Reproductive System and Embryonic Development

Chapter 46-47

Reproductive System

• A population outlives its members only by reproduction, the generation of new individuals from existing ones.
• Sexual reproduction involves fusion of nonflagellated large egg with flagellated sperm to form diploid zygote. By producing offspring of varied phenotypes, sexual reproduction may enhance reproductive success of parents when environmental factors change relatively rapidly.
• Asexual reproduction does not involve any fusion of cells and is done by already diploid cells. Asexual reproduction is expected to be most advantageous in stable, favorable environments.

Types of asexual reproduction in animals:

1. **Budding** is a simple form of asexual reproduction found only among invertebrates. New individuals arise from outgrowths of existing ones.
2. **Fission**: Many invertebrates reproduce asexually by fission, separation of a parent into two or more individuals of about the same size.
3. **Fragmentation** is breaking of the body into pieces, some or all of which develop into adults.
4. Fragmentation must be accompanied by regeneration, regrowth of lost body parts.
5. **Parthenogenesis** is the development of a new individual from an unfertilized egg. It takes place in rotifers, honey bees and some lizards.

Ensuring the Survival of Offspring

• Internal fertilization is typically associated with production of fewer gametes but the survival of a higher fraction of zygotes.
• Internal fertilization is also often associated with mechanisms to provide protection of embryos and parental care of young.

A **cloaca** is a common opening between the external environment and the digestive, excretory, and reproductive systems. A cloaca is common in nonmammalian vertebrates; mammals usually have a separate opening to the digestive tract.

Sexual Reproduction:

**Gonads** are primary sex organs.

- **Testes** in males produce sperms and **Ovaries** in females produce eggs. Sperms and eggs are **gametes**, also called sex cells.

**Male Reproductive System**

It consists of a pair of testes, a pair of vas deferens, a pair of ejaculatory ducts, urethra, penis and associated glands seminal vesicles, prostate gland and bulbourethral glands.

**Testis**

- **Testes** are oval bodies lying in Scrotum, a skin pouch. This arrangement keeps the testes about 2⁰ F cooler than body temperature and is needed to produce viable sperms. Testes produce sperms and male hormone **Testosterone**. If the embryo secretes testosterone embryo grow into a male otherwise by default the sex of embryo is female. Testosterone is responsible for male characters including appearance.
Seminiferous tubules form sperms by meiosis. Seminiferous tubules → Epididymis → vas deferens → ejaculatory duct → urethra → ejection

**Spermatogenesis**

Seminiferous tubules form sperms by Spermatogenesis. Spermatogonial cells divide by mitosis and later by Meiosis to form sperms.
Primary spermatocytes → secondary spermatocytes → spermatids (n) → sperms (n).

**Sperm**

Sperms have Acrosome, head, midpiece and tail. Acrosome has hydrolytic enzymes to dissolve egg membranes. Head has the sperm nucleus. Middle piece has mitochondria and centrioles. Tail is a flagellum for swimming. Sperms enter vagina and swim through uterus to upper parts of oviduct or fallopian tubes where fertilization may take place.

**Glands**

**Seminal Vesicles**: produce 60% of semen. It has vitamin C, Fructose and prostaglandins.
**Prostate Gland**: is a single gland lying below bladder. It produces an alkaline solution which neutralizes acids of vagina.

**Erectile Tissue**: Corpora cavernosa are 2 anterior and Corpus spongiosum is posterior erectile tissues. Normally a little blood flows through them but release of NO causes these tissues to swell with blood.

**Impotence**: is the failure of penis to get erect or to remain erect during intercourse. Smoking and drug use increase the chance of impotence. Drugs like Viagra and Cialis restore temporarily this function.

**Sterility**: if a male cannot produce sperms or enough sperms to ensure fertilization he is called a sterile male.

**Hormones**

**Hormones**: Anterior pituitary gland secretes LH to stimulate Interstitial cells to release Testosterone. FSH to stimulates Seminiferous tubules to undergo spermatogenesis.

