Biology 20 Laboratory
Animal Reproduction

OBJECTIVE

- To study the various types of reproduction.
- To differentiate between asexual and sexual reproduction.
- To observe sperm, ova and the fertilization process of sea urchins.
- To study early embryonic development of sea urchins.
- To study the human reproductive system.

INTRODUCTION

Reproduction is the process by which new individuals of the same species are produced from pre-existing ones, resulting in an increase in the number of individuals. As you may recall, not all organisms have an equal opportunity to reproduce. Individuals within a species with phenotypes that are better suited for the given set of environmental conditions will reproduce more than those that are not as suited (differential reproduction). Thus, reproduction is a means of passing on genetic information from generation to generation. In this week’s lab we will examine two types of animal reproduction: asexual and sexual. Animals can reproduce exclusively by asexual or sexual, or alternate between them.

A. ASEXUAL REPRODUCTION

Organisms that reproduce asexually (a mitotic process) are often found in environments that have stable conditions. Individuals with the favorable phenotypes for that environment perpetuate the successful genotype by producing offspring genetically identical to itself (essentially a clone) in a short amount of time. There are three different types of asexual reproduction. Fission involves the separation of a parent into two or more individuals of the same size. All prokaryotes and some protozoans utilize this strategy. Budding occurs when a new individual grows out from the body of an existing one as a result of unequal division of the organism. The offspring either detaches or remains joined to form extensive colonies. Examples include freshwater hydra, corals and tunicates. Fragmentation is the breaking of the body into several pieces, each of which develops into a complete adult. This must be accompanied by regeneration (the regrowth of lost body parts). Examples include sponges, cnidarians, polychaete worms and tunicates. Sea stars can regenerate lost arms via mitosis (asexual), but that is not considered a form of reproduction to increase the population. However, if a sea star is cut in half, it can regenerate into two identical individuals because integral components are present. Organisms that cannot seek out mates (those that are sessile) or are active animals that have difficulty finding mates (such as when population density is low) will benefit from asexual reproduction. The disadvantage of asexual reproduction is the production of a genetically uniform population with little or no variation (diversity). If conditions change and become unfavorable, many in the population may die out.

Materials:
- Microscope, slide of Hydra budding, slide of prokaryote (non-animal) fission
Procedure:

1. Look at the prepared microscope slides of the *Hydra* and a prokaryote, draw what you see in each and answer the questions on your worksheet.
   Note: A prokaryote will be used to demonstrate fission due to time constraints.

B. SEXUAL REPRODUCTION

Sexual reproduction involves the production of offspring by the fusion of haploid gametes (sperm and ovum). Gametes are produced via meiosis. The fusion of the sperm and ovum (fertilization) results in the formation of a single diploid zygote. Sexual reproduction involves two individuals, each contributing genetic information to the offspring.

There are several types of reproductive strategies employed by animals. **Parthenogenesis** is a form of reproduction in which the ovum develops into a new individual without fertilization. Offspring produced are usually haploid. Certain species of bees, wasps, and ants utilize this strategy for social organization. Male drones are produced via parthenogenesis whereas sterile females and reproductive queens are produced from fertilized eggs. Among vertebrates, several species of fish, amphibians, and lizards also reproduce by parthenogenesis. There are 115 species of whiptail lizards (*Cnemidophorus*) that reproduce exclusively by parthenogenesis. There are no males, but female undergo mock copulatory behaviors depending on hormone levels. After meiosis, the ovum doubles the chromosome number and becomes diploid again.

**Hermaphroditism** is when an organism has both functional male and female reproductive systems, like the Greek goddess Aphrodite. Organisms that utilize this reproductive strategy often times cannot find members of the opposite sex, are sessile, burrowers, or are endoparasites. In most cases, individuals must fertilize another; however, some can fertilize themselves. Examples include barnacles (sessile), earthworms (burrower) and tapeworms (parasite).

