Fertilization

Fertilization, the process by which male and female gametes fuse, occurs in the ampullary region of the uterine tube. This is the widest part of the tube and is close to the ovary .Spermatozoa may remain viable in the female reproductive tract for several days. Only 1% of sperm deposited in the vagina enter the cervix, where they may survive for many hours.

Phases of Fertilization

The phases of fertilization include phase 1, penetration of the corona radiata; phase 2, penetration of the zona pellucida; and phase 3, fusion of the oocyte and sperm cell membranes.

PHASE 1: PENETRATION OF THE CORONA RADIATA

Of the 200 to 300 million spermatozoa deposited in the female genital tract, only 300 to 500 reach the site of fertilization. Only one of these fertilizes the egg. It is thought that the others aid the fertilizing sperm in penetrating the barriers protecting the female gamete. **Capacitated sperm** pass freely through corona cells .

PHASE 2: PENETRATION OF THE ZONA PELLUCIDA

The zona is a glycoprotein shell surrounding the egg that facilitates and maintains sperm binding and induces the acrosome reaction.

. Release of acrosomal enzymes (acrosin) allows sperm to penetrate the zona, thereby coming in contact with the plasma membrane of the oocyte

Permeability of the zona pellucida changes when the head of the sperm comes in contact with the oocyte surface. This **contact results in release of lysosomal enzymes from cortical granules** lining the plasma membrane of the oocyte.

In turn, these **enzymes alter properties of the zona pellucida (zona reaction) to prevent sperm penetration and inactivate species-specific receptor sites for spermatozoa on the zona surface**. Other spermatozoa have been found embedded in the zona pellucida, but **only one** seems to be able to penetrate the oocyte

PHASE 3: FUSION OF THE OOCYTE AND SPERM CELL MEMBRANES

A**ctual fusion is accomplished between the oocyte membrane and the membrane that covers the posterior region of the sperm head** .As soon as the spermatozoon has entered the oocyte,

the egg responds in three ways:

1. Cortical and zona reactions. As a result of the release of cortical oocyte granules, which contain lysosomal enzymes, (*a*) **the oocyte membrane becomes impenetrable to other spermatozoa**, and (*b*) **the zona pellucida alters its structure and composition to prevent sperm binding and penetration. These reactions prevent polyspermy (penetration of more than one spermatozoon into the oocyte).**

2. Resumption of the second meiotic division. The oocyte finishes its second meiotic division immediately after entry of the spermatozoon.

3. Metabolic activation of the egg. The activating factor is probably carried by the spermatozoon. Post fusion activation may be considered to

encompass the initial cellular and molecular events associated with early embryogenesis.

The main results of fertilization are as follows:

_ **Restoration of the diploid number of chromosomes,** half from the father and half from the mother. Hence, the zygote contains a new combination of chromosomes different from both parents.

_ **Determination of the sex** of the new individual. An X-carrying sperm produces a female (XX) embryo, and a Y-carrying sperm produces a male (XY) embryo. Hence, the chromosomal sex of the embryo is determined t fertilization.

_ **Initiation of cleavage.** Without fertilization, the oocyte usually degenerates 24 hours after ovulation.

Cleavage

Once the zygote has reached the two-cell stage, it undergoes a series of mitotic divisions, increasing the numbers of cells. These cells, which become smaller with each cleavage division, are known as **blastomeres** Until the eight-cell stage, they form a loosely arranged clump However, after the third cleavage, blastomeres maximize their contact with each other, forming a compact ball of cells held together by tight junctions **Approximately 3 days after fertilization**, cells of the compacted embryo divide again to form a **16-cell morula** (mulberry). Inner cells of the morula constitute the **inner cell mass,** and surrounding cells compose the **outer cell mass.** The inner cell mass gives rise to tissues of the **embryo proper,** and

the outer cell mass forms the **trophoblast,** which later contributes to the **placenta.**

