Animal Reproduction

Reproduction

- Each earthworm produces sperm and eggs; in a few weeks, new worms will hatch from fertilized eggs.
- Animal reproduction takes many forms.
- Aspects of animal form and function can be viewed broadly as adaptations contributing to reproductive success.

Asexual and sexual reproduction

- Sexual reproduction is the creation of an offspring by fusion of a male gamete (*sperm*) and female gamete (*egg*) to form a *zygote*.
- Asexual reproduction is creation of offspring without the fusion of egg and sperm . One parent *clones* offspring.
- Many invertebrates reproduce asexually by *fission = separation of a parent into two or more individuals of about the same size*.

Asexual Reproduction

- *Budding* = new individuals arise from outgrowths of existing ones.
- *Fragmentation* = breaking of the body into pieces, some or all of which develop into adults.
- *Fragmentation must be accompanied by regeneration* = regrowth of lost body parts.
- *Parthenogenesis* is the *development of a new individual from an unfertilized egg*.

Sexual Reproduction

- Sexual females have half as many daughters as asexual females; this is the “twofold cost” of sexual reproduction.
- Despite this, almost all eukaryotic species reproduce sexually.

Reproductive Cycles

- **Ovulation** is the release of mature eggs at the midpoint of a female cycle.
- Most animals exhibit reproductive cycles related to changing seasons. Reproductive cycles are controlled by hormones and environmental cues.
- Animals may reproduce asexually or sexually, or they may alternate these methods.

- Sexual reproduction is a special problem for organisms that seldom encounter a mate.
- One solution is **hermaphroditism** = *each individual has BOTH male and female reproductive systems*.
- Some hermaphrodites can self-fertilize.
- Individuals of some species undergo sex reversals.
- Some species exhibit male to female reversal (for example, certain oysters), while others exhibit female to male reversal (for example, a coral reef fish).

- *Species with internal fertilization provide greater protection of the embryos and more parental care*.
- The embryos of some *terrestrial animals* develop in ***amniote eggs*** with protective layers.
- Some other animals retain the embryo, which develops inside the female.
- In many animals, parental care helps ensure survival of offspring.

Female Reproductive Anatomy

- The female external reproductive structures include the clitoris and two sets of labia.
- The internal organs are a pair of gonads and a system of ducts and chambers that carry gametes and house the embryo and fetus.

Ovaries

- The female gonads, the ovaries, lie in the abdominal cavity.
- Each ovary contains many follicles, which are egg chambers consisting of a partially developed egg, called an oocyte, surrounded by support cells.
- Once a month, an oocyte develops into an ovum (egg) by the process of oogenesis.

Oviduct and Uterus

- The egg cell travels from the ovary to the uterus via an oviduct, or fallopian tube.
- Cilia in the oviduct convey the egg to the uterus, also called the womb.
- The uterus lining, the endometrium, has many blood vessels.
- The uterus narrows at the cervix, then opens into the vagina.

Vagina and Vulva

- The vagina is a thin-walled chamber that is the repository for sperm during copulation and serves as the birth canal.
- The vagina opens to the outside at the vulva, which consists of the labia majora, labia minora, hymen, and clitoris.

Mammary Glands

- The mammary glands are not part of the reproductive system but are important to mammalian reproduction.
- Within the glands, small sacs of epithelial tissue secrete milk.

Male Reproductive Anatomy

- The male's external reproductive organs are the scrotum and penis.
- Internal organs are the gonads, which produce sperm and hormones, and accessory glands.

Testes

- The testes consist of highly coiled tubes surrounded by connective tissue. Sperm form in these seminiferous tubules. Leydig cells produce hormones and are scattered between the tubules.
- Production of normal sperm cannot occur at the body temperatures of most mammals. So the testes are held outside the abdominal cavity in the scrotum, where the temperature is lower than in the abdominal cavity.

Ducts

- From the seminiferous tubules of a testis, mature sperm pass into the coiled tubules of the epididymis.
- During ejaculation, sperm are propelled through the muscular vas deferens and the ejaculatory duct, and then exit the penis through the urethra.

Accessory Glands

- Semen is composed of sperm plus secretions from three sets of accessory glands.
- The two seminal vesicles contribute about 60% of the total volume of semen.
- The prostate gland secretes its products directly into the urethra through several small ducts.
- The *bulbourethral glands* secrete a clear mucus before ejaculation that neutralizes acidic urine remaining in the urethra.