**Sequential hermaphroditism** occurs when an individual reverses its sex during its lifetime. There are two types of sequential hermaphrodites. When individuals start out life as a female and change sex to male, this is called **protogynous**. A classic example is the wrasse (reef fish). If there is no male present, usually the largest, oldest female changes and becomes the dominant male and will begin to produce sperm within a week. When individuals start out life as a male and change to female, this is called **protandrous**. An example of a protandrous species is oysters. All oysters start out life as males due to their small size. As the oyster grows and attains a certain size, it will change into a female and produce eggs.

Materials:
- Microscope, depression slide, cover slip, sea urchin ova and sperm, whiptail lizard,

Procedure:

1. Obtain a depression slide and cover slip.
2. Place a drop of the fluid that contains the sperm on the depression slide and cover.
3. Obtain another depression slide and place a drop of the fluid that contains the ova (unfertilized eggs).
4. Draw what you see in each and answer the questions on your worksheet.
C. SEA URCHIN FERTILIZATION & DEVELOPMENT

In today’s lab, you will examine the embryonic development of an invertebrate, the sea urchin (Phylum Enchinodermata), from fertilization through several embryonic stages. The embryos of sea urchins are often used for embryological studies because they clearly show the basic stages in the early development of many types of animals, including mammals.

Fertilization is the union of the sperm and ovum nuclei (syngamy) to form the diploid zygote. There are two types of fertilization, internal or external. With external fertilization, eggs are shed by the female and fertilized by the male outside of the body. The release of gametes into the water occurs without any physical contact. Sea urchins are a typical organism that utilizes external fertilization. They are broadcast spawners that release lots of gametes into the water in the hopes that the gametes will become fertilized and develop before they are eaten. The release of gametes into the water occurs without any physical contact. Some vertebrates also utilize external fertilization, but may have courtship behaviors before gamete release (fish and amphibians).

With internal fertilization, sperm are deposited in or near the female reproductive tract and fertilization occurs within the female’s body. Organisms that utilize internal fertilization typically have more sophisticated reproductive systems. These organisms may have copulatory organs for sperm delivery and receptacles for sperm storage and transport. Many have specific reproductive signals and cooperative mating behaviors before copulation can occur.

Upon fertilization, the zygote is still undivided with its nucleus still intact. Just external to the plasma membrane of the zygote is the fertilization membrane which prevents the entry of other sperm. The fertilization membrane is formed when the nucleus of the sperm and ovum fuse (syngamy). The first cell division or cleavage takes place within 50 – 70 minutes. The embryonic cells resulting from the division of the zygote are called blastomeres. The second mitotic cleavage occurs in about two hours creating four cells. The third mitotic cleavage results in the eight cell stage. After the fourth cleavage, there is a solid ball of 16 cells called the morula (because it resembles a mulberry). The embryo is in the blastula stage when there are 32 to 64 cells. A fluid-filled, hollow space in the middle of the embryo will begin to develop during the blastula stage is called the blastocoel. Soon the cells will become arranged in a single epithelial layer around the blastocoel. The blastula stage will begin to undergo a suite of cellular changes into a double-layered gastrula. Gastrulation begins with the invagination of cells at the bottom (or the vegetal pole) into the blastocoel. This produces a tube of cells growing upward called the archenteron (primitive gut). The opening of the archenteron is called the blastopore and will develop into the anus of this animal first. In other types of animals the blastopore may develop into the mouth first. With the development of the archenteron, the developing embryo now has two layers of cells. These are two of the three embryonic germ layers that will ultimately give rise to all of the body parts of the adult.

The ectoderm is the outer layer, formed from the original blastula wall and gives rise to the skin and its derivatives (hair and nails) and the nervous system. The endoderm is the inner layer formed from the archenteron and will give rise to the internal organs such as the digestive system. The layer of cells between the endoderm and ectoderm is the mesoderm. This layer gives rise to organs that are typically located between the two other layers such as bone, blood and muscles. Vertebrates will continue further development of regions of the three germ layers develop into rudimentary organs during organogenesis.
**Protection of the embryo:**

After fertilization, the zygote undergoes embryonic development and the degree of protection varies from the type of organism and the method employed for fertilization. When there is no protective covering around the developing embryo, such as with external fertilization, there is a requirement for water or moisture to prevent desiccation and temperature stress. These organisms produce large numbers of zygotes with only a small amount surviving to complete development. The eggs are typically covered with a gelatinous coat for exchange of gasses, waste and water (fishes & amphibians). There is usually no parental care; however, some fishes will guard their eggs.

