CHAPTER XXII

METHODS AND ORGANS OF REPRODUCTION IN ANIMALS

Introduction. Reproduction in plants is chiefly an alternation between *sexual* and *asexual* generations. Plants also reproduce by fission, by spores, by buds and by cuttings involving regeneration. On the whole, all of these methods are employed by animals, but the prevailing method of reproduction in higher animals is sexual.

Fission. In this case, the body of the mother cell divides into two daughter cells each of which grows to maturity when the process is repeated. The parent animal of course disappears. The new and mature daughters are new animals. Fission occurs in Protozoa. New generations of Protozoa may occur from six to twenty-four hours apart.

Sporulation. This is common in the Sporozoa, but is only part of the life cycle. A Sporozoan encysts, *i.e.*, the cell wall forms a hard, thick wall. The nucleus and cytoplasm divide and subdivide many times, forming many small cells, sporozoites, and these by multiple fission, or sporulation, eventually form male and female gametes which, on fusing, form a cell (*zygote*), which in time will produce sporozoites again. Sporulation or asexual reproduction is associated with sexual reproduction in an alternation of generations. The life cycle of parasitic flatworms, such as liverflukes, involves a succession of asexual stages *suggestive* of sporulation.

Budding. The bud is a small outgrowth of protoplasm which grows into a form like the parent. In some forms it separates from the parent and leads a free life, as illustrated by young Hydras. Budding rarely occurs in Protozoa. It is more common in other Invertebrates. The hydroids, like Obelia, are formed in this way; so are corals and the medusoids of hydroid colonies. Some worms, indeed, reproduce by budding. The process is

present also in the tunicate group of the Chordata. Sometimes internal buds are formed. This is found in fresh-water sponges and some higher forms allied with the Annelids.

The above are examples of asexual reproduction and gametes are not involved. Asexual reproduction does not occur in the Nemathelminthes, Echinodermata, Mollusca, Arthropoda or Vertebrata. It is more usual in lower forms. Since this is true of lower plants also, asexual reproduction may have been the first method which developed in living things. Asexual reproduction tends toward the continuation of the same forms and so suggests the idea that evolution would never have proceeded very far, had this been the sole method of reproduction.

Sexual Reproduction. In sexual reproduction the new individual develops from a single cell (zygote) formed by the fusion of two gamete cells. If of the same size, they are called *isogametes;* when of different sizes, *heterogametes*, in which case one is smaller and more active, called a *microgamete* in Protozoa, or sperm and *spermatozoan* in Metazoa; the other gamete is larger and passive and is called a megagamete or macrogamete in Protozoa, egg or *ovum* in Metazoa. In flagellate Protozoa, the Mastigophora, are found cases of fusion (or fertilization) of isogametes or heterogametes. Many instances of union between microgametes and megagametes occur in Sporozoa.

In the Infusoria occurs a specialized form of sexual reproduction, *i.e.*, conjugation.

In Metazoan animals, sperm and eggs are called *germ cells.* These are produced by special glands called *gonads*, the ovary of the female producing eggs and the testis of the male producing sperm. These glands are set apart from the other organs to produce eggs and sperm. The germ cells take no part in carrying out the functions of metabolism or adjustment of the organism as a whole. And yet the gonads are constantly in vital relation to all other organs and metabolism and adjustment of a sort occur in them. The blood which flows through other organs flows through them. Material for the protoplasm of new germ cells or somatic cells comes from substances furnished by the blood. Sperm and eggs are in a sense generalized cells — different from the special cells which compose the other parts of the body, such as nerve and muscle cells. United (*i.e.*, egg and sperm), they have the power to form a new individual.

Parthenogenesis. There are some exceptions to this rule. Drone bees develop from unfertilized eggs laid by the queen. In the Aphids, females develop from unfertilized eggs. This type of reproduction is known as *parthenogenesis, i.e.*, generation of a new individual from part of the parent. Its relation to budding is obvious.

It is a type of reproduction in which eggs develop without fertilization.

Artificial parthenogenesis is the experimental production of certain animals from their eggs alone and without sperm, although they normally reproduce from eggs and sperm. The eggs are treated with various physical and chemical agents such as immersion in concentrated or diluted sea water for a short time, or with chloroform, ether, alcohol, toluol, saponin, salts or bases and also by shaking the eggs or pricking them.

