

## Chapt. 46 – Animal Reproduction

### How does the human reproductive system work?

Mammals, including humans produce gametes in paired organs called gonads

In males: **testes** (singular: **testis**); produce **sperm**

In females: **ovaries**; produce **eggs**

### HUMAN MALE REPRODUCTIVE TRACT [See Fig. 46.10]

**Testes** (in scrotum)

**Sperm; testosterone**

**Accessory structures**

**Seminal vesicles** →

**Prostate gland** → (together produce **semen**)

**Bulbourethral gland** →

**Epididymis** (sperm storage)

**Vas deferens** (connects **testes** to **urethra**)

**Testes produce sperm & testosterone** [See Fig. 46.12]

**Sperm** production occurs in **seminiferous tubules**

At **puberty**, **testosterone** production begins in **interstitial cells**

**Sertoli cells** regulate sperm production & nourish developing sperm

**Spermatozoa** are produced by **spermatogonia**

**Spermatogenesis**

**Spermatogonia** (2n) either undergo mitosis to produce new **spermatogonia**, or undergo meiosis to produce **sperm** (1n)

Human **sperm** – almost no cytoplasm; carries male DNA to egg DNA

**Head**

**Nucleus** – DNA

**Acrosome** – Enzymes

**Midpiece**

**Mitochondria** – Energy

**Tail**

**Flagellum** – Propeller

### HUMAN FEMALE REPRODUCTIVE TRACT [See Fig. 46.9]

**Ovaries**

**Eggs; estrogen / progesterone**

**Accessory structures**

Receive & move **sperm** to **egg** & nourish developing **embryo**

**Vagina** – receives sperm

**Fallopian tubes (oviducts)** – sites of fertilization

**Uterus** – site of development of embryo

**Oogenesis** – formation of egg cells via meiosis [Fig. 46.11 & 13]

It has long been thought that women have all their primary oocytes (halted at Prophase of Meiosis I) by the time they are born

### Monthly menstrual cycle coordinates

- 1) maturation of several **eggs**
- 2) release of one **egg**
- 3) preparation of the **uterine lining** for possible **pregnancy**

### Hormonal control of the menstrual cycle:

Hormones from the brain's "**master gland**" (**pituitary**) initiate development of **egg-bearing follicles** in the **ovary**

**Estrogen** produced by egg-bearing follicles stimulates the growth of the **uterine lining**

**Ovulation** occurs on about day 14; remnants of ruptured **follicle** become the **corpus**

**luteum**, which produces both **estrogens** and **progesterone**

Combination of **estrogens** + **progesterone**:

- 1) Inhibits hormone release from **pituitary**, preventing development of more **follicles**
- 2) Stimulates further growth of **uterine lining**

If pregnancy does not begin:

- 1) The **corpus luteum** breaks down
- 2) **Estrogens** & **progesterone** levels fall
- 3) **Uterine lining** is shed as **menstrual flow**

### Fertilization may lead to pregnancy...

**Sperm** deposited in the **vagina** during **copulation** swim through the **uterus** into the **Fallopian tubes**, where they may encounter an **egg**

**Sperm** release **enzymes** that break down the barriers around the **egg** (**corona radiata** and **zona pelucida**)

Fusion of the nuclei of an **egg** and one **sperm** (**fertilization**) produces a **zygote**

If **pregnancy** begins, the **embryo** secretes a hormone that prevents the breakdown of the **corpus luteum**

**Corpus luteum** continues to produce **estrogens** and **progesterone**, so the **uterine lining** continues to grow and develop

Most pregnancy tests detect the presence of a hormone produced by the embryo – and present in the woman's urine

### Fetal development...

The inner wall of the **uterus** together with **embryonic tissues** become the **placenta**, which transfers oxygen, carbon dioxide, nutrients and wastes between the mother and the developing **fetus** [Fig. 46.16]

### Two basic reproductive modes:

#### Asexual reproduction

- Requires only one parent
- Offspring are genetically identical to parent and to each other

### **Sexual reproduction**

- Requires meiotic cell division in two parents
- Produces genetically variable offspring, with different combinations of parental genes

### **Asexual reproduction: budding**

Occurs in sponges and some cnidarians (*e.g.*, *Hydra*)

Miniature animal begins as a bud on an adult, then becomes independent

### **Asexual reproduction: fission followed by regeneration**

Occurs in some cnidarians, flatworms, and some segmented worms (annelids)

Body splits into two or more pieces

Each piece regenerates any missing body parts

### **Asexual reproduction: parthenogenesis**

In rotifers, as well as some insects, fish, amphibians and reptiles the eggs produced by females develop directly into adults without being fertilized by sperm

This process is called **parthenogenesis**

*E.g.*, aphids, some whiptail lizards, honeybee production of fertile males (drones)

### **Sexual reproduction requires fusion of sperm & egg**

Requires the production of **gametes** (egg and sperm), which are haploid (1n) cells

