Fertilization Summary

- Sperm capacitation – increased motility of sperm and destablises its membrane (enables preparation for the acrosome reaction)
- Sperm-zona pellucida binding
- The acrosome reaction
- Penetration of the zona pellucida
- Sperm-oocyte binding
- Egg activation and the cortical reaction
- The zona reaction
- Post-fertilization events

Key Points

- Site of fertilization
- Usually in the ampulla of the uterine tube
- The ampulla is the widest part of the tube
- Fertilization may occur in any other part of the tube
- Fertilization never occurs in the uterine cavity
- At ovulation the egg is arrested in metaphase of the second meiotic division

Sperm Capacitation

Freshly ejaculated spermatozoa are not capable of fertilizing an egg. They require the ability to penetrate the cell layers surrounding the oocyte through a process known as capacitation. Capacitation occurs in the uterus and oviducts and is facilitated by substance of the female genital tract. During capacitation the glycoprotein coat that adheres to the spermatozoa cell membrane is initially removed, initiating changes in the surface charge of the sperm membrane and reorganisation of that membrane.

Glycosaminoglycan’s and cholesterols are also stripped from the plasma membrane of sperm head. The result is a more fluid membrane with an increased permeability to Ca2+.

Capacitation destabilizes the sperm’s membrane to prepare it for the acrosome reaction. The capacitation causes a hyper activated motility pattern productin “whiplash” beats of the sperm tail, which when in the vicinity of the oocyte helps produce the acrosome reaction and aids navigation and penetration of cumulus mass.

Non-mammalian spermatozoa do not undergo capacitation step and are ready to fertilize an oocyte immediately after release from the male.
Sperm-Zona Pellucida Binding

Binding of the capacitated sperm to the zona pellucida is a receptor-ligand interaction with a high degree of species specificity.

The carbohydrate groups on the zona pellucida glycoproteins function as sperm receptor. The sperm molecule that binds this receptor is not known with certainty, and indeed there may be several proteins that can serve this function.

Sperm capacitation allows for the acrosome reaction. In the absence of an acrosome reaction, a sperm is incapable of penetrating the zona pellucida. When the sperm bind to the zona pellucida, intracellular calcium is low. The binding causes an opening of calcium channels and an influx of calcium and second messengers that results in the acrosome reaction. Other substance may also induce the acrosome reaction – e.g. the addition of perivulatory follicular fluid to capacitated spermatozoa.

Contact of an intact, capacitated sperm with the zona pellucida of an egg cell allows interaction of a specific sperm cell surface glycoprotein, ZP3, with specific zona protein. These interactions are likely mediated by the sugars on sperm–egg binding proteins. ZP3-binding induces further calcium influx into the spermatozoa and intracellular cAMP levels rise. The acrosome swells, its outer membrane fuses with the sperm plasma membrane, and the enzymatic contents of the acrosome are released into the extracellular space surrounding the head of the sperm. This exposes the inner acrosomal membrane and another zona-binding protein, ZP2, which hold the spermatozoa and zona pellucida in contact. More Proteolytic enzymes are released from the acrosome which facilitate penetration of the zona pellucida by the whiplashing sperm. Complete penetration of the zona takes about 5-20 minutes.

**Definition**

The acrosome reaction is a crucial step during gamete interaction in all species, including man. It allows spermatozoa to penetrate the zona pellucida and fuse with the oocyte membrane. Spermatozoa unable to undergo the acrosome reaction will not fertilize intact oocytes.
It is thought that the production of progesterone from the cumulus mass of granulosa cells surrounding the oocyte, acts on the spermatozoa to make the acrosomes leaky, releasing the enzymes hyaluronidase. This digests the intracellular matrix of hyaluronic acid molecules holding together the cumulus mass.

The calcium released at gamete fusion causes the release of enzymes from cotrical granules that act on the ZP to prevent further binding and penetration by spermatozoa and also remove the ZP2 and ZP3.
The fertilizing spermatozoon contributes a centrosome (centrioles plus precentriolar) material as well as the nucleus. Without it cellular division fails.
All other spermatozoal contents, including the mitochondria, are digested in the oocyte proteasome.