**Female Reproductive System**

It consists of a pair of ovaries, a pair of uterine = fallopian tubes, a uterus, a vagina and eternal genitalia.

**Ovaries** produce eggs in follicles. Follicles start developing before birth and stay in stage called primary follicles. Follicle stimulating hormone is secreted by anterior pituitary, initiates growth and maturation of follicles. Many follicles start maturing but only 1, the largest, releases the secondary oocyte with 1st polar body.

**Uterine = Fallopian tubes** draw egg through opening of fallopian = uterine tubes by beating cilia. Fertilization takes place in upper uterine = fallopian tubes.

**Uterus**: is the womb for development of baby. Both fallopian tubes lead to it. Uterus has smooth muscle fibers = myometrium and inner glandular and vascular tissue = Endometrium. The neck part of uterus protrudes into vagina and is called Cervix. In many women it becomes cancerous.

**Vagina** is genital duct used for intercourse and birth. The opening of vagina is partially closed by a mucous membrane, Hymen. Greater Vestibular glands secrete mucous to lubricate distal vagina.

**Oogenesis**
Primary oocyte (the cell ready to divide by meiosis) → secondary oocyte (has undergone Meiosis-1 and produced 1st polar body) → 2 Secondary oocyte → 1 ovum (unfertilized) and 2nd polar body. Follicles release female hormones called estrogens (Estradiol).

Follicles

Ovaries produce eggs in follicles. Follicles start developing before birth. Primordial follicles (before puberty) → primary follicles → growing follicles → Mature follicles (with large fluid filled space antrum). FSH = Follicle Stimulating hormone secreted by anterior pituitary initiates growth and maturation of follicles.

Ovulation: Many follicles start maturing but only 1, the largest survives and releases the secondary oocyte with 1st polar body.

Hormones

Anterior Pituitary secretes FSH and LH.
FSH = Follicle Stimulating hormone secreted by anterior pituitary initiates growth and maturation of follicles.
FSH also stimulates follicles to release Estrogens the female sex hormones.
LH stimulates ovulation and ruptured follicle (after ovulation) to form Corpus Luteum. Corpus luteum secretes Progesterone.

Ovarian Cycle: Ovaries have large number of follicles. Under the influence of FSH and LH some follicles start developing. Ultimately only one follicle reaches maturity. In most women ovarian cycle is of about 28 days. Ovulation is the release of secondary oocyte around 14th day of cycle.

Menstruation: Each ovarian cycle, under the influence of Estrogen and Progesterone hormones, uterus prepares for development of baby by growing glandular/vascular tissue called Endometrium. If there is no pregnancy corpus luteum degenerates. Therefore, no progesterone is secreted and endometrium is shed off as menstruation, a flow of blood and tissue.

Embryonic Development

1. Egg: Released secondary oocyte is covered by a non-cellular Zona Pellucida and Corona radiata formed of follicular cells. Fallopian tubes draws coelomic fluid in them by beating cilia and sperms can come in contact in proximal uterine tubes.
2. Fertilization is the formation of zygote from a sperm and an egg. Enzymes released by several sperms remove cells of corona radiata. The contact of 1st sperm results in Oocyte Activation. The sperm is engulfed and changes in egg membrane prevent entry of any further sperms. Secondary oocyte undergoes Meiosis-2 and produces the female pronucleus and 2nd polar body. Sperm produces male pronucleus. Spindle formation is initiated and degeneration of nuclear membranes results in intermixing of chromosomes of male and female pronuclei = Amphimixis. Fertilization is complete. The first diploid cell is called zygote.
3. The Acrosomal Reaction:
   a. The acrosomal reaction is triggered when the sperm meets the egg
   b. The acrosome at the tip of the sperm releases hydrolytic enzymes that digest material surrounding the egg
4. Blocks to Polyspermy: Gamete contact and/or fusion depolarizes the egg cell membrane and sets up a fast block to polyspermy
5. The Cortical Reaction:
6. **Cleavage** is the series of mitotic divisions that divide the zygote into $2 \rightarrow 4 \rightarrow 8 \rightarrow 16 \rightarrow 32$ and so on cells. At first a solid ball of cells, Morula is formed. The embryo continues to roll towards uterus.