Vertebrates with internal fertilization will protect the developing embryo to a certain degree. Reptiles, birds and mammals can produce shelled eggs as an outer covering for protecting the embryo from desiccation and physical damage. Reptiles and monotremes (platypus and echidnas) have a leathery covering for their eggs, whereas birds have a hard shell composed of calcium. Organisms that lay eggs are **oviparous**. Some other animals are **ovoviviparous**, where the fertilized eggs are retained within the female's reproductive tract and then she gives live birth. Marsupials and placental mammals have their young begin embryonic development within the female’s reproductive tract without any leathery or hardened covering. They then give live birth (**viviparous**) to their young. Marsupial young are born after a short stint in the uterus. They crawl out of the vagina into the marsupium and attach to a teat to complete development. Placental mammals complete the entire embryonic development in uterus and then are born live. Organisms that give live birth produce fewer zygotes than those with external fertilization. There is often more parental care resulting in an increased chance of survival of the young through development. Mammals are not the only vertebrates that are capable of having live birth. Fishes and reptiles are also capable of live birth.

**Materials:**
- Live sea urchins, KCl, sterilized sea water, syringe, fingerbowls, depression slides

**Procedure:**

1. Obtain a depression slide.
2. Carefully place a drop of each solution: sperm and egg solution. **Be careful not to contaminate the droppers.**
3. Place a coverslip on the slide and observe under the microscope.
4. Find the following stages in the various solutions or prepared microscope slide. Draw and label the stages indicated below on your worksheet:
   a. Fertilized egg and fertilization membrane
   b. Two cell stage
   c. Four cell stage
   d. Eight cell stage
   e. Morula
   f. Blastula - blastocoel
   g. Gastrula – endoderm, mesoderm (if present), ectoderm, archenteron, blastopore
D. MALE REPRODUCTIVE SYSTEM

The male reproductive system consists of the testes, glands and ducts. The testes are the structures located within the scrotum that produce sperm, testosterone and other androgens (male hormones). When sperm are produce in the seminiferous tubules of the testes, they migrate to the epididymis, a comma shaped structure located in the scrotum, for maturation and storage. Upon ejaculation, the sperm move into the vas deferens (ductus deferens) to the urethra. The urethra passes into the penis and the ejaculate then passes to the outside world. As sperm is ejaculated from the epididymis, there are several glands that add their secretions to the ejaculate along with the sperm to form semen. This alkaline fluid provides the ideal environment for the sperm by providing nutrients, lubrication, etc.

Materials:
Labeled model of the male reproductive system.

Procedure:
1. Use the models in the laboratory to locate the following male reproductive parts and label them on the drawing in your worksheet:
   a. Testis
   b. Epididymis
   c. Vas deferens
   d. Urethra
   e. Penis
   f. Bulbourethreal (Cowper's) gland
   g. Prostate gland
   h. Seminal vesicle

E. FEMALE REPRODUCTIVE SYSTEM

The female reproductive system consists of the ovaries, fallopian (oviducts or uterine tubes) tubes, uterus and vagina. The ovaries produce unfertilized eggs (ovum = singular, ova = plural). Human females typically release only one ovum each month. The ovulated ovum then moves into the fallopian tubes by tiny, fingerlike projections called fimbrae. Once in the fallopian tube, sperm have approximately 24 hours to fertilize the ovum. If fertilization occurs, the zygote will begin to divide via mitosis and move towards the uterus, via ciliary action, for implantation in the endometrial lining of the uterus. The entrance of the uterus from the fallopian tubes is just below the rounded fundus. The dividing embryo will then implant into the enlarged main portion of the uterus, the body. The body leads into the cervix of the uterus that opens into the vagina.