Alternation of generations is not the rule, but occurs among the Sporozoa, Hydroids, Flatworms, possibly among a few marine Annelids and in some Insects. For example, insects, which are parthenogenetic, interpolate a bisexual phase at some time. The female Aphids parthenogenetically produce female broods all summer. In the fall males and females appear. These males fertilize the eggs of females. The eggs have hard shells which resist the cold of winter. From them females alone are hatched out in the spring. These again produce parthenogenetically until autumn.

Paedogenesis. In certain animals the immature and undeveloped can reproduce sexually. Thus in a certain fly, Miastor, ova develop larvae parthenogenetically. The larvae escape from the parent and reproduce in a similar fashion. After several generations the larvae pupate, and reproduce sexually as adults. The axolotl, an Amphibian, has been known to reproduce sexually in the larval stage if prevented from maturing on land. The adult form is Ambystoma. Paedogenesis, parthenogenesis and sporulation bring about a tremendous production of offspring which insures the continuance of the species even though the chances of survival are limited.

Relation of Sexual Reproduction to Evolution. There may be a question as to why sex arose when reproduction can take place without it. Sexual reproduction insures variation in new individuals. The chances are that the protoplasm of any sperm is not the same

as that of the egg, and so in sexual reproduction there is the combination of different protoplasms. The resulting individual is unique. No other exactly similar individual ever existed before. Thus the chance production of some organisms more fitted to the environment is possible. The importance of variation is indicated in the discussion of heredity. Its relation to evolution is discussed later.

Reproductive Organs. The establishment of special sex cells occurs even in the Protozoa. It appears in Volvox in which there are no special organs for metabolism or adjustment. It is also known, that *very early* in embryonic history of Metazoa certain cells are set aside to form sex glands. These facts indicate that sexual reproduction is very old in the history of living things, that the continuance of the species is as important as are breathing, digestion and locomotion to the individual. Animals live to reproduce. In some animals, the gonads grow and become functional only during that period of the year when conditions are most favorable for breeding.

Monoecious and Dioecious. Both types of sex glands often appear in the same animal. Such an animal is called *monoecious*, or *hermaphroditic*. Hermaphroditism is more often the rule than not in the lower animals. For example, it is noted in Sponges, Coelenterates, Flatworms, Roundworms and Annelids. It continues to be present in other groups, although it is rare in the higher Vertebrates. Sometimes the same gland normally functions as a testis and ovary, that is, the animal possesses an hermaphrodite gonad. This is the case in certain land snails.

Self-fertilization, or physiological hermaphroditism, is more rare than anatomical hermaphroditism. It occurs in tapeworms (Fig. 152). The monoecious animal *usually* first functions as a male, then later as a female or vice versa. Most Tunicates first produce eggs and then when this period passes, their testes become functional and they produce sperm. In the hag-fish, Myxine, the animal first produces sperm, then later eggs. In this way the eggs from any one animal are not likely to be fertilized by the sperm from that animal. There is strong evidence to indicate that hermaphroditism was the primitive condition, but the separate sexed or dioecious condition is the rule in higher forms.

Gonads and Gonaducts. While sex glands (ovary and testis) are usually present in multicellular animals, yet special ducts for convey-

ing their products from the animal are not always necessary and may be absent. For example, in Hydra simple sex organs are found on the surface of the body and sperm escape directly from the testis into the sea water. In the jellyfish, on the other hand, sex glands occur in the walls of the gastro-vascular cavity, and sperm and eggs pass into this cavity and thence out. Gonaducts of one kind or another for conveyance of sperm and eggs are found in Flatworms, Roundworms, Annelids, Mollusks, Arthropods and Vertebrates. Where the gonads are developed from tissues lining the body cavity, their products (eggs and sperm) are first discharged into the body cavity, and then escape. They must be discharged from this by one kind of duct or another. In many female Teleosts the ovary lies in a sac which extends to the cloaca. In Cyclostomes the eggs and sperm pass into the body cavity and from this through pores into the cloaca.

