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INTRODUCTION

The ability to reproduce is the fundamental feature of all living organisms and may be analysed from various points of view, starting with molecular and cellular levels and ending with complex relations occurring between individuals in a population. These various approaches are reflected in the present volume entitled „Biology of Reproduction"; it contains articles written by various specialists who discuss the progress in our understanding of mechanisms underlying many forms of reproduction and genetic recombination. The main idea underlying all these articles and explaining fascinating problems of reproduction and sex is the theory of evolution.

The simplest form is asexual (vegetative) reproduction, when the new individual develops from somatic cell(s), as a result of division, budding etc., and is genetically identical to the parent, excepting the rare incidence of new mutations. This type of reproduction is prevailing in prokaryotic organisms as well as in some lower Eukaryota (e.g. protists, algae, yeasts), and may be also found in many plants and some lower animals. Asexual reproduction is monoparental and usually very prolific, and yet, in the course of evolution, it became dominated by sexual reproduction, although the latter process is very complicated and usually two individuals are needed to generate offspring. The most important feature of sexual reproduction is genetic recombination resulting in new gene combinations, which appear in every generation. In sexual organisms recombination is the most important source of genetic variability required for the process of evolution.

Some forms of genetic recombination, represented by parasexual processes, not necessarily linked with reproduction, occur in Prokaryota, and serve as models for studying DNA recombination at the molecular level. Even in such simple organisms, these processes are very complicated and only partly understood, as described in the articles on recombination in viruses (A. PIEKAROWICZ) and bacteria (M. WŁODARCZYK).

However, the typical sexual reproduction occurs only in eukaryotic organisms; they produce haploid (1 n) gametes, two of which must fuse together to form a diploid (2 n) zygote. Thus, in sexual reproduction, recombination occurs at two steps. First, in the process of meiosis, during reductional division, chromosomes derived from the father and the mother are reshuffled and their fragments exchanged (crossing-over), resulting in a new haploid gene combination in the gamete. The second source of recombination is fertilization when gametes with different gene sets fuse. In consequence, in a randomly mating population, every individual is genetically different from the others, and the population contains vast resources of variability on which Darwinian selection is operating. It should be emphasized that sexual reproduction resulted in the evolution of diploidy (2 n) which is the main form of life in higher organisms. Diploidy plays an important role in evolution, enabling interactions between alleles (dominance, overdominance) which result in masking nonfunctional alleles and may protect from elimination some alleles which are deleterious at the moment but may be of advantage in the future, when the population is exposed to new environmental conditions.

In the course of evolution of sexual reproduction some new mechanisms and adaptations were generated. One of them is a modification of the cell cycle. In asexual organisms, cells undergo a normal cycle, ending with mitotic division. On the other hand, in sexual organisms, the necessity of chromosome number reduction led to the development of a complicated meiotic cycle, whose mechanisms are not yet fully understood. J. KUBIAK and Z. POLAŃSKI consider main points of its control in animal cells during production of ova (oogenesis) and spermatozoa (spermatogenesis): why there is no DNA replication before the second meiotic division, and how the egg cell is arrested at metaphase for a long time until sperm penetration.

These processes and their control are very expensive for the organism. No wonder that many groups, especially of plants, developed apomixis, which — as shown in the article of K. NIEMIROWICZ-SZCZYTT — may take very different forms: from partly to completely abolished meiosis and/or fertilization. Although this does not prevent accumulation of variation, no recombination can occur when both processes are omitted. However, such extreme cases are rare in nature. Apomictic reproduction seems to reflect episodes in plant and animal evolution, as evidenced by their independent appearance in different phylogenetic lines and taxa.

How was sexual reproduction developed and how is it maintained, despite the fact that — in comparison with asexual reproduction — it is much more expensive for the organism in terms of materials and energy expenditure. As we learn from the article of R. KORONA, population geneticists cannot give yet a satisfactory answer to those, seemingly simple, questions. The author considers several current hypotheses and models which may explain (at least partly) the maintenance of sexual reproduction, and shows that a constant race with time is taking place in populations: deleterious consequences of asexual reproduction must accumulate so quickly that the initial superiority of asexual forms disappears, before sexual forms are lost.

Why were gametes differentiated into bigger (ova) and smaller ones (spermatozoa) in the course of evolution? Why are animals usually dioecious and plants hermaphroditic? Why is a similar number of females and males usually born? As shown by J. KOZŁOWSKI, the thinking in terms of evolutionarily stable strategies can give convincing answers to all those questions.

As a consequence of sexual reproduction, individuals of many species are differentiated into females and males. The processes of sex determination in various species may differ and their genetic mechanisms are only partly understood at the molecular level. J. STYRNA discusses sex determination in four model species: nematode, fruitfly, mouse and human.

The differentiation of two types of gametes (big ova produced by females, and small, motile spermatozoa produced by males) resulted in different costs of gamete production in either sex. This led to the evolution of different reproductive strategies in females and males, to the competition between individuals of the same sex and to development of specific preferences in the choice of their sexual partners. These phenomena were noticed already by Charles Darwin who coined the term: sexual selection. As shown by J. RAFIŃSKI, these processes do not end with copulation, but may take place also later in the form of sperm competition in the female reproductive tract, and sometimes even after sperm entry into the ovum. Fertilization is usually assumed to be a random process (indeed, on this assumption Mendelian genetics is based); however, there are cases when some combinations of gamete genotypes may be favourized.

For a long time the process of fertilization and early embryonic development could be studied exclusively on animals with external fertilization. Only recently the development of *in vitro* techniques of maintaining gametes and embryos enabled such investigations to be performed also on animals with internal fertilization. The rapid development of experimental embryology of mammals led to invention of many biotechnological methods, e.g. different variants of fertilization *in vitro*. The most radical of them, the technique of intracytoplasmic sperm injection (ICSI), is already used in human reproduction; it enables to get healthy offspring in those cases when the male produces only a few spermatozoa, and even when they are morphologically deformed or non motile at all. As described by M. MALESZEWSKI, the invention of these techniques has a great impact on our knowledge of the mechanisms of fertilization in mammals. It appeared that specific shapes of spermatozoa and the development of special adaptation (as chromatin condensation in the nucleus, the presence of the flagellum and the acrosome) are necessary only for crossing several barriers to reach the ovum, but have no special function in the very process of fertilization.

Still more radical ingerence in the process of reproduction is (which recently has been given so much publicity) cloning of mammals which enables the development of a new individual without participation of the male gamete. What is cloning, why clones are being produced and what are the perspectives of these studies

— we learn from the article of A.K. TARKOWSKI, one of the pioneers of experimental embryology in mammals.

Many people fear that spectacular achievements of biology and medicine may result in accumulation of genes responsible for various defects, leading to genetic deterioration of human populations. The question may be asked: are human populations endangered by the deficiency of natural selection? A.ŁOMNICKI and R. KORONA discuss this difficult problem in an article closing the volume.