7. The cells of morula continue to divide and rearrange to form a hollow ball of ball of cells called **Blastocyst**. **Blastocyst** is formed of about 150 cells. It has an inner mass of embryonic cells surrounded by extra-embryonic Trophoblast. Inner Mass develops into embryo. Trophoblast absorbs nutrient rich uterine fluid and participates in formation of extra-embryonic membranes. It takes 6-7 days to form Blastocyst after fertilization / conception. **Implantation**: Blastocyst reaches uterus and gets attached to inner wall of uterus called Endometrium.

8. **Gastrulation**: The 1st embryonic structure to possess 3 distinct germ layers is Gastrula. 3 germ layers are Ectoderm, Mesoderm and Endoderm. Each germ layer produces particular tissues/organs in embryo called fate of germ layers.

9. Ectoderm is layer facing amniotic cavity.
10. Endoderm is layer facing blastocoel.
11. Mesoderm is the 3rd layer formed between ectoderm and endoderm by migration of cells from the surface.
12. **Ectoderm** forms epidermis and associated glands, nails and hair, nervous tissue including brain and spinal cord, and mucous linings of mouth, anus and nasal cavities; pituitary and adrenal medulla.
13. **Mesoderm** forms muscles, bones and cartilages, heart and vessels, kidneys, gonads and secondary sex organs.
14. **Endoderm** produces Respiratory lining, thymus, thyroid, pancreas, liver, stem cells that produce gametes; distal portions of ducts of urinary and reproductive systems.
15. During pregnancy ovaries stop ovarian cycles and therefore no menstruation. It is 1st sign of pregnancy and can be confirmed with pregnancy kits testing urine.
16. **Gestation Period** = length of human development from day of fertilization is 270 days.
17. Early embryo is covered with embryonic membranes, amnion, chorion, yolk sac and allantois.
   1. **Amnion** surrounds amniotic fluid to cushion the embryo against shocks and protect against dehydration.
   2. **Yolk Sac** encloses yolk in chick. In humans produces blood cells in early embryo, later this function is taken over by liver.
   3. **Chorion**: Used for gas exchange. In mammals early embryo develops placenta, to get food and oxygen from mother’s blood and pass out wastes, from another embryonic membrane.
   4. **Allantois** collects wastes materials inside chick egg. It is reduced in humans and forms urinary bladder.

18. **Placenta**: Chorionic Villi enter into Endometrium. The composite of chorionic villi and Endometrium surrounding them form Placenta. The embryonic blood capillaries in chorionic Villi
and maternal capillaries in Endometrium lie very close to each other and exchange of materials (O₂, CO₂, glucose, amino acids, vitamins, urea and lot of others) takes place.

19. **Labor and Delivery**: Oxytocin hormone and many other factors initiate spasmodic contractions of uterine smooth muscle fibers termed Labor. The goal of labor is forcible expulsion of fetus from uterus = Parturition. Birth takes place after about 40 weeks from last menstruation.

20. **Dizygotic Twins**: result from fertilization of 2 separate eggs. They are like any other siblings, may be of same or different sexes. They have different combination of genes.

21. **Monozygotic or Identical Twins**: form from separated blastomeres of same zygote. They have similar genes and are of same sex and look alike.

22. **Sex Determination**: Human Male has 44 + XY chromosomes and female has 44 + XX chromosomes. Therefore, males make sperms of 2 types half with 22 + X chromosome and other half with 22 + Y chromosomes. Human females produce all eggs with 22 + X chromosomes. Fertilization of egg by a sperm with a X chromosome results in a girl fetus. Fertilization of egg by a sperm with a Y chromosomes result in a boy fetus.