Spermatogenesis-Oogenesis

- Spermatogenesis differs from oogenesis:
  - In oogenesis, one egg forms from each cycle of meiosis; in spermatogenesis four sperm form from each cycle of meiosis.
  - Oogenesis ceases later in life in females; spermatogenesis continues throughout the adult life of males.
  - Oogenesis has long interruptions; spermatogenesis produces sperm from precursor cells in a continuous sequence.

Animal Development

- It is difficult to imagine that each of us began life as a single cell (fertilized egg) called a zygote.
- A human embryo at about 6–8 weeks after conception shows development of distinctive features.

- Important events regulating development occur during fertilization and the three stages that build the animal's body
  - *Cleavage*: cell division creates a hollow ball of cells called a blastula
  - *Gastrulation*: cells are rearranged into a three-layered gastrula
  - *Organogenesis*: the three germ layers interact and move to give rise to organs.

Fertilization

- Fertilization brings the haploid nuclei of sperm and egg together, forming a diploid zygote.
- The sperm's contact with the egg's surface initiates metabolic reactions in the egg that trigger the onset of embryonic development:
  - Acrosomal Reaction
  - Cortical Reaction

The Acrosomal Reaction

- The ***acrosomal reaction*** is triggered when the sperm meets the egg.
- The *acrosome at the tip of the sperm releases hydrolytic enzymes that digest material surrounding the egg*.
- Gamete contact and/or fusion *depolarizes the egg cell membrane* and sets up a ***fast*** *block to polyspermy.*

The Cortical Reaction

- Fusion of egg and sperm also initiates the ***cortical reaction*:**
- This reaction induces a *rise in* Ca^{2+} that stimulates *cortical granules* to release their contents outside the egg.
- These changes cause formation of a *fertilization envelope* that functions as a ***slow*** *block to polyspermy***.**

Activation of the Egg

- The *sharp rise in* Ca^{2+} in the *egg's cytosol* increases the rates of cellular respiration and protein synthesis by the egg cell.
- With these *rapid changes in metabolism*, the egg is said to be activated.
- The sperm nucleus merges with the egg nucleus and cell division begins.

Fertilization

- Fertilization in mammals and other terrestrial animals is internal.
- In mammalian fertilization, the cortical reaction modifies the **zona pellucida**, the extracellular matrix of the egg, as a *slow block to polyspermy*.
- In mammals the first cell division occurs 12–36 hours after sperm binding.
- The diploid nucleus forms after this first division of the zygote.

Cleavage

- Fertilization is followed by **cleavage**, a period of rapid cell division without growth.
- Cleavage partitions the cytoplasm of one large cell into many smaller cells called **blastomeres.**
- The **blastula** is a ball of cells with a fluid-filled cavity called a **blastocoel.**

- The eggs and zygotes of many animals, except mammals, have a definite polarity.
- The polarity is defined by distribution of **yolk** (stored nutrients).
- The **vegetal pole** has more yolk; the **animal pole** has less yolk.

Gastrulation

- **Gastrulation** rearranges the cells of a blastula into a three-layered embryo, called a **gastrula**, which has a primitive gut.
- The three layers produced by gastrulation are called embryonic **germ layers:**
  - The **ectoderm** forms the outer layer
  - The **endoderm** lines the digestive tract
  - The **mesoderm** partly fills the space between the endoderm and ectoderm.

Organogenesis

- During **organogenesis**, various regions of the germ layers develop into rudimentary organs.
- The frog is used as a model for organogenesis.
- Early in vertebrate organogenesis, the ***notochord*** forms from mesoderm, and the ***neural plate*** forms from ectoderm.

Developmental Adaptations of Amniotes

- Embryos of birds, other reptiles, and mammals develop in a fluid-filled sac in a shell or the uterus.
- Organisms with these adaptations are called **amniotes.**
- Amniotes develop extra-embryonic membranes to support the embryo.

Amniotic egg: Extra-Embryonic Membranes

- During amniote development, four **extraembryonic membranes** form around the embryo:
  - The **chorion** *outermost membrane* / functions in gas exchange.
  - The **amnion** encloses the *amniotic fluid*.
  - The **yolk sac** encloses the yolk.
  - The **allantois** disposes of *nitrogenous waste* products and contributes to *gas exchange*.

Morphogenesis in animals involves specific *changes in cell shape, position, and adhesion*

Morphogenesis is a major aspect of development in plants and animals.

Only in animals does it involve the movement of cells.