

The background features several faint, overlapping silhouettes of fish swimming in various directions. A central horizontal band with a grey, textured background contains the title text. Two red circular accents are positioned on the right side of the slide.

# REPRODUCTION IN FISHES



# CONTENTS

- **Introduction**
- **Anatomy of the reproductive system**
- **Reproductive cycle and fertilization**
- **Care of the embryos**
- **Environment and reproduction**
- **References**

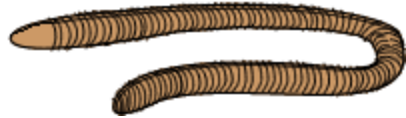


# INTRODUCTION

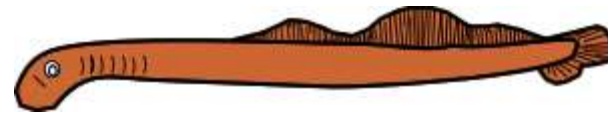
- Brief classification of fish species

Of the approximately 21,000 known species of fish, about 95% are teleosts (bony fish), about 4% are cartilaginous fish (sharks, rays) and about 1% are agnathans (jawless fish) and others.

**A. Agnathia** (very primitive e.g. Hagfish, lampreys)



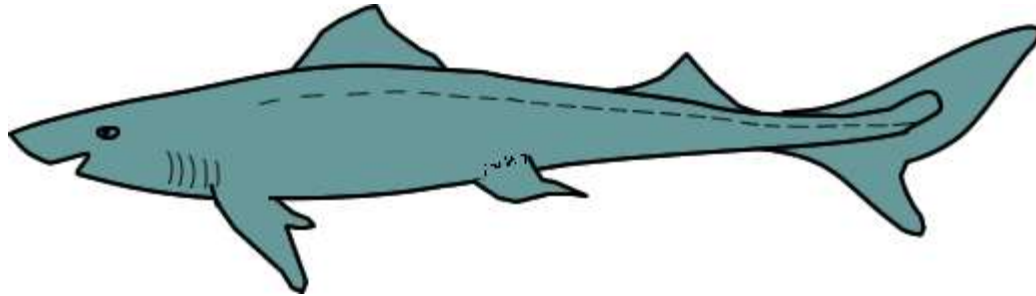
**Figure 1 - Hagfish**



**Figure 2 - Lamprey**



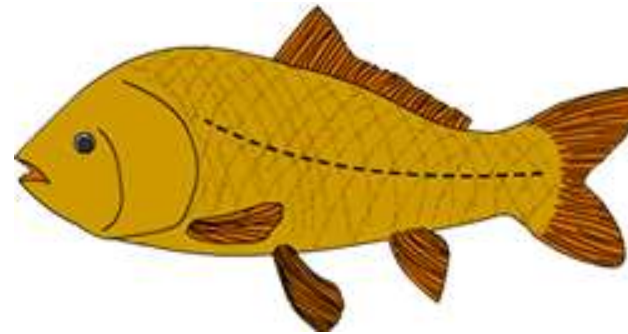
## B. Cartilaginous fish “Elasmobranchs” (sharks, rays)



**Figure 3 - Shark**

## C. Bony fish

1. Chondrostei (sturgeons, paddle fish)
2. Holostei (gar pike, bowfin)
3. Teleostei (most present day fish)
  - Salmonids (salmon, trout)
  - Cyprinids (carp, goldfish, catfish)
  - Cyprinodontids (guppy)
  - Percoids (cichlids, tilapia)



**Figure 4 - Teleost**



# Anatomy of the reproductive system :

## Male reproductive system:

### Elasmobranchs

❖ **Consists of testes, genital ducts, urogenital papilla, siphon sacs, claspers**

The testes are paired and suspended from the body wall by mesorchia .

Close to each testes lies the epigonal organ, which consists of lymphoid or hemapoietic tissues.

The testes consist of :

- 1- ampullae, which are arranged in zones of the spiny dog fish
- 2- many lobules separated by connective tissues

Only the cranial portion of the opisthonephros communicates with the testis.

The number of efferent ducts that lead to the ductus deferens varies according to species.

( The sexual part of the opisthonephros of elasmobranchs functions as the epididymis >> this leads into >> the ductus deferens.

Ductus deferens at its caudal end have diverticula ( serve as sperm storage organ “ sperm sac” ) or may have a wide ampulla .

The cranial part of the kidney forms a Leydig gland “ which secretes the seminal fluid “ composed of sperm + seminal plasma” .

