*, *Rhabditis aberrans.* 3. In **androgenesis**, the egg is activated by the sperm and development takes place without the participation of the egg nucleus. For example, if the **ova** of frogs and

toads are treated with radium and then fertilized by normal sperms, the egg nucleus does not take part in development, but sperm (paternal) nucleus participates in normal development. 4. In **merogony**, egg fragments devoid of nucleus develop when fertilized by a normal sperm. If sea urchin eggs are shaken to produce small pieces, the fragments round up to form spheres. Some of these spheres are without nuclei. If such enucleated spheres are normally fertilized, they may develop into dwarf larvae.

The parthenogenesis may be of two types :

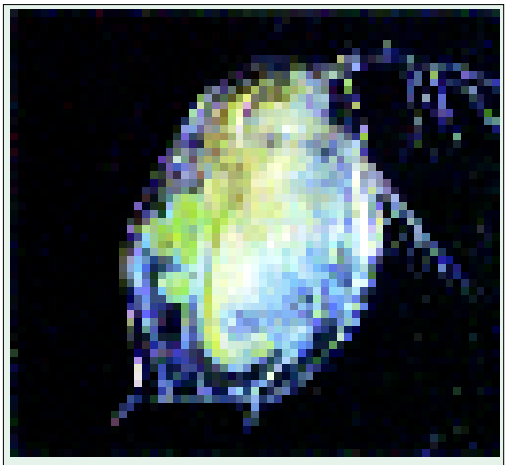
1. Natural parthenogenesis; 2. Artificial parthenogenesis.

NATURAL PARTHENOGENESIS

In certain animals the parthenogenesis occurs regularly, constantly and naturally in their life cycles and is known as the **natural parthenogensis**. The natural pathenogenesis may be of two types, *viz.*, complete or incomplete.

(i) Complete parthenogenesis. Certain insects have no sexual phase and no males. They depend exclusively on the parthenogenesis for the self-reproduction. This type of parthenogenesis is known as the **complete parthenogenesis** or **obligatory parthenogenesis**. It is found in some species of earthworms, badelloid rotifers, grasshoppers, roaches, phasmids, moths, gall flies, fishes, salamanders and lizards.

(ii) Incomplete parthenogensis. The life cycle of certain insects includes two generations, the sexual generation and parthenogenetic generation, both of which alternate to each other. In such cases, the diploid eggs produce females and the unfertilized eggs produce males. This type of parthenogenesis is known as the **partial** or **incomplete** or **cyclic parthenogenesis**.



In the summer water fleas reproduce very rapidly by parthenogenesis. 10-12 unfertilized eggs are seen here inside the brood pouch of female.

Cyclic parthenogenesis shows several variations in the alternation of sexual (S) and parthenogenetic (P) generations : (1) In gall flies (*e.g.*, *Neuroterus*) there is an alternation of one sexual and one parthenogenetic generation per year (P, S,....P, S,.... P, S). (2) In aphids (plant lice), daphnids and rotifers, the sexual generation may come after many parthenogenetic generations during the summer of the year (P, P, P, P, P, P, S,.... P, P, P, P, P, P, S....). (3) In gall midge (*Miaster*) the larvae reproduce indefinitely by **paedogenetic parthenogenesis**. In this case, germ cells within the larvae develop parthenogenetically into parasitic larvae which feed on the mother larvae. These larvae tend to live under the bark of rotting logs and feed on fungus. Under favourable conditions winged males and females are produced. These stages reproduce sexually and help in dispersion. (4) In some groups there is no regularity between parthenogenetic and sexual generations.

The complete and incomplete type of natural parthenogenesis may be of following two types :

(a) Haploid or arrhenotokous parthenogenesis; (b) Diploid or thelytokous parthenogenesis.

(a) Haploid or arrhenotokous parthenogenesis. In the arrhenotokous parthenogenesis, the haploid eggs are not fertilized by the sperms and develop into the haploid individuals (Fig. 22.1). In these cases the haploid individuals are always males and the diploid individuals are the females *e.g.*, 1. Insects : (i) Hymenoptera (Bees and Wasps) (ii) Homoptera, (iii) Coleoptera (*Micromalthus debilis*), (iv) Thysanoptera (*Anthothrips verbasi*). 2. Arachnids, *e.g.*, ticks, mites and certain spiders (*Pediculoids ventricusm*). 3. Rotifers, *e.g.*, *Asplanchne amphora.*

Thus, the queen bee is fertilized only once by one or many males (drones). She stores the sperm in her seminal receptacles and as she lays her eggs, she can either fertilize the eggs or allow them to pass unfertilized. The fertilized eggs become females (fertile queens or sterile workers depending up on the amount of royal jelly the developing young receives); the unfertilized eggs become fertile males or drones.

