Meiosis

Female vs. Male Meiosis

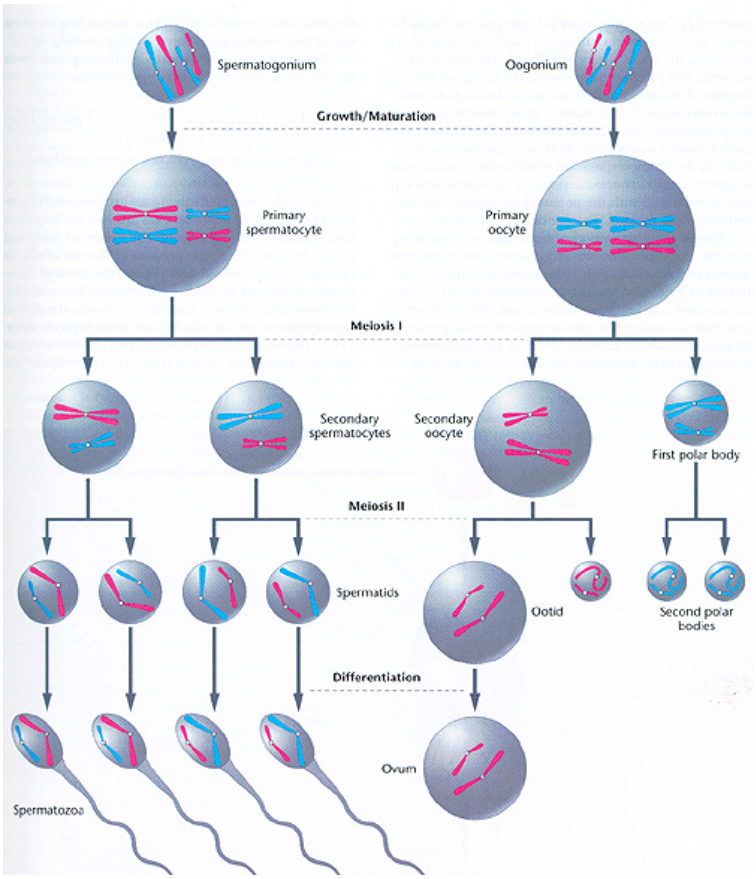
- Spermatogenesis has equivalent meiotic divisions resulting in four equivalent spermatids.
- Oogenic meiosis is asymmetrical: only one egg is formed together with three polar bodies.
- In females, meiosis *begins during embryogenesis*, and stops at prophase I.
    - Meiosis is reinitiated at puberty in specific oocytes that begin to mature, and then stops at metaphase II.
    - Meiosis is not completed in the ovary until fertilisation has occurred.
- In males meiosis *begins at puberty* and does not stop.

Interphase I

- 'Resting' phase
- Centriole and DNA is replicated

Meiotic Prophase I

- Condensation of chromosomes (leptotene)
- Centrioles move to the poles; these are critical for formation of the spindles that will attach to the chromosomes
- Homologous chromosomes form synapses between equivalent regions on the chromosomes (zygotene)
- Recombination/crossing over occurs (pachytene) and completes during diplotene.
- Nuclear envelop disappears during diakinesis



Meiotic Metaphase I

- Chromosomes align at the equatorial plate
- Spindle fibres attached to chromsomes

Meiotic Anaphase I

- Homologous chromosomes separate (sister chromatids stay together) and move towards the poles.

Meiotic Telophase I

- Nuclear envelope reforms around chromosomes
- Cell begins to split, forming haploid daughter cells

Meiotic II

- Similar to mitosis.
- Sister chromatids get pulled apart at centromere

Factors Underlying Genetic Variation

1. Crossing over
    - Although all of your genes are received from your mother and father, they are not the same chromosomes.
    - Recombination during meiosis ensures "shuffling" of the alleles.
2. Independent assortment
    - Homologues line up and cross randomly on the metaphase plate in Meiosis I.
    - With 23 chromosomes assorting independent, there are 2^{23} , or 8 million, possible assortments of chromosomes inherited for every cell.
3. Random fertilisation
    - The ovum has 8 million possible chromosome combinations—so does sperm.

- 64 trillion possible diploid combinations!

Fertilisation

Leaving the Testis

- Male germ cells undergo spermatogenesis to produce sperm which occurs in the seminiferous tubules of the testis.
- The sperm leaves the testis through the epididymis, during which they acquire motility (testicular sperm cannot swim).
- Sperm don't acquire their full motility until they reach the female reproductive tract for "capacitation".

Capacitation of the Sperm

- Capacitation 'primes' the sperm for penetrating the egg.
- Enzymes are secreted by the uterine wall which generates an influx of Ca++ (to increase sperm motility—hyperactive) and alters the plasma membrane of the sperm head (to facilitate binding to the egg).