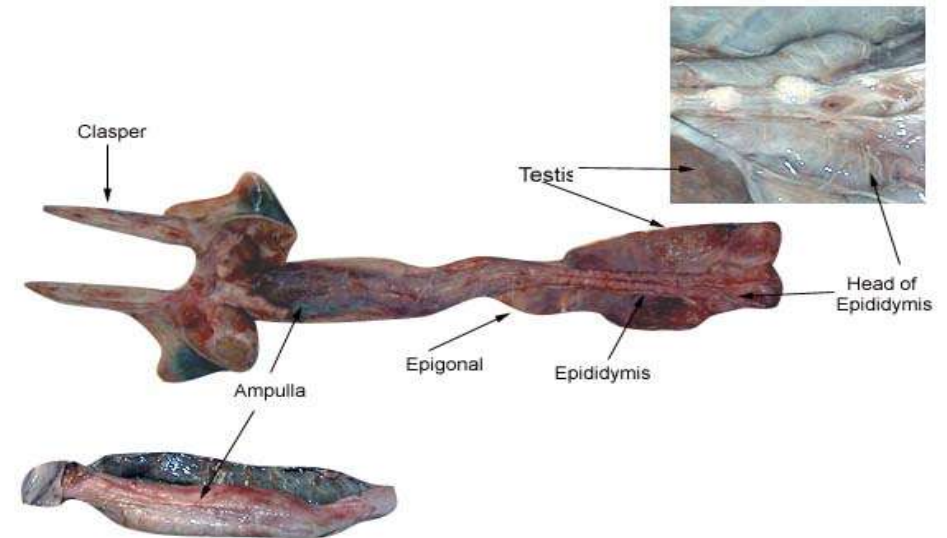
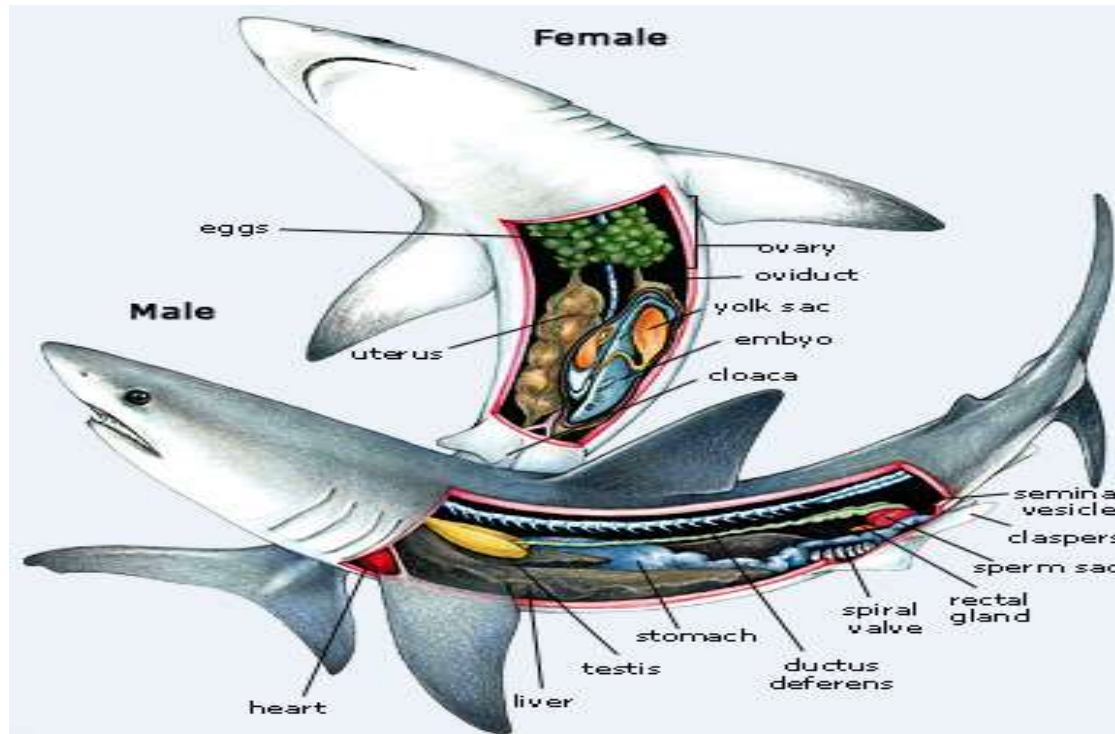
- This gland is not homologous with the Leydig cells of the higher vertebrates.

The sperm may be packed into spermatophores.