Gametes are produced from diploid (2n) cells by meiosis

Fusion of egg and sperm (**fertilization**) produces a diploid zygote, which divides by mitosis and develops into new diploid animal

Some organisms are **hermaphrodites**: they produce both eggs and sperm & can self-fertilize  
*E.g.*, tapeworms

Some **hermaphrodites** cannot self-fertilize and so must exchange sperm to fertilize each other's eggs

*E.g.*, some snails

Most animals are **dioecious**, with separate females and males

*E.g.*, ducks

**Females** produce large, non-motile **eggs**, that contain food reserves

**Males** produce small, motile **sperm**, with no food reserves

### **External fertilization: Spawning**

Union of sperm and egg takes place outside the bodies of the parents

External fertilization is common in animals that live in water

Release of sperm and eggs into the water is called **spawning**

Release is often synchronized using environmental cues (*e.g.*, seasons, tides)

*E.g.*, grunion, coral

### **External fertilization: Amplexus**

Male frogs mount females in a pose called **amplexus**

Female releases eggs and male then releases a cloud of sperm over them

### **Internal fertilization**

Important adaptation to life on land  
Fertilization occurs inside female's body

**Copulation:** Male deposits sperm directly into female's reproductive tract

## Chapt. 47 – Animal Development

**NOTE:** You should review **growth, differentiation, and morphogenesis** (*i.e.*, **development**) in angiosperms (multicellular flowering plants) from Chapt. 35; see the chapter outline for Chapt. 35 for those details.

**NOTE:** You are strongly encouraged to examine and know the details in figures listed from Chapt. 21, since they illustrate concepts that are assumed as background for Chapt. 47.

**Growth, differentiation, and morphogenesis** also occur during the **development** of multicellular organisms...

*E.g.*, from a single-celled zygote (about the size of a period on a printed page) to a fully mature adult human

Cell division alone would simply result in a growing mass of identical cells

Development produces cells of different types, arranged in a particular three-spatial dimensional pattern and appearing in a particular temporal pattern **[Fig. 21.4]**

All of the autosomal cells of a given organism share the same genetic material (the organism's genome)

Differentiation and morphogenesis result from differences in **gene expression** among cells, *i.e.*, different portions of the common genome are **expressed** in different cells

Differentiation occurs as **tissue-specific proteins** are produced, some of which are **transcription factors**

*E.g.*, skeletal muscle cells **[Fig. 21.10]**

**Transcription factors** = regulatory proteins that can “switch on” developmental cascades by causing gene expression

*E.g.*, stem cells used in medical research and treatment **[Fig. 21.9]**

This example also illustrates the critical nature of the **environment** for a cell's differentiation  
The environment determines which genes are expressed

The internal **and** external environments influence gene expression

*E.g.*, differences in the chemical constitution of a cell's cytoplasm received from the parent cell cause divergent differentiation in the daughter cells **[Fig. 21.11 & 47.24]**

*E.g.*, **induction** by signals from other cells causes selective gene expression [Fig. 21.11 & 47.25]

Consider this classic example from Hans Spemann and Hilde Mangold (1920s)

A piece from the dorsal side of a nonpigmented newt gastrula was transplanted to the ventral side of a pigmented gastrula

A secondary embryo developed on the primary embryo's ventral side

The secondary embryo's tissues were largely derived from the primary embryo's gastrula, indicating that induction from the cells of the small piece of transplanted non-pigmented gastrular tissue "triggered" or "switched on" the developmental cascade that caused the development of the secondary embryo

As specific genes are expressed, owing to the particular environment a cell experiences, tissue-specific proteins are produced that cause changes in a differentiating cell

*E.g.*, a tube, such as the neural tube in vertebrates, may form from cells in a single layer becoming wedge shaped [Fig. 47.19]

In this example, tissue-specific proteins including those forming microfilaments and microtubules, cause the cells to change shape

A major difference in morphogenesis in plants and animals is that only in animals do some cells change position within the developing organism

In this example, cell shape and positional changes result in a sheet of cells becoming narrower and longer [Fig. 47.20]

As cells change shape and position, embryologists have used dyes to create fate maps of regions of cells [Fig. 47.23a] and individual cells [Fig. 47.23b]

Developmental biologists have also discovered that molecular cues convey positional information to cells, informing cells of their positions relative to other cells in the developing body

For example, cell-specific gene expression in this chick's wing depended and continues to depend upon cells' positions relative to other cells in 3D [Fig. 47.26]

Vertebrate limbs, like a chick's wing, begin as bumps of tissue known as **limb buds**

Two main **organizer regions** of cells send chemical signals that form concentration gradients that define two of the main **spatial axes** of the developing limb

The apical ectodermal ridge (AER) defines the proximal-distal axis

The zone of polarizing activity (ZPA) defines the anterior-posterior axis

Development isn't restricted to embryonic and juvenile states; it occurs throughout the lifetime of an organism...

*E.g.*, in all organisms some cells are continually being replaced (*e.g.*, red blood cells in humans)

*E.g.*, in humans one's behavior changes throughout one's lifetime