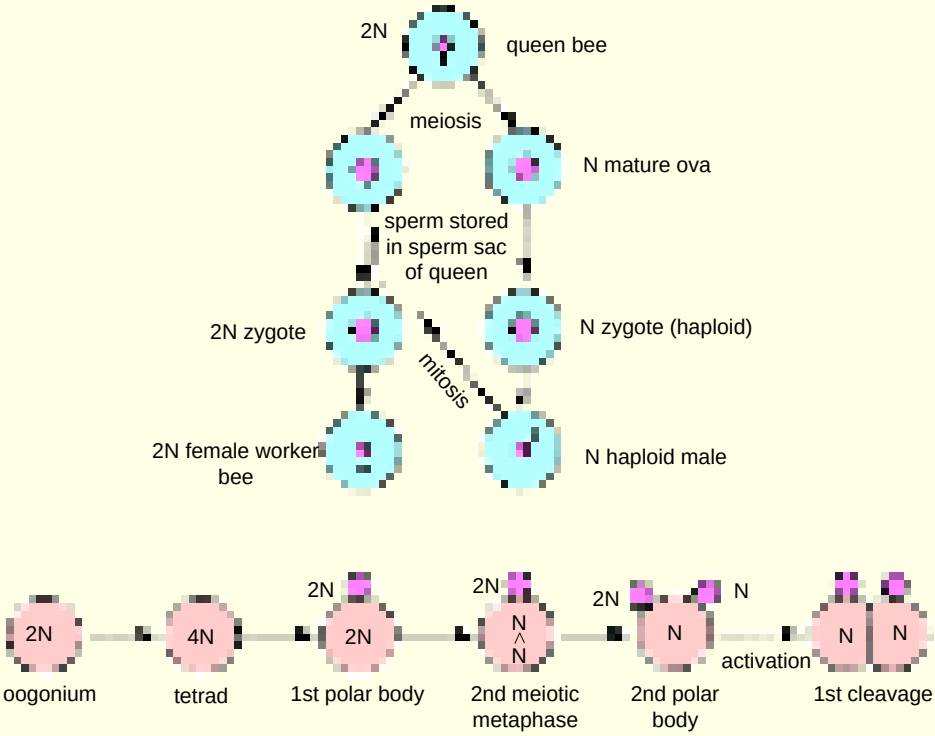


Fig. 22.1. Schematic representation of haploid parthenogenesis in bees (after Grant, 1978).

(b) Diploid or thelytokous parthenogenesis. In the diploid parthenogenesis, the young individuals develop from the unfertilized diploid eggs. The offspring of thelytoky could theoretically be either male or female; but normally it produces only diploid females (Fig. 22.2). For example, in aphids, females emerging in the spring produce several generations of females by diploid parthenogenesis resulting from suppression of first or second polar body. At summer's end some females produce sexual males and females by diploid parthenogenesis, males differing from females in lacking one sex chromosome. Males produce haploid gametes through normal meiosis which fuse to form diploid zygotes that emerge again in the spring as parthenogenetic females. Further, since thelytoky is also found in polyploid forms, it is also called **somatic parthenogenesis**.

Following types of the thelytoky have been recognised :

(i) Ameiotic parthenogenesis. Sometimes during the oogenesis, first meiotic or reduction divsion does not occur but second meiotic division occurs as usual. Such eggs contain diploid number of chromosomes and develop into new individuals without the fertilization. This type of parthenogenesis is known as **apomiotic** or **ameiotic parthenogenesis** and occurs in *Trichoniscus* (Isopoda), *Daphnia pulex* (Crustacea) *Compelona rufum* (Mollusca), weevils and long-horned grasshopper.

(ii) Meiotic parthenogenesis. Certain eggs develop by the usual process of oogenesis but at certain stages **diplosis** or doubling of chromosome number and production of diploid eggs occur. Such eggs develop into the diploid individuals and this phenomenon is known as the **meiotic parthenogenesis**.