# The copulatory organs are very elaborate, they consist of :

- Claspers “ modifications of the pelvic fin”
- Siphon sac “ are paired structures in the pelvic area between the skin and the abdominal wall , they have muscular tissue and lined by a secretory epithelium”



# Teleosts:

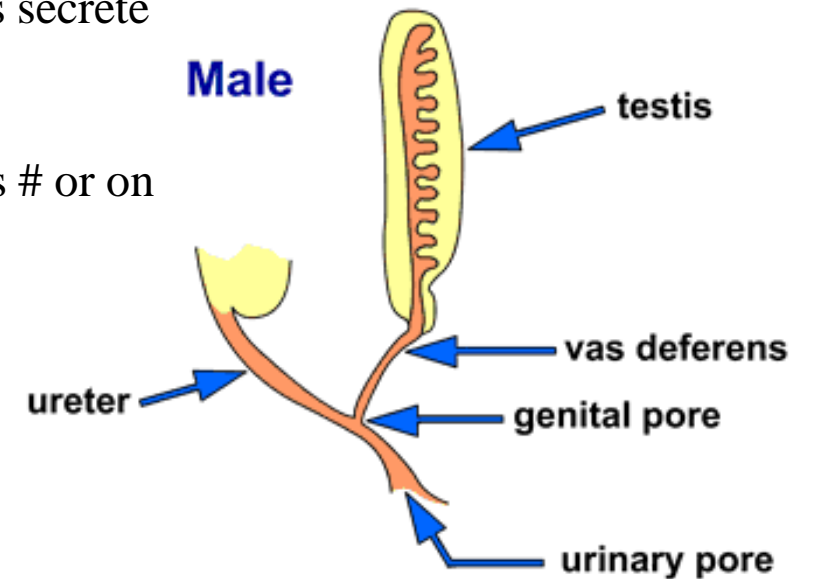
**There is no connection between testes and kidney in teleosts.**

## Testes:

- The testes of most species of teleosts are paired, but sometimes only one testis is present.
- The testes are oval or cylindrical or Y shaped or fingerlike organs
- Spermatogenesis takes place only in the anterior part. The posterior lobes secrete a fluid which seals off the vagina after mating.
- The testes are suspended by mesorchia.
- Classified on the basis of either the presence of acini (lobules) or tubules # or on the basis of the distribution of spermatogonia

## Spermatogonia :

Are present along the entire length of each tubule .



## **Sertoli cells :**

- Associated with Spermatogonia and when spermatogenesis begins these cells form the border of the cysts within which spermatogenesis occurs.
- Have several functions:
  - Nourishment of germ cells.
  - Production of steroids.
  - Phagocytosis of the residual bodies of spermatids.
  - In some cases, participation in the formation of efferent duct cells.

## **Sperm duct and ductus deferens:**

- do not produce secretions, but there are sometimes accessory sexual organs such as seminal vesicles
- the secretions of the seminal vesicles reach the exterior via >> sperm duct & genital papilla.





# The copulaory organ:

- The copulaory organ of teleosts varies from being absent in many groups to the bizarre priapus of the Phallostethidae (phallus = penis , stethus=chest)
- It may be formed by :
  - The genital papilla which may be elongated
  - Some brotulid fish have a penislike structure.
  - The anal fin may be modified to form organ called gonopodium“transfer of sperm into the female eproductive tract”



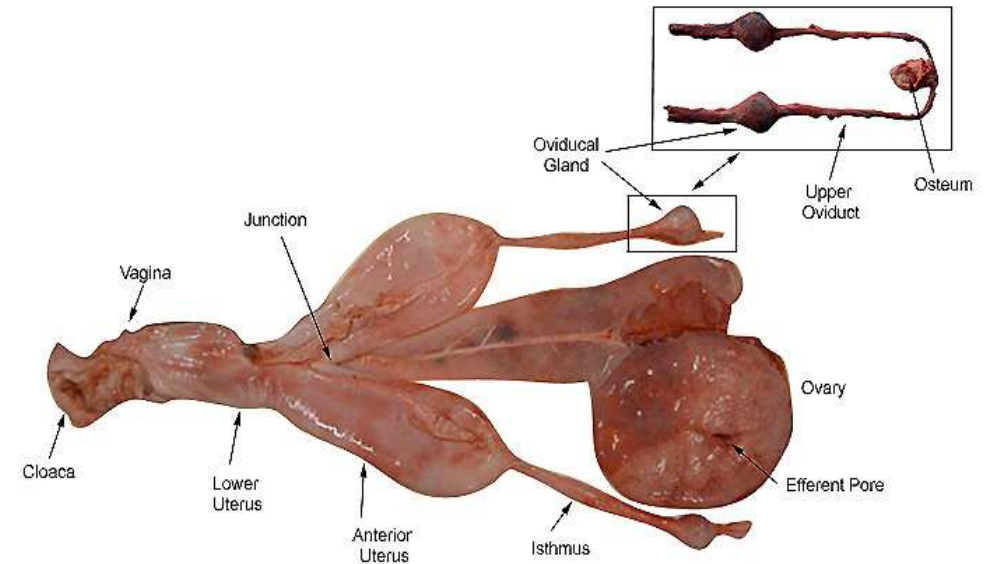
# Female reproductive system:

## Elasmobranchs

### Morphology:

In many species the ovary is large, unpaired organ, the left ovary fails to develop, but in some it is paired, in both oviducts are present.

