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Review Article

A New Look at the Reproduction of Higher Organisms

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Abstract

The approach defining the gender based on the social function seeks the biological basis allowing to support this approach. From the biological point of view, there are reasons for creating a technique of reproduction without fertilization with opposite gametes in higher organisms, in particular in mammals. Authors of this publication made a short review of the current stage of studies on asexual reproduction in plants and animals, with particular consideration of humans. Obtained evidence indicates that the development of studies in this field for this day is the basis for overcoming the stereotype of the procreative necessity for the survival and development of species of higher organisms, including humans.

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ABBREVIATIONS

DH: doubled haploid; UV: Ultraviolet radiation; DNA: deoxyribonucleic acid; WGD: whole-genome duplication; COs: crossovers

INTRODUCTION

Determination of the role of individual in society perceived based on the gender is broadly discussed. Particularly the approach specifying the gender based on the social function is searching for the biological bases allowing supporting such attitude.

In the space of biological sciences connected with the biotechnology of higher organisms, i.e. plants and animals, the studies on the gametic reproduction without the fertilization are expanding. The development of this study will allow redefining the conception of procreation in relation to plants, animals and human.

In eukaryotes, the evolution of the biphasic life cycle with alternating diploid and haploid gametic phases is a consequence of the sexual reproduction [1]. Bringing to the diploid state through the fusion of haplid reproductive cells is an attribute of sexual reproduction. In XIX century, the theory of totipotency appeared, which assumed that every cell possess the potential for forming all the cell types in the adult organism. This theory was confirmed through the development of clonal reproductive techniques, in which even a single somatic cell can be the source of a new organism. Above-mentioned technology is a form of the asexual reproduction. This method is well developed in most economically useful plants. Increasingly, we come across the studies on the clonal reproduction of animals in the scientific field. Two approaches should be distinguished in defining the concept of clonal reproduction. It is assumed that clonal reproduction is understood as gaining the genetically identical individuals through the division of the donor and this is most often applied in vegetative propagated plants. In relation to animals, in particular with regard to the mammals, this process consists in obtaining descendant with the identical genotype as the donor of the genetic material. For both semantic approaches, a characteristic feature is that somatic cells are used in these technologies. Studies are known, in which the nuclei of somatic cells of the mammary gland of an adult sheep were used with a success, which were implanted into an egg without its own nuclei. It is referring to the sheep named Dolly, which was considered to be the first cloned sheep in the world [2]. Results of above-mentioned experiments were used to develop the technique of clonal reproduction in animals. Nevertheless, clonal methods do not enrich the genetic pool, which is necessary for the genetic evolution of the species and the maintenance of their life potential. Reproductive cells formed as a result of meiosis are characterized by genetic variation, which is gained by the random distribution of genetic material and crossing-over phenomenon in the early stages of meiotic divisions of forming gametic cells. Meiosis is known to be the main factor of the genome variations, which is responsible for the evolution of genes and genome in nature [3]. Therefore, gametic cells have a great potential in studies on the development of reproductive techniques without the fertilization.

Gametic cells subjected to various factors in in vitro conditions, mainly stress factors, can change their course of development from gametic to sporophytic, producing a haploid embryo. In relation to male reproductive cells, we are reffering to androgenesis process and in case of cells, this process is known as gynogenesis. Organisms regenerated from haploid embryo are most often not viable, therefore in an artificial and intended manner the number of chromosomes is doubled, which result in obtaining lines of doubled haploid organisms.

PLANTS

In plants, these methods are based on the effect of various factors inducing the change of development course of reproductive cell from gametic to sporophytic without the participation of cells of opposite sex.

The most often applied method of DH production in major crops is androgenesis [4]. Androgenesis can be induced by anther or isolated microspore cultures, where haploid embryos are formed in the microspore that are in the late mononuclear phase or in the early binuclear phase.

There is no accurate data on the number of plant species, in which scientist were managed to obtain efficient methods of producing androgenetic plants. Currently, more than 280 varietis was obtained in the world from plant material derived through in vitro androgenesis in anther or isolated microspore cultures [5].

