ACROSOMAL REACTION

The reaction allowing the binding and the fusion of opposite gametes.

♀ Reproductive functions ♂ Male

About Acrosomal reaction

The very first interaction of a sperm cell head part, the acrosome, with the second protective layer of an oocyte, the zona pellucida, is called acrosomal reaction. The main purpose of the acrosomal reaction is to start the fusion of the oocyte membrane with the sperm cell membrane allowing the combination of genetic material contained in both gametes, leading to the fertilization of the oocyte.

After a long voyage through the female reproductive tract, when sperm cells finally reach the oocyte, usually the fertilization is about to happen. One of the initial parts of the fertilization with utmost importance is the process called acrosomal reaction and its abnormal progression can be a reason of male infertility. The acrosomal reaction is including several mechanisms, that ensure the successful binding of a sperm cell with an oocyte and the sperm cell incorporation into the oocyte. During the acrosomal reaction the sperm cell’s head part, called acrosome, interacts with a protective layer of the oocyte, called zona pellucida. The zona pellucida (pellucida = “transparent”) is a transparent, but thick, glycoprotein membrane that surrounds the cell’s plasma membrane.

A well-developed acrosome is a sac-like structure filled with enzymes such as hyaluronidase, acrosine and others chemical substances. It is formed by an inner and an outer acrosomal membrane that covers the anterior portion of the nucleus. The acrosomal reaction can be defined by the morphological changes of the sperm cell and by the molecular interaction happening between opposite gametes. The primary inducer of the acrosomal reaction is considered to be zona pellucida, although there are others physiological compounds that are known to induce the acrosomal reaction in capacitated sperm cell as well. The physiological inducers of the acrosomal reaction include progesterone, prostaglandins, sterol sulphate, glycosaminoglycans, the epididymal growth factor, atriopeptin, platelet activating factor, and adenosine triphosphate.

There is a phenomenon called spontaneous acrosomal reaction. Although it differs in its characterisation, it is closely related to acrosomal reaction. The main difference is that spontaneous acrosomal reaction is not triggered by the contact of the sperm cell with zona pellucida, meaning it happens of its own accord. Spontaneous acrosomal reaction undergo sperm cells that are first to reach the oocyte. The implication and importance of this specific phenomenon and its relation to the acrosomal reaction is briefly discussed in the section below named mechanism of the acrosomal reaction.

Mechanism of the acrosomal reaction

The acrosomal reaction normally takes place in the ampulla of the fallopian tube (site of fertilization) when the sperm cells are trying to penetrate the oocyte. Before the acrosomal reaction itself can happen, the sperm cell first has to penetrate the outer layer of cumulus cells called corona radiata. To do so a digestive enzyme called hyaluronidase is released from the acrosome while the spontaneous acrosomal reaction happens. Hundreds of sperm cells must undergo the spontaneous acrosomal reaction before the commonly called “winner sperm” cell is able to reach the next layer, zona pellucida. This explains one perhaps surprising fact about fertilization, that the first sperm cell that reaches the oocyte is never the one to fertilize it. It also explains why the low sperm count can cause male infertility. When the sperm cell reaches the zona pellucida the actual acrosomal reaction happens. Acrosine, another digestive enzyme contained in the acrosome, dissolves the zona pellucida and the plasmatic membrane of the oocyte. This is followed by the fusion of the sperm’s cell membrane with the oocyte cell’s membrane so the contents of the sperm cell head can transfuse into the oocyte.

Morphological changes of the sperm cell acrosome

From the morphological point of view, the acrosomal reaction occurs in several steps. The first step is the irreversible binding of opposite gametes resulting in increase of Ca2+ ions between the sperm cell plasmatic...
membrane and the outer acrosomal membrane. Second step is the gradual fusion of these two membranes at multiple sites in the head region. As the third step happens, the plasmatic membrane and the outer acrosomal membrane fuse resulting in the formation of hybrid membranes (hybrid vesicles). The last step leads to the release of acrosomal contents containing powerful enzymes at the site of sperm-zona binding. The action of these powerful enzymes makes it possible for the hyperactive sperm cell to penetrate the ZP and fertilize the egg.

Molecular interaction between sperm cell and oocyte

The contact of the sperm cell with an oocyte triggers the signalling pathway that activates sperm cell by opening of Ca2+ channels on the sperm cell’s plasmatic membrane. This step elevates levels of Ca2+ ions and other chemical substances (called secondary messengers). The elevation of Ca2+ levels initiate a cascade of signalling events that result in the acrosomal reaction and an exocytosis of the acrosomal contents. These contents include glycohydrolases, proteinases, esterases, phosphatases, phospholipases, sulphatases and others.

Gallery

Sperm and the Process of Fertilization
Before fertilization, hundreds of capacitated sperm must break through the surrounding corona radiata and zona pellucida so that one can contact and fuse with the oocyte plasma membrane.

Sources

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