- Ovaries are attached by a mesovarium to the dorsal body wall.
- Ovary contains :
  - follicles which as they enlarge and become yolked, are surrounded by a granulosa and two-layered theca.
  - Corpora atretica, which are derived from egg-containing follicles that have degenerated
  - Corpora lutea : which ruptured follicles that have reorganized into structures that resemble mammalian corpora lutea.
  - Functional corpora atretica: show luteinization and the presence of steroids “ found in ovoviviparous.

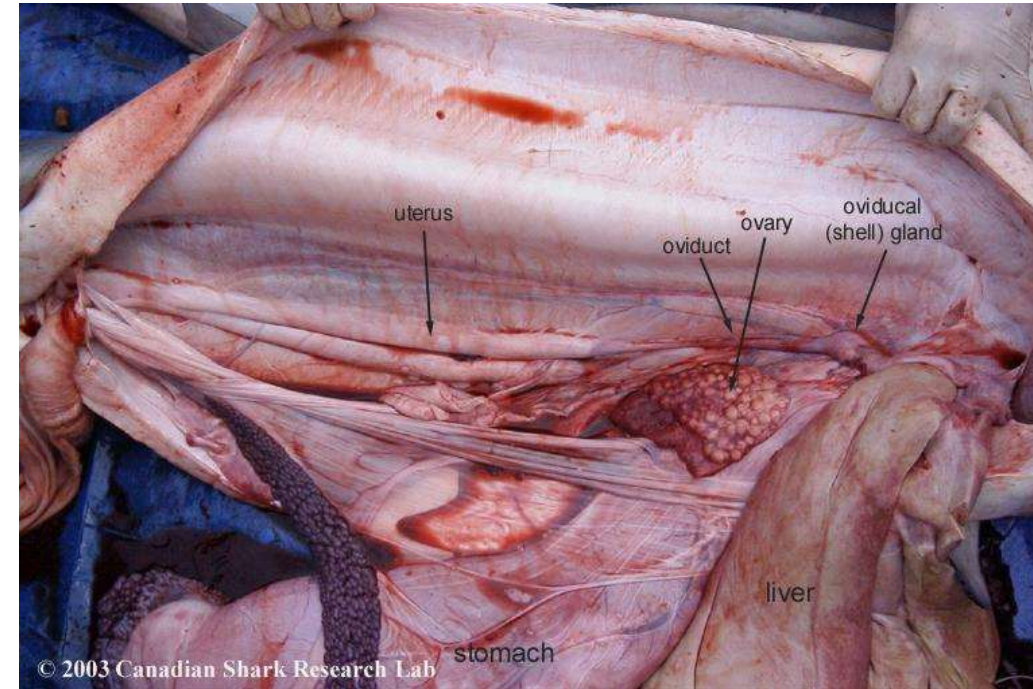


**- The oviduct has four regions:**

- Funnel >> collects the ovulated oocytes .
- Shell gland>> this structure is well developed in oviparous and ovoviviparous species “ its secretes albumin, mucus, egg proteins and may be its stored sperm”
- Isthmus >> connects the shell gland to the uterus.
- Uterus >> play a role in the nutrition of the embryos

**- The left and the right uterus may :**

- Fuse posteriorly and open into >> vagina then >> cloaca
- Open separately into >> cloaca