The Acrosome Reaction

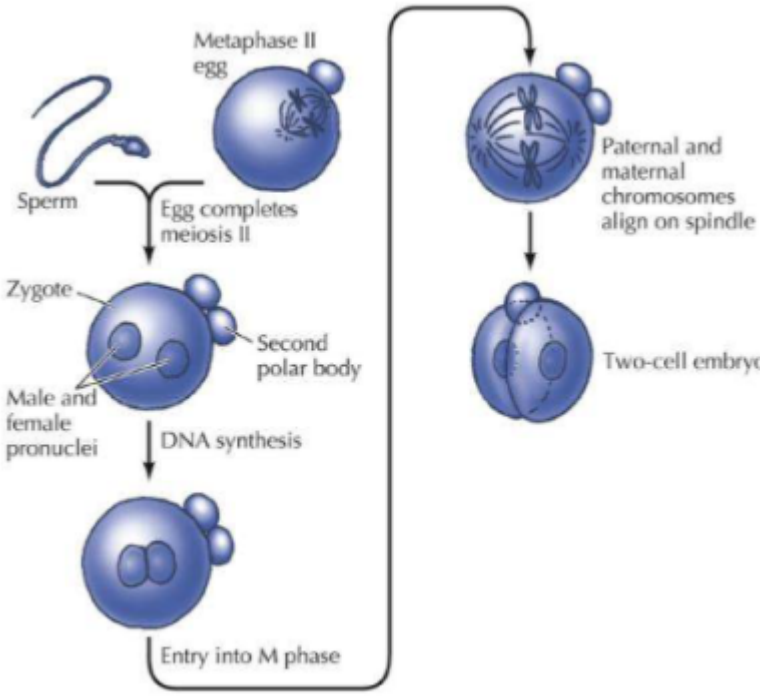
- The acrosome of the sperm is derived from the Golgi apparatus and contains digestive enzymes including hyaluronidase and acrosin.
- These enzymes are needed to break through the layer of cumulus cells that surround the egg.
- Once the cumulus layer is breached by acrosomal enzymes, the sperm head can reach the egg surface.
- The acrosome contents then help the sperm head break through to the zona pellucida proteins on the surface of the egg, allowing the sperm and egg to fuse.
- The contents of the sperm head (haploid nucleus and centriole) can then enter the egg.

Fast Block to Polyspermy

- Once the acrosome reaction has occurred, the oocyte immediately commences the fast block to polyspermy.
- The membrane electrical potential of the egg undergoes a massive depolarisation, through a Na+ influx, stopping any more sperm from binding to the egg.

Slow Block to Polyspermy: Cortical Reaction

- A cascade of events is initiated by the binding and fusion of the sperm's membrane to the egg's membrane.
- This results ultimately in the release of Ca2+ into the egg, which stimulates the "cortical granule response".
- The cortical granules (just under the surface of the egg) fuse, and release their contents into the space between the cell membrane and the vitelline envelope (called ZP in mammals).
- This results in the hardening of the vitelline envelope and permanently blocks further sperm from binding; usually this is the point at which sperm fall off.



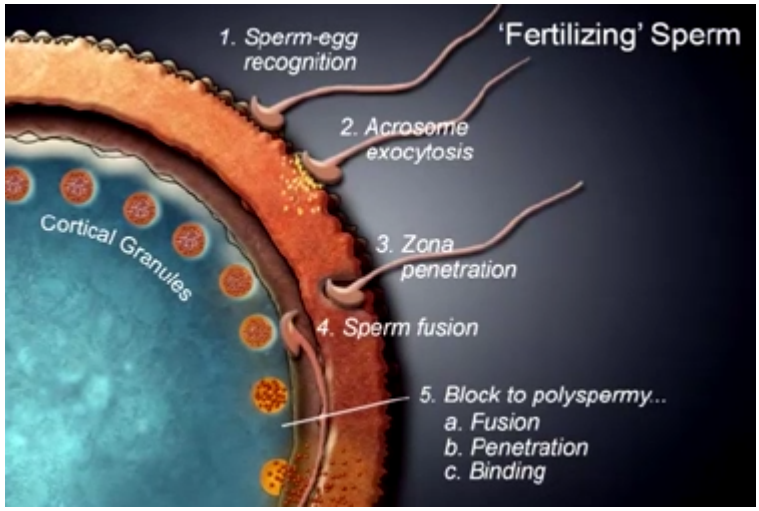
Completion of Meiosis

Unification

- Apposition and unification of sperm and egg pronuclei after fertilisation.
- The egg completes meiosis II
- Note that sperm centriole (from the neck of flagellum) duplicates and thus forms the critically important mitotic spindle.

First Cleavage

- The chromosomes from the egg and sperm align on a single metaphase spindle which is an essential structure for the first cleavage.



First Cleavage

- The pronuclei make contact, fuse and their chromosomes intermingle,

forming the zygote, which is about to commence cell division.

- The zygote is surrounded by a shell rich in glycoproteins (the zona pellucida) formed initially in early folliculogenesis, deep to which is a polar body.