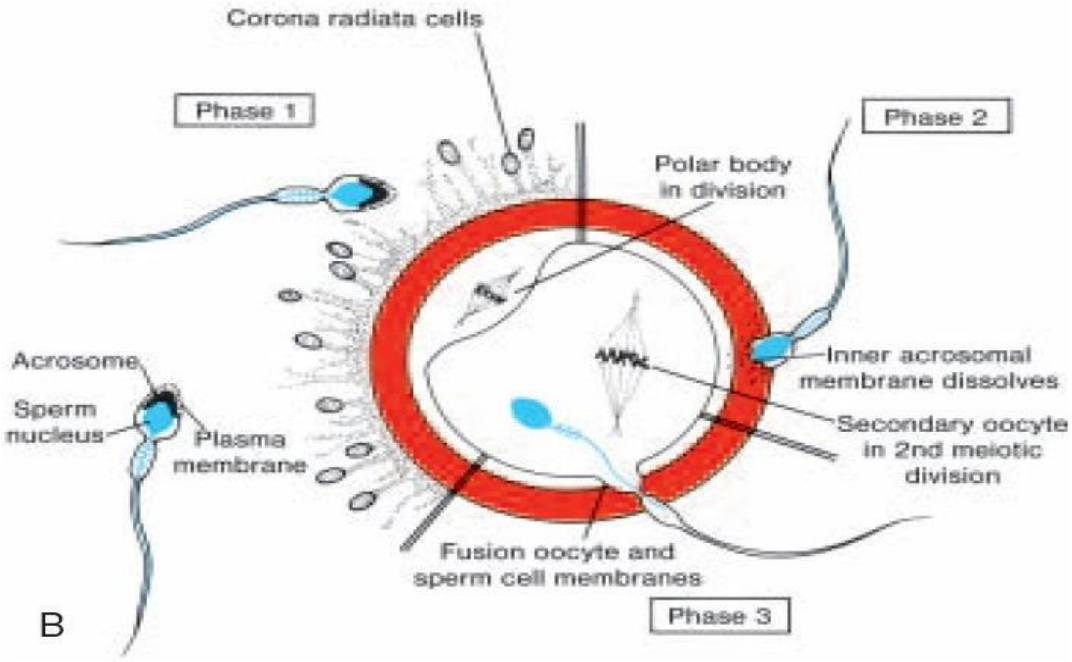

Figure 2.5 A. Scanning electron micrograph of sperm binding to the zona pellucida. **B.** The three phases of oocyte penetration. In phase 1, spermatozoa pass through the corona radiata barrier; in phase 2, one or more spermatozoa penetrate the zona pellucida; in phase 3, one spermatozoon penetrates the oocyte membrane while losing its own plasma membrane. *Inset*. Normal spermatocyte with acrosomal head cap.