## **Pituitary control of ovarian cycles:**

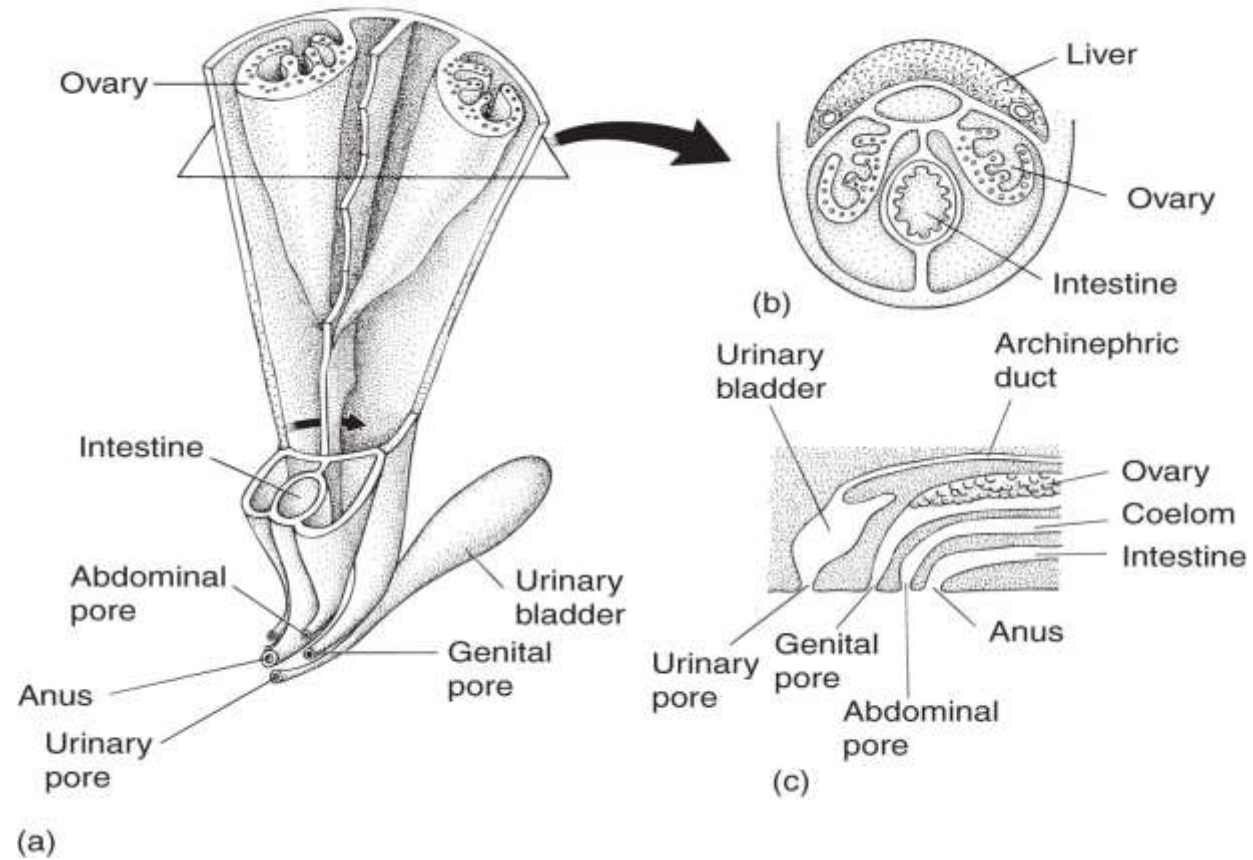
The ventral lobe of the elasmobranch pituitary is the source of gonadotropic hormone, and extirpation of this lobe in several species leads to inhibition of ovulation and atresia of vitellogenic oocytes ; small previtellogenic oocytes are not affected.

## **Teleosts**

### **Morphology**

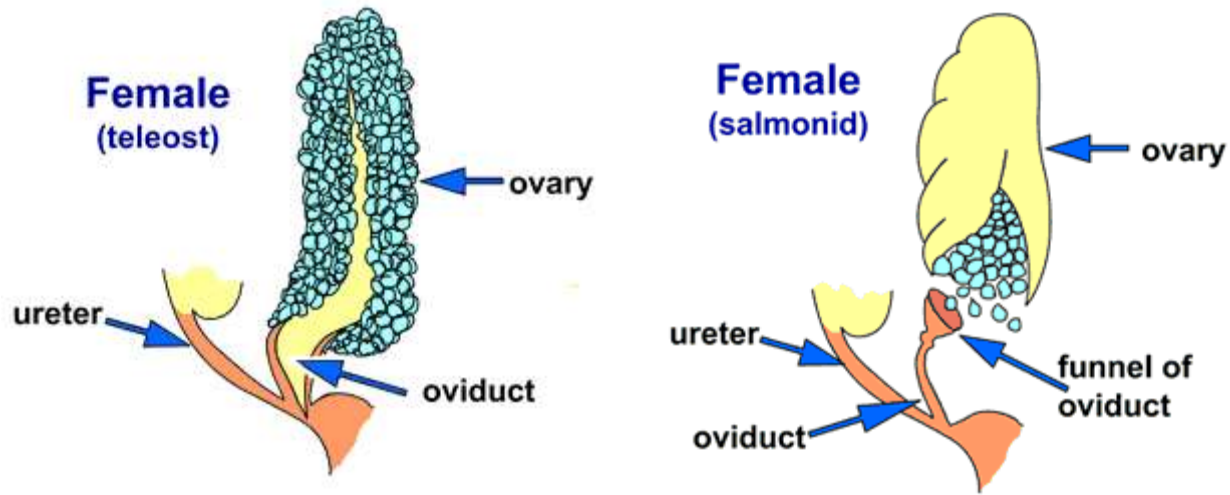
- ❑ Ovaries of many adult teleosts are paired , hollow organs suspended by mesovaria
- ❑ The ovary has a central cavity lined by germinal epithelium. Numerous connective tissue lamellae traverse the ovarian tissue and project to this cavity; >> lamellae are lined by germinal epithelium and contain “ cell nests” of oogonia.
  - Ovarian follicles develop along the lamellae
  - And oocytes are ovulated into the ovarian cavity
  - Externally , ovaries are covered by a muscular sac
- ❑ Oviducts: Ova travel from pocket down duct formed by peritoneal folds (not homologous to oviduct of other vertebrates) which leads to exterior
- ❑ Genital opening may be in various location
- ❑ Ovipositor: teleosts have some specialized and associated behaviors, e.g. the ovipositor “ a skinlike structure derived from the genital papilla .





