

LECTURE 26

Meiosis, part 2: Oogenesis, spermatogenesis & fertilization

From CHAPTER 20: GERM CELLS AND FERTILIZATION

Mature eggs are larger than somatic cells

- Size depends on species-specific differences in embryonic development (Fig. 20-19, -20)
- Eggs are stockpiled with essential materials for early embryonic development
- Eggs have specialized ECM forming protective outer coat; species specific sperm barrier in some cases (Fig. 20-21)
- Eggs are totipotent cells once activated by sperm or parthenogenesis
- Egg cytoplasm can even reprogram somatic cell nucleus to direct embryonic development (basis of animal cloning, e.g., Dolly)

Eggs are the end products of oogenesis (Fig. 20-22)

- PGCs that migrate into genital ridge of female embryo during early embryogenesis become oogonia
- Oogonia proliferate by mitosis, then become primary oocytes (at 3-8 months of gestation in human female embryos)
- Primary oocytes begin meiosis division I; arrest in prophase for days or years depending on animal species/time to sexual maturity
- During prophase I, primary oocytes grow, synthesize a protective coat, accumulate ribosomes, cortical granules, mRNA, and proteins (Fig. 20-24) (often receive products from neighboring support cells, e.g. nurse & follicle cells; Fig. 20-23)
- Large nonmammalian oocytes also accumulate yolk, lipids, glycogen
- In sexually mature female, hormones trigger primary oocytes to mature and complete meiosis division I; each generates a secondary oocyte and a polar body (asymmetric cytokinesis)
- In most vertebrates, secondary oocytes are arrested at metaphase of division II until ovulation (release of mature egg from ovary) and fertilization
 - Fertilization triggers anaphase of division II to generate female pronucleus and second polar body

Spermatozoa are end products of spermatogenesis

- Sperm are compact, mobile cells specialized for fertilization of egg, delivery of paternal DNA to egg (Fig. 20-25, -26)
- Sperm develop from PGCs that migrate into genital ridge of male embryo (Fig. 20-27)
- In contrast to oogonia, spermatogonia do not enter meiosis until sexual maturity/puberty, and thereafter, enter meiosis continually (pool of spermatogonia maintained by continuous mitotic divisions of stem cells)
- In contrast to oogenesis, each primary spermatocyte generates 4 haploid spermatids (Fig. 20-27) (in humans, these take 5 wks to differentiate to mature spermatozoa/sperm after meiosis is complete)
- Spermatogonia and spermatocytes remain connected by cytoplasmic bridges (no cytokinesis) so sperm differentiation is directed by full set of maternal and paternal gene products (Fig. 20-29)
- Spermatids escape into lumen of seminiferous tubules (Fig. 20-28) and finish maturation in the epididymis

Fertilization

- In order to fertilize an egg, sperm must undergo capacitation: alteration of sperm pm and motility induced by factors in female reproductive tract; takes 5-6h in humans
- sperm must bind and cross the zona pellucida in mammalian eggs; latter composed of mainly 3 glycoproteins: ZP1, ZP2 and ZP3.
- ZP3 responsible for species-specific binding of sperm to zona
- Acrosome reaction: on binding of sperm, ZP3 triggers Ca^{2+} influx into sperm and release of acrosome contents (hydrolytic enzymes) by exocytosis (Fig. 20-30, -31, -32; movie 20-2)
- The sperm provides centriole (unfertilized eggs lack one); this establishes the zygotic centrosome and, following fusion of male and female pronuclei, the zygotic mitotic spindle (Fig. 20-34, -35)

Terms to know:

gamete
vitelline layer, zona pellucida, cortical granules
oogonia, primary vs secondary oocytes
polar body
oocyte
ovulation, oviduct
nurse cells, follicle cells
spermatogonia, primary vs secondary spermatocytes
spermatid, spermatozoa
acrosomal vesicle, acrosome reaction
seminiferous tubules, epididymis
syncytium
fertilization
capacitation
polyspermy
cortical reaction
pronucleus
zygote

Figures to know:

Fig. 20-19 through -32, 20-34, 20-35
Movie 20-2 (CD)

WHAT'S NEXT: EMBRYOGENESIS!

(Chapt. 21: Development of Multicellular Organisms)