

Relation of the male gametes with embryo sac cells. The hypothesis  
of double fertilization

N. S. BELAYEVA

Institute of Botany, Uzbek Academy of Sciences, Tashkent, U.S.S.R.

## Abstract

The sperms one after another get out of synergids. The front sperm gets the first into the egg cell attraction zone and then the sperm comes into contact with egg membrane. At this moment attraction ceases and the second sperm is led by a current of cytoplasm to the central nucleus. In the egg cell the sperm nucleus is led to the nucleus by cytoplasmic current too. After fertilization the character of cytoplasmic motion changes, because of a cell membrane damage. The presence of the sperm in the female nuclei may also serve as a regulating factor.

The problem, why the sperm after getting into the embryo sac are moving in different directions — one towards egg cell, the other towards the central cell nucleus, remains unsettled since the phenomenon has been discovered by Navashin (1898) and Guignard (1899).

A lot of hypotheses have been promoted with the purpose of accounting for the phenomenon. The viewpoints of the authors may be classified into two groups — one supporting active motion, the other supporting passive motion. Navashin (l.c.) first proposed the idea of active motion. At first he made a supposition that sperms moved like zoospores. Later he came to the conclusion that sperms are of different quality by nature, as well as female gametes with which sperms merge. Owing to the difference in quality each sperm moves to its corresponding gamete. Strassburger (1900) and others supported the passive motion. They explained the sperms motion by cytoplasmic currents.

Gerassimova-Navashina (1954) proposed an original mitotic hypothesis. She explained the divergence of sperms by the push away force effect, which acted upon telophase nuclei like during mitosis. Their motion towards the female nuclei was explained by their tendency to get into the "dynamic centre" — the place in the cell where the nucleus always stays.

Studying for a long time the process of fertilization of angiosperms of various groups we succeeded in discovering some regularities which allow us to explain in another way the behaviour of sperms in the embryo sac after their release from the synergids. In preceding works we have explained the sperms way through synergids, therefore we shall state only the principal facts and draw some conclusion that make it possible to explain in a certain way the sperm behaviour in female cells.

The facts and conclusions from our investigations are as follows:

1) Sometimes in various objects there occur embryo sacs with a different number of cells of the egg apparatus. More often an egg apparatus with two egg cells and one synergid is observed. If a pollen tube opens in the embryo sac then both sperms merge with the egg cells, but the central cell nucleus stays not fertilized. We have observed this in *Tribulus*, *Tulipa*, *Delphinium*. From these facts we can draw the following conclusions: a) the sperms do not correspond to the female gamete (because if they corresponded to each other, one egg cell would have remained unfertilized and the central cell would have been fertilized); b) the egg cell has the ability to attract activity the sperm, and the central cell has not this ability. Only by this fact we can explain the fertilization of both egg cells.

2) It is known that there are embryo sacs of elongated form, in which the central nucleus is situated not under the egg apparatus but in the chalasal end, where the sperm nucleus merge with the central nucleus. The fact itself makes doubtful the presence of active attraction froces between the sperm nucleus and the central nucleus.

3) The first sperm fertilizes the egg, the second — the central cell. Usually this fact is not described in literature. The authors usually write: "one sperm" and "another sperm" without mentioning their proper sequence. But we have met with the former statement in the work by Kostryukova and Benetskaya (1958). Our investigations on a series of objects, especially on *Gagea*, allow us to establish for certain that just the first sperm gets into the egg cell and the second one moves to the central cell. The data were obtained that the changes of the first and the second sperm cell in the embryo sac take place not simulataneously.

4) It is known from literature and from our data that the sperms get out from the synergid one after another, and the sperms dispersal takes place simultaneously.

Summing these facts we can say that the sperms get out of synergids one after another and diverge simultaneously. The sperms do not correspond to a definite female gamete. The egg cell has an ability of the active sperm attraction, but central nucleus has not got this ability.

From these conclusions the scheme of the sperm behaviour becomes apparent. The sperms one after another get out of synergids. The front sperm gets the first into the zone of egg cell attraction and then the sperm comes into contact with its membrane. At the same moment attraction ceases (otherwise the second sperm would have been attracted too). The second sperm nucleus is led by a current of cytoplasm to the central nucleus. In the egg cell the sperm nucleus is led evidently by cytoplasmic current.

After fertilization the character of cytoplasmic motion changes. The cytoplasmic current usually connects the upper part of the central cell with the polar nucleus, when it is at the chalazal end, and after the sperm's passing the current disappears. This change of the cytoplasm motion explains why additional sperms that get into the embryo sac of such structure stay near the broken synergid, not moving to the female nuclei.

That character of the cytoplasm motion changes as a result of damage of the cell wall. In that case damage of the cell membrane takes place. About 10 minutes elapses from the moment of damaging the cell wall to the change of the cytoplasm motion (K a m i y a, 1962). Therefore it is quite possible for the sperm nuclei to reach the female nuclei. The presence of the sperm nuclei in the female nuclei may also serve as a regulating factor.

In our scheme, isolated facts are brought into a system of general laws on the behaviour of sperms in the egg cell and in the central cell. These laws are as follows: female nuclei are not capable to attract sperm nuclei. Sperms nuclei are brought to them by regulated cytoplasmic currents. Evidently, damage of the female cell membrane is a regulating factor. The egg cell as a whole has an ability to attract sperms, but the attraction ability ceases at the moment the sperm gets into contact with the egg cell membrane. The central cell has not such ability because the sperm nucleus gets into it with cytoplasm flowing from the broken synergids. The membrane of the central cell is broken by the same flow.

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