Teleost reproductive system. Note how the ovary is enclosed within peritoneal folds that form a new ovarian duct.





Reproductive organs of female showing common pattern in teleosts (left) and pattern seen in salmonids (right)  
(after Hoar, 1969)



view of ovary showing multiple large eggs



# Reproductive cycle and fertilization :

- There is three type of reproduction in fish :

## 1- Viviparity

animals that give birth to live young that have been nourished inside the mother's body

examples: Mammals except for platypuses and echidnas, some reptiles and fish

## 2- Oviparity

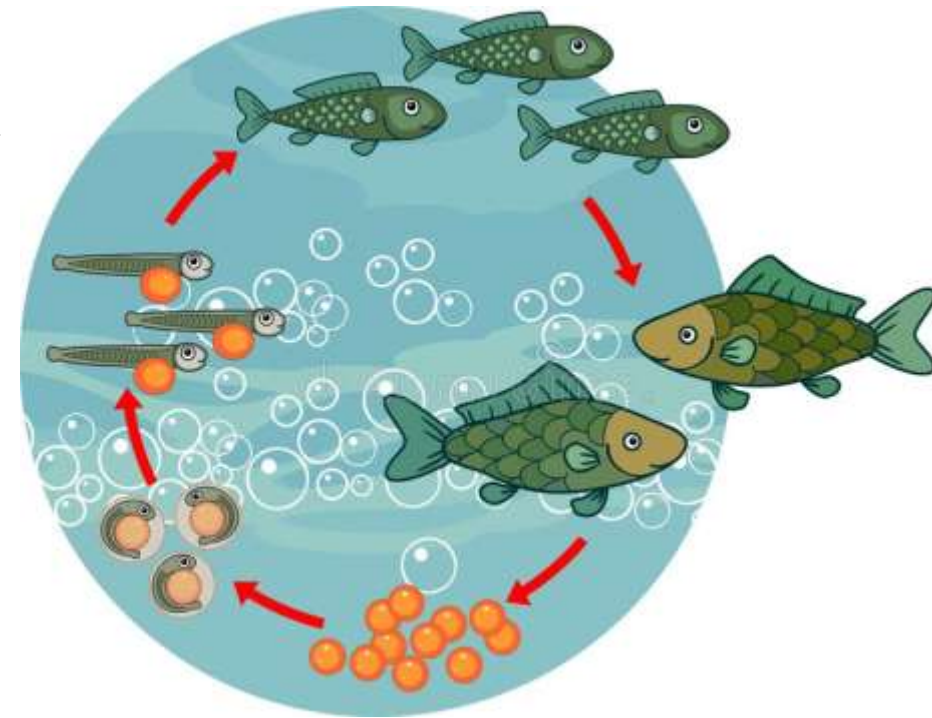
Oviparity- animals that lay eggs

Examples: Bird, insects, some amphibians, and most reptiles and fish

## 3- Ovoviviparity

like a combination of both. The young are hatched from eggs, but the eggs are kept in the mother's body until they are ready to hatch.

Ex: Many fish, reptiles, amphibians and invertebrates



## Elasmobranchs

Three types of cycles can be distinguished :

- 1- a cycle in which species reproduce throughout the year
- 2- a partially defined annual cycle
- 3- a well defined annual or biennial cycle.

