Chapter 27: Animal Reproduction & Embryonic Development

1. Male Reproductive System
2. Female Reproductive System
3. Basic Animal Development
4. Human Development
Asexual Reproduction

Asexual reproduction does **NOT** involve fusion of haploid sperm & egg.

Reproduction occurs via **mitotic** growth of cells from parent.

**Advantages:**
- avoids the “hassles” of courting, mating
- less energy expenditure

**Disadvantages:**
- no genetic diversity
- produces genetic clones of the parent
3 Types of Asexual Reproduction

Budding
- new individual “buds”, separates from parent

Fission
- parent “splits”, missing parts are regenerated

Parthenogenesis (e.g., male honey bees)
- haploid, unfertilized eggs develop via mitosis
Sexual Reproduction

Sexual reproduction requires the fusion of haploid sperm & egg.

- genetically unique gametes produced by meiosis

Advantages:
- genetic diversity in the population
- favors species survival amidst change

Disadvantages:
- very competitive, not everyone will reproduce
- extra energy to produce lots of gametes, compete for mates
Internal vs External Fertilization

Most aquatic species reproduce sexually via fertilization outside the parents’ bodies
  • requires a watery environment
  • aka “spawning”
  • requires synchronization of gamete release
  • requires lots and lots of gametes

Other species rely on fertilization inside the female
  • land animals, and some aquatic species
  • requires less gametes (due to their being “contained”)
1. Male Reproductive System
Male Reproductive System

- Production & delivery of male gametes (sperm)
- Testis
- Epididymus
- Vas deferens
- Seminal vesicle
- Prostate
- Bulbourethral gland
- Urethra

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Male Reproductive Organs

- **Testes**: sperm, hormone production, primary male reproductive organ (gonad)
- **Epididymus**: sperm storage & maturation
- **Vas deferens**: conducts sperm to prostate
- **Seminal vesicle**: secretes fructose, prostaglandins to nourish, protect sperm
- **Prostate**: adds more fluids to semen, helps propel semen during ejaculation
- **Bulbourethral gland**: adds alkaline mucus
- **Urethra, Penis**: conduct, deliver semen to female reproductive tract
Spermatogenesis

In seminiferous tubules:

1) **spermatogonia** give rise to **primary (1°) spermatocytes**

2) **1° spermatocytes undergo meiosis I** to produce **secondary spermatocytes**

3) **2° spermatocytes undergo meiosis II** to produce **spermatids**

4) **spermatids differentiate into mature sperm**

***begins at puberty, continues throughout adulthood***
Summary of Spermatogenesis

spermatogonium

primary spermatocyte

secondary spermatocytes

spermatids

sperm

Meiosis I

Meiosis II

Differentiation
The Sperm Cell

**Acrosome**
- enzyme-filled vesicle necessary to penetrate the egg

**Nucleus**
- haploid genome (1n)

**Midpiece**
- many mitochondria

**Flagellum**
- propels the sperm

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Hormonal Control

Beginning at puberty:

• Gonadotropin-Releasing Hormone (GnRH) from hypothalamus triggers release of Follicle Stimulating Hormone (FSH) & Leutinizing Hormone (LH) from anterior pituitary

• this triggers sperm & Androgen (testosterone) production in testes
2. Female Reproductive System
Female Reproductive System

- **ovary**
- **oviduct**
- **uterus**
- **vagina**
- **cervix**

Production of hormones & female gametes, support & giving birth to young
Female Reproductive Organs

Ovaries → egg, hormone production, primary female reproductive organ (gonad)

Oviduct → ciliated pathway from ovary to uterus, site of fertilization (aka “Fallopian tubes”)

Uterus → inner lining (endometrium) nourishes fetus (breaks down at menstruation), outer muscular layer (myometrium) essential for giving birth (i.e., labor & contractions)

Cervix → entrance to the uterus, closes off during pregnancy

Vagina → roles in sexual intercourse (receiving sperm) and child birth (aka “birth canal”)
Oogenesis (within ovarian follicles)...

1) **Oogonia** give rise to **primary (1°) oocytes**
   - occurs during fetal development (done by 3rd month)

2) 1° oocytes begin meiosis only to halt the process in prophase I
   - also occurs during fetal development

Beginning at puberty, once per month...

3) Several 1° oocytes finish meiosis I, begin meiosis II producing a **secondary (2°) oocyte (& polar body)**
   - the 2° oocyte is arrested in metaphase II

4) A 2° oocyte ("egg") is released at ovulation
   - meiosis II is completed only after fertilization
Oogenesis & Meiosis

Only 1 cell per meiosis becomes an egg cell...