Gynogenesis is rarly used and least elaborated method in order to produce haploid plants, nevertheless it was mainly applied in case of crops that shown a little or even no response to wide hybridization, microspore, or another culture [6]. Gynogenesis is the type of parthenogenesis, where mitotic divisions of the egg cell in the ovule result in the formation of an embryo. Therefore, we have the lower number of gametic cells than in the case of anthers, in which, depending on the species, we can find from several hundred up to several thousand microspores. This allows obtaining haploid progeny on the larger scale than from the single egg cell, within the ovule.

Doubled haploid lines of plants have found a wide use in crop breeding programs and have become a valuable research material in plant biotechnology.

DISCUSSION & CONCLUSION

Animals

In the world of vertebrates, the studies on the use of the gametic embryogenesis phenomenon are the most advanced in different species of fish. Wherein, both types of reproductive cells are used to induce the processes of gametic embryogenesis. In case of androgenesis, the connection of the viable sperm cell with the egg cell occurs, in which, with the use of physical factors: UV, gamma irradiation and γ-ray radiation, nuclear DNA is deactivated. During gynogenesis the structure is reversed, that is the male gamete is treated with the physical factors and then it is fused with the untreated egg cell [7]. As a consequence, a dihaploid individual is formed as a result of the inhibition of either the second meiotic division or the first cell division [8]. Until now the application of gynogenesis allowed to obtain gynogenetic progeny in 25 fish species and in case of androgenesis in 15 species. In mammals, the studies were conducted on inducing gametic embryogenesis also by applying the method of stimulating an egg cell with a sperm cell with deactivated DNA. In the group of mammals, the most advanced studies on this issue are carried out on mice. For the generation of mice, sperm or oocyte genome of mice was replaced by haploid embryonic stem cells collected from the uniparental blastocysts without the use of manipulation of genomic imprinting [9]. Avise described this reproductive system as a quasi-clonal mechanisms, since the line between artificial and natural cloning occasionally blurs. This is because the nature also deploys nuclear transplantation cloning from time to time, as for example under parthenogenesis, when an egg cell receives an unreduced nuclear genome and start to proliferate mitotically into a daughter organism that is genetically identical to the mother [10].

So far it was possible to clone with a success a wide range of domestic animals, ranging from laboratory mice to dogs, cats, horses and pigs [11-14].

Intensive studies are conducted on the parthenogenesis in humans, where parthenogenetic activation of human oocytes was obtained from infertility treatments. In summary of the current state of knowledge on this topic stated that parthenogenetic activation of human oocytes collected from infertility treatments results in embryos, which are comparable to their biparental counterparts [15].

The hypothesis presented by Carli and Pereira throw the light on the development of reproduction by gametic embryogenesis in humans [16]. Authors noted that the spontaneous parthenogenetic and androgenetic events appear in humans, but they result in tumours. Such cases are recorded only when cancerous events occur in the human body. Whereas according to the authors there is a high probability that rare cases of human parthenogenesis resulting in viable, clinically normal individuals occur and pass unnoticed due to the absence of any abnormalities.

According to Normark [17] the existence of successful parthenogenetic lineages shows that sex is not indispensable for reproduction. The development of techniques using the phenomenon of gametic embryogenesis gives a perspective for obtaining an efficient technology of asexual reproduction in mammals. The main problem that needs to be solved will be the generation of the level of genetic variation allowing to function and development of the population. The hope gives the recent studies on the mechanisms of meiosis. It was discovered that the meiosis is often surprisingly divergent in primary sequence and the responsibility for this is assign to so-called meiosis genes. This mechanism of directional selection is natural in populations [18]. Authors of these studies suggest that there are possibilities of directional steering of meiosis through the WGD and temperature. Particularly important phase for the genetic recombination is homologous recombination, which promotes homologous pairing and generates COs to connect homologous chromosomes until their separation at anaphase I [19]. This is potentially the most significant stage of meiosis for the generation of variation within gametes. The development of the studies in this area is the fundamental element in the direction to changing the approach to fertility. In the first place, it redefines the concept of procreation perceived as the process of combining the genetic material of two individuals of the different sex. It also answers the question whether the connection of male and female gametes is a necessary factor for the biological development of populations of higher organisms, including homo sapiens.

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