- All elasmobranchs have internal fertilization
  - Improves likelihood and efficiency of fertilization
- Two main groups
  - 1-Oviparous (egg-laying)
  - 2-Viviparous (live-bearing)

### **External fertilization:**

- Male and female gametes are released into the surrounding medium in large numbers >> then the water may turn milky white >> there is no parental care.
- Or male and female gametes are brought in proximity e.g., seahorses when the female deposits the oocytes into pouch of the male.
- Spatial restriction of the release of gametes e.g., the male three – spined stickleback after building nest, chases the gravid female into nest, after which the female and male spawn succession





## Internal fertilization :

- Typically elasmobranchs have internal fertilization , with the claspers of the male acting as an intromittent organ.
- Much more reliable than the external fertilization ( where male and female gametes are just shed into the sea), this allowa the fish to concentrate its reproductive efforts in a small number of eggs each with a large supply of yolk.

## Oviparous Forms:

- Lay eggs on substrate or attach to bottom structures
- Nourished solely by yolk sac
- Small slit in egg case for ventilation & oxygenation

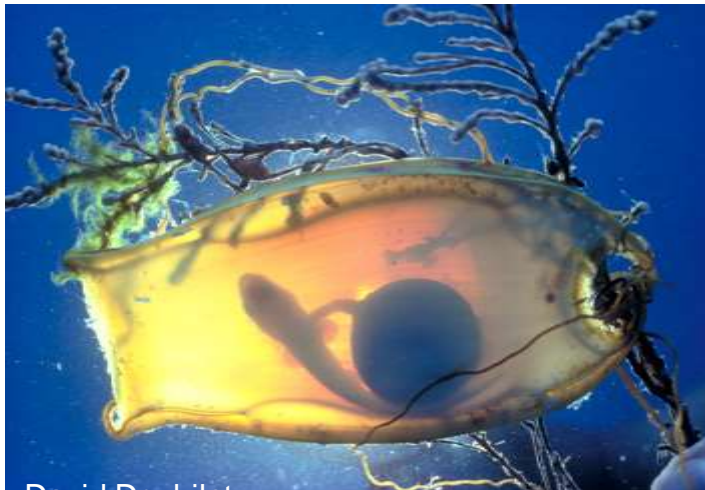


Cat shark egg case



## 1- Oviparity:

- Females store sperm, fertilization occurs in shell gland.
- Secrete egg case in shell gland.
- Paired eggs or multiple eggs, depending on species.
- Eggs in tough cases, attached to substrate, vegetation.
- Slit in egg case for water/O<sub>2</sub> circulation.
- External yolk sac for gestation, becomes internal in late stages.



Egg cases split open at 3 stages of development:

1. Immediately after egg-laying,
2. 3-4 months, yolk begins to be used,
3. 6-7 months, yolk absorbed internally,
4. Immediately post-hatch



## 2- Viviparity:

- Retain embryos in the uterus during entire period of development.
- Can be divided into placental and aplacental.

### Aplacental Viviparity:

- ❖ Also called ovoviviparous
- ❖ No placental connection
- ❖ Three types :
  - Depend solely on yolk reserves
    - Embryos depend solely on yolk
    - Embryos still in the uterus (protection)
    - Relatively small at birth
  - Oophagous
    - ✓ Ovary is huge, many small eggs
    - ✓ Uses yolk at first, then ingests other eggs
    - ✓ Fertilized and unfertilized
    - ✓ Large size at birth
  - Nourished through placental analogues



Black dogfish embryos



Porbeagle embryo



## Placental Viviparity

- Most advanced form aplacental
- Yolk-sac placenta attach to uterine wall
- ✓ - More efficient than just yolk-sac
- ✓ - Trophonemata structure grows from uterine lining - for nutrient supply, once embryo has absorbed all yolk
- ✓ - Trophonemata envelop anterior of embryo
- ✓ - enter gills/mouth, provide O<sub>2</sub>, waste removal and milk
- ✓ - Uterine milk (histotroph)
- ✓ - secreted by uterine epithelium, consists of lipids, proteins
- Provides high growth potential
- Found in about 30% of sharks



# Teleosts

## 1- Oviparous fishes

The reproductive cycle divides into two parts :

- Gametogenesis

- In salmonids, gametogenesis occurs during the summer and fall, at the time of decreasing photoperiod
- Decreasing photoperiod and temperature of about 16° C accelerate spermatogenesis.
- That associated with a small increase in plasma GTH and sharp rise in testicular weight and activity in male , and high estrogen concentration in female.

- Spawning

Most teleosts produce a very large number of yolky eggs at a time , the exact number depending on the food supply in the environment at the time .

The stimulus for ripening of the gonads is >>> supplied by pituitary hormones which depend for their secretion on seasonal environmental changes such as day length.