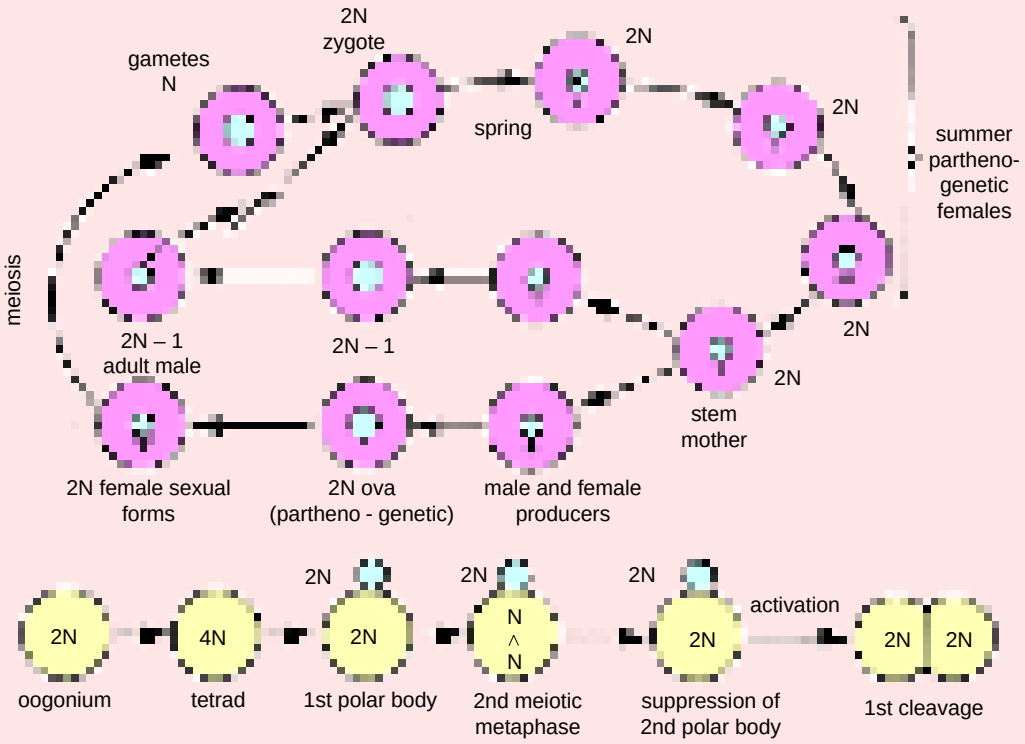


Fig. 22.2. Schematic representation of diploid parthenogenesis in aphids (after Grant, 1978).

The **diplosis** of the diploid thelytoky may occur by the following methods :

(a) By autofertilization. In certain cases the oocyte divides meiotically up to the formation of ootid and secondry polocyte. But the ootid and the secondary polocyte unite together to form a diploid egg which develops into a new individual, *e.g.*, *Artemia salina* (Crustacea) and various other organisms.

(b) By restitution. Sometimes in primary oocyte karyokinesis forms a nucleus of the secondary oocyte and a nucleus of the first polocyte. But the karyokinesis is not followed by the cytokinesis. The chromosomes of both daughter nuclei are arranged on the equator and undergo second meiotic division to form a diploid ootid and a diploid polocyte. The dipioid ootid or ovum develops into a parthenogenetic diploid individual. This type of diplosis is known as the restitution, *e.g.*, insects of order Hymenoptera (*Nemertis conesceus*) and Lepidoptera.

Natural Parthenogenesis in Vertebrates

A few cases of natural parthenogenesis have also been reported in the vertebrates. The fish *Carassius auratus gibelio* is reported to consist of females only (**Lieder**, 1955). Likewise, males are found totally lacking in the lizard *Lacerta sexicola armeniaca* (**Lantz** and **Cyren**, 1936). In it females are reported to be originated by parthenogenesis. In turkeys 80 per cent of incubated eggs show early cleavage stages. Such parthenogentic forms have hatched and grown to reproducing adults which are found to be diploid male with ZZ sex chromosomes. In mammals too, up to 60 per cent of hamster eggs becomes spontaneously activated and develops up to two-cell stage (**Austin**, 1956).

ARTIFICIAL PARTHENOGENESIS

The eggs which always develop into the young individuals by the fertilization sometimes may develop parthenogenetically under certain artificial conditions. This type of parthenogenesis is known

as **artificial parthenogenesis**. The artificial parthenogenesis may be induced by various physical and chemical means.

A. Physical means. The following physical means cause the parthenogenesis :

(i) Temperature. The range of temperature may induce parthenogenesis in the eggs. For instance, when the egg is transferred from the 30° C to 0–10° C the parthenogenesis is induced.

(ii) Electrical shocks can cause parthenogenesis.

(iii) Ultraviolet light can cause parthenogenesis.

(iv) When the eggs are pricked by the fine glass needles the development of young ones takes place parthenogenetically.

This whiptail lizard reproduces by parthenogenesis.

B. Chemical means. The following chemicals have been found to cause parthenogenesis in the normal eggs :

1. Chloroform 2. Strychnine 3. Hypertonic and Hypotonic sea waters. 4. Chlorides of K^+, Ca^{++}, Na^{++}, Mg^{++}, etc. 5. Acids as butyric acid, lactic acid, oleic acid and other fatty acids. 6. Fat solvents, *e.g.*, toulene, ether, alcohol, benzene and acetone. 7. Urea and sucrose.

The artificial parthenogenesis has been induced by above mentioned physical and chemical means by various workers in the eggs of most echinoderms, molluscs, annelids, amphibians, birds and mammals.

SIGNIFICANCE OF PARTHENOGENESIS

1. The parthenogenesis serves as the means for the determination of sex in the honey bees, wasps, etc., and it supports the chromosome theory of inheritance.

2. The parthenogenesis is the most simple, stable and easy process of the reproduction, *e.g.*, aphids (insects).

3. The parthenogenesis eliminates the variation from the population, but encourages development of the advantageous mutant characters.

4. The parthenogenesis causes the polyploidy in the organisms.

5. Due to the parthenogenesis, there is no need for the organisms to waste their energy in the process of mating but it allows them to utilize that amount of energy in the feeding and reproduction.

6. Honey bee and other social insects also control their sex ratio by parthenogenesis.

7. In aphids, parthenogenesis is a means of rapid breeding; the females reproduce by diploid parthenogenesis during summer.

REVISION QUESTIONS

1. What is parthenogenesis ? Describe different types of natural parthenogenesis in animals.
2. Give an account of artificial parthenogenesis.
3. What is the significance of parthenogenesis ?