Materials:
Labeled model of the female reproductive system.

Procedure:
1. Use the models in the laboratory to locate the following male reproductive parts and label them on the drawing in your worksheet:
   a. Ovary
   b. Fallopian tube and fimbria
   c. Uterus
   d. Cervix
   e. Vagina
A. ASEXUAL REPRODUCTION

1. Draw and label asexual reproduction of a *Hydra* and a prokaryote (non-animal).

2. What types of organisms undergo asexual reproduction to increase their numbers?

3. What is the advantage of asexual reproduction?

4. What is the disadvantage of asexual reproduction?

B. SEXUAL REPRODUCTION

5. Draw and label a sperm and an ovum.

   **SPERM**

   **OVUM**

6. What structure is utilized by the sperm for locomotion?
C. **SEA URCHIN FERTILIZATION & DEVELOPMENT**

7. Diagram the various stages of embryonic development in the sea urchin below:

<table>
<thead>
<tr>
<th>Zygote with fertilization membrane</th>
<th>Two cell stage</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 cell stage</td>
<td>8 cell stage</td>
</tr>
<tr>
<td>16 cell stage (morula)</td>
<td>Blastula</td>
</tr>
<tr>
<td>Early gastrula</td>
<td>Late gastula</td>
</tr>
</tbody>
</table>

8. What is the function of the fertilization membrane?

9. Are the cells in the blastomeres in the eight-cell stage the same as in the two-cell stage? *Explain why or why not.*
10. Which embryonic germ layer does your brain develop from? Skin?

11. The clownfish, *Amphiprion sp.*, live in colonies of several individuals with its host sea anemone. The largest most dominant individual is the female and the rest are males. When the female is removed, the second most dominant male, transforms into the female. What type of sexual reproductive strategy do they have?

12. What is the difference between a viviparous and ovoviviparous organism?

D. MALE REPRODUCTIVE SYSTEM

13. Label the diagram of the male reproductive system below:
14. Table 14.1: Sperm pathway and associated glands. Use the information from the movie, lecture or textbook in answering the function of the male reproductive parts.

<table>
<thead>
<tr>
<th>Organ/Duct</th>
<th>Activity or Secretion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Testis</td>
<td></td>
</tr>
<tr>
<td>Epididymis</td>
<td></td>
</tr>
<tr>
<td>Vas deferens</td>
<td></td>
</tr>
<tr>
<td>Cowper’s gland</td>
<td></td>
</tr>
<tr>
<td>Seminal vesicle</td>
<td></td>
</tr>
<tr>
<td>Prostate gland</td>
<td></td>
</tr>
<tr>
<td>Urethra</td>
<td></td>
</tr>
<tr>
<td>Penis</td>
<td></td>
</tr>
</tbody>
</table>

15. Testes develop inside the abdominal cavity and descend into the scrotum before birth. **Explain** why male mammals have their testes outside the abdominal cavity but within the external scrotum.

16. What structure is typically cut during a vasectomy?

17. What structures are common to both reproductive and excretory systems?

**E. FEMALE REPRODUCTIVE SYSTEM**

18. Where does fertilization take place?

19. Where does the fertilized egg implant?

20. List the path of a sperm on its way to “fertilize” an ovum.
21. Label the diagram of the female reproductive system below:

![Female Reproductive System Diagram](image-url)

22. Table 14.2: Female reproductive system. Use the information from the movie, lecture or textbook in answering the function of the female reproductive parts.

<table>
<thead>
<tr>
<th>Organ/Structure</th>
<th>Activity / Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ovary</td>
<td></td>
</tr>
<tr>
<td>Fallopian tube and fimbria</td>
<td></td>
</tr>
<tr>
<td>Uterus</td>
<td></td>
</tr>
<tr>
<td>Cervix</td>
<td></td>
</tr>
<tr>
<td>Vagina</td>
<td></td>
</tr>
</tbody>
</table>

23. What structure is cut when the “tubes are tied?” Describe this form of human female sterilization process.