Behaviors in the mating : in some teleosts fish ( such as pipefish) the sexes are morphologically very different in the breeding season and reproduction may involve :

- Territorial behavior
- Courtship ceremonies
- Nest building



- Subsequent parental care :
  - Some species e.g., salmon build simple type of nest for their young
  - Some incubate their young within the buccal cavity
  - In the case of the pipefish , the young are reared in a special brood pouch by the males

## 2- viviparous fishes

- The eggs always develop within the ovary
- There are large variations between species in the food supply that the mother donates to the developing embryo after fertilization from very little to almost 100%
- The sequence and time intervals between ovulation, fertilization, hatching and parturition differ.. three principal patterns have been found :
  - Zoarces type pattern: ovulation occurs first the fertilization >> gestation period of about 25-30 days>> embryos hatch but retained until parturition occurs
  - Jenynsia type pattern: fertilization occurs in the follicle >> the fertilized oocyte is released >> the young hatch about 5-8 days later >>parturition occurs about a month after fertilization occurred
  - Gambusia type pattern: the oocyte is fertilized in the follicle >> gestation about month>> hatching and parturition then follow in relatively quick succession



# SEX HORMONES IN FISHES:

Reproductive processes in fishes , as in all vertebrates , are under the dual control of gonadotrophic hormones from :

- The pituitary
- Gonadal hormones from the gonads

<b>FSH</b> <b>Follicle stimulating hormone</b>	Controls ovarian function in the female
<b>Gonadal oestrogens</b>	plays a major part in sexually developing the female body through what is known as puberty
<b>prolactin</b>	Is found in fishes but it fuctions in osmoregulation and salt balance
<b>LH luteinizing hormone</b>	In teleosts

The teleosts pituitaries may secretes only one gonadotrpyn which is like mammalian luteinizing hormone (LH):

- (LH) >> can maintain vitellogenic follicles after hypophysectomy
- Induce germinal vesicle breakdown and ovulation in some species
- Mediated by estrogen secretion, e.g., stimulation og oogonial division and stimulation of hepatic synthesis and secretion of vitellogenin.



# CARE OF THE EMBRYOS :

## ▪ Elasmobranchs

Aplacental species of elasmobranchs have different ways of caring for embryo:

- When the yolk is provided serves as the entire source of nourishment .
- To obtain food during gestation is the eating of yolks or of embryos that follow the oldest or strongest embryo in the uterus.

placental species have a placental way of nutrient transfer.

## ▪ Teleosts

After external fertilization, the zygote may:

- ☞ simple be abandoned
- ☞ or they may be protected
- ☞ or protected and nourished

**Protective strategies:**

- ☞ Nest building
- ☞ Mouth breeding
- ☞ Skin incubation
- ☞ Incubation in another animal “ may be uses crab”



Bubble nest



Mouth breeding





## **PROTECTIVE AND NUTRITIONAL STRATEGIES:**

- Feeding on skin secretions
- Pouch breeding
- Nutrition from pseudoplacenta

## **Environment and reproduction:**

The reproductive success of organisms depends on the interaction between their genetic endowment and environment.

Nearly all studies on the environmental control of fish reproduction have, to date, focused on the roles played by various parameters of the natural environment, such as:

- changes in water temperature
- Photoperiod Long days and high water temperatures do not stimulate the gonads
- Pollution in water Many freshwater habitats, particularly rivers in urban areas, now receive substantial volumes of effluent from various sources (both industrial and domestic). This effluent can contain chemicals capable of mimicking endogenous hormones, and hence has the potential to disrupt endocrine-mediated processes such as reproduction.
- Tidal effects



## ▪ Tidal effects:

- In some species the grunion breeding season lasts from March to September . the fish land on the beaches during the high tide with one wave , and the males and females , with their genital opening in proximity , spawn in the sand, in which they have made a hole
- With the next wave the fish swim back to the sea
- The fertilized eggs develop in the warm wet sand and with the next high tide the embryos are returned

## To avoid environment effects

### Migration:

Some species (e.g., Salmon) have used their rather efficient means of travel to migrate to favorable breeding grounds and to spend either their growing period in environment that are most favorable for those parts of their life cycle



# REFERENCES :

Jones, R. E. (1978). The Vertebrate ovary : comparative biology and evolution. New York, Plenum Press.

Marshall, P. T. and G. M. Hughes (1980). Physiology of mammals and other vertebrates. Cambridge Eng. ; New York, Cambridge University Press.

Nelsen, O. E. (1953). Comparative embryology of the vertebrates; with 2057 drawings and photos. grouped as 380 illus. New York,, Blakiston.

Van Tienhoven, A. (1983). Reproductive physiology of vertebrates. Ithaca, N.Y., Comstock.





**Thank you**