...the other 3 cells become inactive polar bodies

Meiosis I  Meiosis II (after fertilization)

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Secondary Oocyte

- released at ovulation
- has not completed Meiosis II
- surrounded by follicular cells (corona radiata) & jelly-like zona pellucida
- barrier to be penetrated by sperm cells
- much larger than sperm
Oogenesis in the Ovary

- Start: Primary oocyte within follicle
- Growing follicles
- Corpus luteum
- Degenerating corpus luteum
- Secondary oocyte
- Ovulation
- Mature follicle
- Ruptured follicle
- Ovary
Menstrual Cycle

Hormones regulate menstruation through effects on follicle and uterine development:

- hypothalamus and pituitary gland (brain)
- GnRH          FSH, LH
- developing follicles & corpus luteum (ovary)
- estrogen, progesterone

**w/o pregnancy, hormone levels fall, endometrium & corpus luteum degenerate**
Ovarian cycle

Menstrual (Uterine) cycle

if NO implantation of embryo
3. Basic Animal Development
Stages of Animal Development

Fertilization
  • union of sperm and egg to form a zygote

Cleavage
  • cell divisions partition egg into a multicellular morula which hollows out to become a blastula

Gastrulation
  • involution of cells to form multiple germ layers

Organogenesis
  • development of specific tissues & organs

Growth
  • growth in size that precedes birth
Fertilization

1. The sperm approaches the egg
2. The Sperm’s acrosomal enzymes digest the egg’s jelly coat
3. Proteins on the sperm head bind to egg receptors
4. The plasma membranes of sperm and egg fuse
5. The sperm nucleus enters the egg cytoplasm
6. A fertilization envelope forms

- fusion of sperm & egg membranes results in prevention of fertilization by other sperm
- complementary receptors on egg & sperm prevent fertilization between species (receptors must “match”!)
Cleavage

- a series of rapid cell divisions (mitosis) without any growth in size
- partitions the huge amount of cytoplasm in the zygote into several thousand smaller cells of the morula
- morula “hollows out” to form a blastula (or blastocyst)
During oogenesis, RNA & proteins that effect gene expression are deposited **unevenly** within the egg.

- due to uneven “packaging” of the egg by follicle cells
- following cleavage, each new cell contains a unique set of regulatory factors resulting in the expression of a unique set of genes!
Gastrulation

- cells migrate internally through a “blastopore” to form the 3 germ layers

**essential** for subsequent tissue & organ development

(b) Cells migrate at the start of gastrulation. Cells migrating in will form the endoderm and mesoderm layers of the gastrula; the cells remaining on the surface will form ectoderm.

(gastrulation in a frog egg)

(c) Mesoderm differentiates.
The 3 Germ Layers

Gastrulation produces the 3 germ layers:

**Ectoderm**
- outermost layer
- gives rise to skin and nervous system

**Mesoderm**
- middle layer
- gives rise to muscle, bone, blood…

**Endoderm**
- innermost layer
- gives rise to gut, lungs, digestive organs
### Fates of the 3 Germ Layers

#### Table 37-2 Derivation of Adult Tissues from Embryonic Cell Layers

<table>
<thead>
<tr>
<th>Embryonic Layer</th>
<th>Adult Tissue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ectoderm</td>
<td>Epidermis of skin; hair; lining of mouth and nose; glands of skin; nervous system</td>
</tr>
<tr>
<td>Mesoderm</td>
<td>Dermis of skin; muscle, skeleton; circulatory system; gonads; kidneys; outer layers of digestive and respiratory tracts</td>
</tr>
<tr>
<td>Endoderm</td>
<td>Lining of digestive and respiratory tracts; liver; pancreas</td>
</tr>
</tbody>
</table>
Organogenesis

- the proper arrangement of the germ layers allows the induction of specific tissues & organs, beginning with the central nervous system (neural plate > neural tube...).
4. Early Human Development
The 1st 2 Weeks

The fertilized egg (zygote) undergoes cleavage to produce a ball of cells called a **morula**

The morula develops into a hollow **blastocyst** which implants in the uterus

- in the endometrium of the uterus

**human chorionic gonadotropin (HCG) released by embryo puts menstruation “on hold”**
By the 3rd Week...

Gastrulation has occurred, all 3 germ layers present

extraembryonic membranes & placenta begin to form
By the 5th Week...

placenta is fully formed, eventually limited to one side
Exchange in the Placenta

- gases, nutrients & wastes pass from mother to fetus, fetus to mother, largely by diffusion
By the 8th Week...

Embryo begins to look human, now called a “fetus”

Most major organs have begun their development
Childbirth

**Estrogen**
(from ovaries)
- Induces oxytocin receptors on uterus

**Oxytocin**
(from fetus & pituitary)
- Stimulates uterus to contract
- Stimulates placenta to make Prostaglandins
- Stimulate more contractions of uterus

Positive feedback:
1) Dilation of the cervix
2) Expulsion: delivery of infant
3) Delivery of placenta
Key Terms for Chapter 27

• budding, fission, parthenogenesis

• testes, epididymus, vas deferens, seminal vesicle, prostate, bulbourethral gland, urethra

• spermatogonia, primary, secondary spermatocytes, spermatids

• ovaries, uterine tube, uterus, cervix, vagina
• oogonia, primary, secondary oocytes

• cleavage, morula, blastula, gastrulation

• endoderm, mesoderm, ectoderm

Relevant Review Questions: 1-13