CAPACITATION

Biochemical process of structural and functional changes in sperm cell essential for reaching its full fertilization capacity.

🧬 Reproductive functions ♂ Male

About Capacitation

The mature male gamet present in female genital tract after ejaculation still does not possess the motility and real fertilizing ability required to fuse with an egg cell. The fully fertilizing ability of male gamet is only reached after undergoing a progressive process named capacitation. Sperm reaching the oocyte before capacitation won't be able to penetrate the oocyte’s thick outer layer of cells (zona pellucida). The process of capacitation goes on while the sperm cell realizes its journey through the female genital tract. The female genital tract itself takes an important part in the capacitation process by secreting specific chemical substances: albumin, lipoproteins, proteolytic, glycosidic enzymes and others. These chemical substances help the induction of capacitation. The process of capacitation can be characterized by the structural and functional changes in the sperm cell. Such changes involve membrane modification, protein modification (through phosphorylation) and modulation of enzymatic activity. Above mentioned changes are only partially known at a molecular level but most of them require an adequate supply of energy. For this reason, sperm cells also modify their metabolism in order to adequately sustain capacitation and the closely related phenomenon of sperm hyperactivation.

Membrane modifications

Albumin, the major protein present in the female reproductive secretion, has the leading role in the structural membrane modification. Albumin possesses the ability to drain sterols (mainly cholesterol) from plasma membrane. The loss of cholesterol destabilizes the sperm plasma membrane. This way the membrane becomes more permeable allowing easier Ca2+ transportation into the sperm cell (Pic. 1). The destabilization of sperm cell membrane also increases its capacity to fuse with an egg. In another words the membrane of sperm cell becomes to be fusogenic. This quality is essential in the very beginning of the fertilization when the acrosomal reaction happens.

Protein modifications

One way of changing the protein activity is through the phosphorylation of tyrosin residues. This kind of change affects for example proteins involved in signal transduction through plasma membrane. Another important part of sperm cell, where the protein phosphorylation takes place, is the flagellum. Flagellum is responsible for the progressive movement of the sperm cell. The phosphorylation of proteins in flagellum is associated with the process of hyperactivation resulting in increased movement activity of flagellum. The hyperactivation process is thought to be necessary for sperms to penetrate the cumulus complex surrounding the ovulated egg, bind to the zona-intact egg, and undergo the acrosomal reaction.

Modulation of enzymatic activity

The modulation of enzymatic activity is the result of above mentioned increased permeability of plasma membrane for the Ca2+ ions, which are important signal molecules in eukaryotic cells. Calcium is effecting the sperm capacitation through Ca2+-binding proteins that undergo conformational changes upon interaction with Ca2+ ion. This interaction plays an important role in several cell signalling pathways by modulating biological activities of multiple enzymes and ion pumps (including Ca2+/calmodulin-dependent kinases). Another way of modulating the enzymatic activity is through the transmembrane movement of HCO-3 anions into sperm cells, that may be responsible for the increased pH inside the sperm cell during the process of capacitation. HCO-3 is also stimulating adenyl cyclase, the sperm enzyme responsible for raising the levels of cAMP by increased
The primary target of cAMP is protein kinase A (PKA), an enzyme that is stimulated in capacitating/capacitated sperm cells.

**Gallery**

Simple diagram shows selected sperm cell modifications during capacitation.

**Sources**

“Anatomy and Physiology of the Female Reproductive System” —sourced from OpenStax College licensed under CC BY 4.0 Download for free at http://cnx.org/content/col11496/latest/

“Bioenergetics of Mammalian Sperm Capacitation” —by Ferramosca and Zara licensed under CC BY 3.0

“Fertilization” —sourced from Boundless licensed under CC BY-SA 4.0

“Spermiomics: A New Term Describing Sperm Function by the Combined Utilization the Global Survey of the Overall of Immunocytochemistry, Metabolomics, Proteomics and Other Classical Analytical Techniques” —by Rodriguez-Gil licensed under CC BY 3.0

“Molecular Markers in Sperm Analysis” —by Payan-Carreira et al. licensed under CC BY 3.0

“Modulation of spermatozoon acrosome reaction” —by Vigil et al. licensed under CC BY-NC 4.0

“Biological Processes that Prepare Mammalian Spermatozoa to Interact with an Egg and Fertilize It” —by Tulsiani and Abou-Haila licensed under CC BY 3.0

“Capacitation of sperm cell - diagram” —by Kadlec, created for Fertilitypedia.org licensed under CC BY-SA 4.0