Usually ducts associated embryologically or otherwise with excretion are used. The oviduct in some Vertebrates originated as a separation from a primitive ureter. In male Fishes and Amphibia the ureter became connected with the testis and serves a double purpose. In the Amniota (Reptiles, Birds and Mammals) it is no longer a ureter but functions wholly as a vas deferens.

Oviparous and Viviparous. In lower forms, fertilization of eggs occurs normally outside the body. In most aquatic animals — Coelenterates, Echinoderms, Fishes and Amphibia — eggs are discharged into the water, sperm are shed near them and are attracted to the eggs. In land animals, eggs and sperm would easily be destroyed if exposed to the air for long, so sperm are introduced into the oviducts of the female. Internal fertilization is the rule in Elasmobranchs, which are more primitive than Teleosts in which fertilization usually is external. Internal fertilization is also the rule in Arthropods, Reptiles, Birds and Mammals. In most Elasmobranchs, in Reptiles, Birds and Insects fertilized eggs are discharged from the body. Such animals are said to be *oviparous*. The eggs of Birds, Reptiles, Amphibia and Fishes have stored up in them considerable quantities of food called yolk, which is formed by the ovary. The oviduct secretes a surrounding mass of white or albumen and also shell membrane and a shell in Reptiles and Birds and a group of Mammals. The egg case of the skate is horny while those of turtle and hen are calcareous.

Although many Vertebrates are *oviparous*, yet some of these classes have representatives in which the young are developed within the body of the mother, *i.e.*, are *viviparous*. Such cases are found among sharks, Teleosts, tailed Amphibia and Reptiles. In all Mammals with the exception of the Monotremes, development occurs within the body of the mother. In the case of oviparity, yolk is produced by the ovary, but it is also true that in viviparous Mammals, ovarian hormone is greatly concerned in developing the placental system of foetal nourishment. The latter is a further modification of the form of yolk feeding. In Reptiles, Birds and Mammals the embryo is kept more quiescent, which condition is more favorable for development and growth. The beginning of independent life is delayed and the period of greatest mortality is safely passed. The chance of survival is thus increased, and this is especially true of the placental Mammals, in which the feeding and the care of offspring by the mother is of further benefit to the individual. It is now known that milk contains important vitamins.

Intromittent Organs and Uterus. To secure the safe transfer of sperm to the oviducts of the female, organs of intromission appear, such as the claspers of the male dogfish. Special structures called penes are found in certain Reptiles and Birds; the penis of higher Mammals is a specialized development of these. The oviducts of Vertebrates remain separate tubes, terminating in the cloaca in Elasmobranchs, Amphibia, Reptiles and Birds and Monotreme Mammals. Examination of the Placental Mammals shows that, beginning posteriorly, there is a fusion of the oviducts to form a common vaginal chamber for the reception of sperm, and in apes and man a single uterus or womb in which the eggs will develop. In Carnivora, the uterine portions of the oviducts are still quite separate but partly fused and young develop in each horn. In the mouse and elephant they are separate.

Conclusion. The essential fact in all types of reproduction in plants and animals is this, that a small mass of protoplasm, a cell, separated from the body of one organism (in asexual reproduction) or formed from two (in sexual reproduction) has the power of developing into another organism like the parent or parents. A sperm or egg of itself is usually incomplete. In sexual reproduction animals develop from a single cell. This single cell, a complete whole, is present after the egg cell and

sperm cell unite, and all the structures, organs, devices, secondary sex organs, sex antics of animals and sex emotions are but part of the machinery concerned in bringing about the formation of a fertilized egg, *i.e.*, union of egg and sperm. And for what? So that the race may continue! And yet race continuance is not the primary consideration of the individual animal for, as a rule, the first consideration seems to be self-preservation. Hunger and thirst are examples of primary sensations, but the reproductive instinct closely follows these. It should be remembered that reproduction has produced the animal that has these instincts. Of the three great groups of functions comprising the physiological life, those of metabolism and adjustment are not only primary but preessential to reproduction. Many examples could be cited indicating that the third is the goal of the first two. The queen bee dies when her reproductive activity ceases. The life of the adult May fly is limited to a few hours devoted to reproductive activity. Numberless instances are recorded of maternal sacrifices among Mammals in an attempt to preserve the life of offspring, so much so that these words, paraphrased from those of Tennyson, are indeed appropriate: "So careless of the individual, so careful of the type."

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