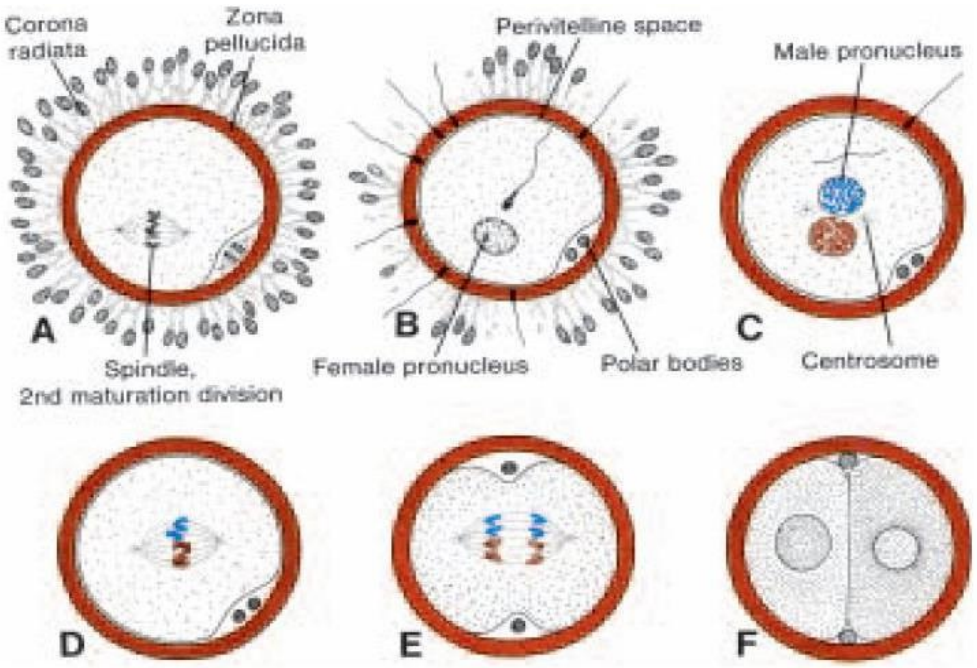

Figure 2.6 A. Oocyte immediately after ovulation, showing the spindle of the second meiotic division. **B.** A spermatozoon has penetrated the oocyte, which has finished its second meiotic division. Chromosomes of the oocyte are arranged in a vesicular nucleus, the female pronucleus. Heads of several sperm are stuck in the zona pellucida. **C.** Male and female pronuclei. **D** and **E.** Chromosomes become arranged on the spindle, split longitudinally, and move to opposite poles. **F.** Two-cell stage.

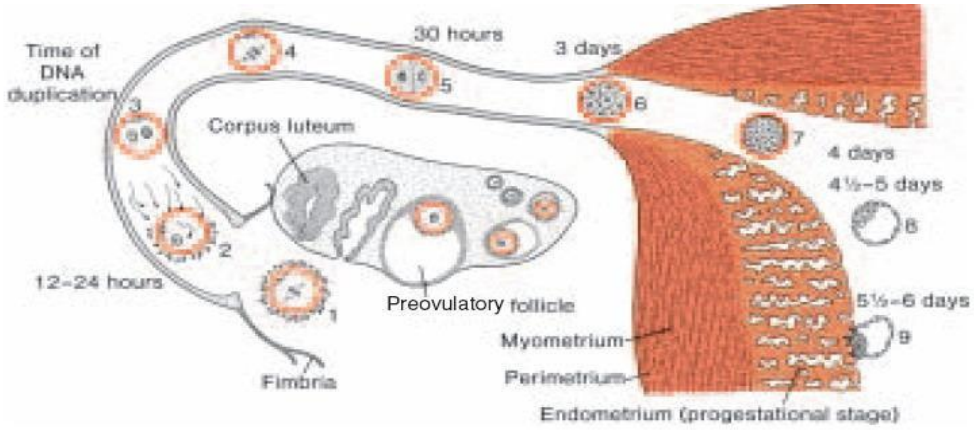

Figure 2.11 Events during the first week of human development. *1,* Oocyte immediately after ovulation. *2,* Fertilization, approximately 12 to 24 hours after ovulation. *3,* Stage of the male and female pronuclei. *4,* Spindle of the first mitotic division. *5,* Two-cell stage (approximately 30 hours of age). *6,* Morula containing 12 to 16 blastomeres (approximately 3 days of age). *7,* Advanced morula stage reaching the uterine lumen (approximately 4 days of age). *8,* Early blastocyst stage (approximately 4.5 days of age). The zona pellucida has disappeared. *9,* Early phase of implantation (blastocyst approximately 6 days of age). The ovary shows stages of transformation between a primary follicle and a preovulatory follicle as well as a corpus luteum. The uterine endometrium is shown in the progestational stage.

C L I N I C A L C O R R E L A T E S

Infertility is a problem for 15% to 30% of couples. **Male infertility may be a result of insufficient numbers of sperm and/or poor motility**. Normally, the ejaculate has a volume of 3 to 4 ml, with approximately 100 million sperm per ml. Males **with 20 million sperm per ml or 50 million sperm per total ejaculate are usually fertile**. **Infertility in a woman may be due to a number of causes, including occluded oviducts (most commonly caused by pelvic inflammatory disease), hostile cervical mucus, immunity to spermatozoa, absence of ovulation, and others.**

Contraceptive Methods

1. **Barrier techniques** of contraception include the male condom, the female condom
2. **contraceptive pill** is a **combination of estrogen and the progesterone** analogue progestin, which together inhibit ovulation but permit menstruation