



Textbooks usually tell students what we know about a subject. But another function of textbooks is to tell the student what we don't know. One of the most interesting and relatively unknown areas of mammalian fertilization is called capacitation, and here's why it's important. In sea urchins and frogs, for instance, the male releases sperm, the female releases eggs. Sperm meets egg, egg meets sperm, and the fertilized egg begins development. Not so with mammals.

The sperm that is ejaculated into the vagina is not fully developed, and it cannot fertilize the egg. It is an immature sperm. This was discovered independently in several species of mammals by Colin Austin and Min Chueh Chang. When sperm was introduced immediately into the oviduct upon ovulation, the sperm would meet the eggs, but most sperm could not bind to the eggs. If they added the sperm a few hours before the egg was ovulated, the sperm were capable of binding to the egg and fertilizing it. This means that in vitro fertilization in humans could not be done yet. If you just add sperm to eggs, nothing happens. The biochemical events enabling the released sperm to mature into sperm capable of fertilizing an egg, is called capacitation, the acquisition of a capacity.

Normally, capacitation occurs in the female reproductive tract, in the uterus or fallopian tubes, the oviducts. Here, the cells of the female reproductive tract physically bind the sperm. They slow it down, and they change the biochemistry of the sperm cell membrane. Before capacitation, the membrane of the sperm is rigid, and won't fuse with the egg cell membrane. After capacitation, the membrane is more fluid, and can fuse. Capacitation also changes the flow of calcium ions into the sperm, allowing the sperm to move quickly, and to undergo the acrosome reaction. Capacitation also equips the sperm head with molecules that can better sense the presence of the egg and follow the signal to the egg.

The key to capacitation seems to be an adenylyl cyclase enzyme, which when activated, activates a protein kinase enzyme. This protein kinase first activates those proteins associated with sperm motility. However, after a few hours, cholesterol is



removed from the cell membranes of the sperm by serum proteins. This allows more ion channels to work, further activating the protein kinase A to higher levels. It's thought that these proteins eventually phosphorylate the proteins that are involved in sperm motility, in those proteins allowing the sperm to undergo the acrosome reaction and in other sperm proteins involved in self-fusion. We do not know the identity of these proteins. So the first sperm to reach the egg are not usually capable of binding to or fertilizing the egg. The sperm have to be modified by the cells of the female reproductive tract.

The female body may also use capacitation as a way of prolonging the duration over which mature, functional sperm can enter the area where the egg is to be found. So instead of there being a brief period of time where the egg sees numerous sperm, capacitation may be a time-release mechanism, by which sperm are released slowly, so that there's a longer period of time when fertilization can take place.

Capacitation has enabled human in vitro fertilization. First, hormonal stimulation is used to get the oocytes from the woman. These immature eggs are then removed surgically and then are mixed with newly ejaculated sperm in a medium that contains the necessary chemicals: the bicarbonate ions, the calcium ions, and the serum albumin, to effect capacitation. Incubating the fertilized egg for around two days to make certain that they divide and are healthy, is then accomplished before implanting these eggs into the woman's uterus. There is no certainty of success here. Most eggs do not adhere or implant into the uterus.

So, this has many interesting consequences, as well as those for in vitro fertilization. It means that sperm in condoms is probably not able to fertilize eggs. It also means that there is usually a four to five day period between intercourse and fertilization. One does not get immediately impregnated. As one researcher said, "Fertilization does not take place in a moment of passion. It occurs four to five days later. Maybe in the library."