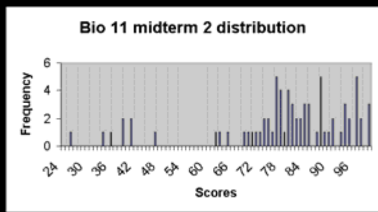
Exam 2

As	19
Bs	23
Cs	24
Ds	0
Fs	8



Reproduction and Development

Modes of Reproduction

1. Sexual reproduction
   - Meiosis, gamete formation, and fertilization
   - Offspring show genetic variation
2. Asexual reproduction
   - Single parent produces offspring
   - Offspring are genetically identical

Asexual Reproduction

Asexual Reproduction

Only one parent contributes genes to the offspring.

All offspring are genetically identical to one another and to parent.

Examples: fragmentation in sponges, budding in cnidarians, transverse fission in flatworms.

Asexual Reproduction

Types of Asexual Reproduction

1. Budding – offspring develop as a growth on the body of the parent.
   - Jellyfish and echinoderms – buds break off and develop independently.
   - Coral buds remain attached and become a colony.
2. Fragmentation – some worms spontaneously break up into many buds.
3. Parthenogenesis – eggs develop without being fertilized, like Jesus.
   - Occurs in some fishes, insects, frogs and lizards.
   - Usually occurs under special conditions.
4. Hermaphroditism – self fertilize – produce male and female gametes.

Parthenogenesis:
development of embryo from unfertilized egg

- ameiotic: no meiosis; diploid egg formed by mitosis.
  some flatworms
  rotifers
  some crustaceans
  some insects CLONES
- meiotic: haploid ovum formed by meiosis-then either activated by sperm or spontaneous development.
  some reef fish
  bees, wasps and ants: haplodiploidy
  whiptail lizards: meiosis modified such that all offspring are female clones.

Parthenogenesis:
development of embryo from unfertilized egg

• Often, parthenogenic reproduction coincides with food availability. For example, aphids use parthenogenesis in the spring when they find themselves with ample food. Reproduction by parthenogenesis is more rapid than sexual reproduction, and the use of this mode of asexual reproduction permits the animals to quickly exploit the available resources.

Parthenogenesis example:
many populations of whiptail lizards

These desert lizards are all female yet still participate in sexual behavior. Female will mount one another depending on their hormonal levels; females without eggs and low estrogen levels will assume the male role. This behavior has been shown to increase fecundity. It is believed that mating behavior increases hormone levels resulting in more reproductive success.

Parthenogenesis - Haplodiploidy – Hymenoptera (bees, wasps and ants)

• Males are haploid--they have only one copy of each chromosome.
• females are diploid--two copies of each chromosome.

Female Hymenoptera come about in the usual way, with a sperm from a male fertilizing a female's egg, yielding a diploid daughter.

Males develop from an unfertilized egg, making them haploid .

Interesting consequences:

1. If a queen mates only once, her daughters are highly related to each other (called supersisters), because the father's sperm are all identical.
2. A female is more related to her sisters (on average, 75% similar) than she is to her own daughters (on average 50% similar).
3. A female is more related to her son (50 % similar) than she is to a brother (on average, 25% similar).

These three factors combine to create a condition in which it may be more advantageous, evolutionarily speaking, for a female to help her mother produce sisters than to produce her own daughters. Thus haplodiploidy opens the way for the evolution of a worker caste, devoted to helping their mother.

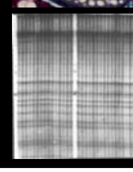
Hermaphroditism: male and female gonads

It's a male and a female!

It has an ovary and a testis!

testis

ovary



Drawback for this species: the population is genetically identical!

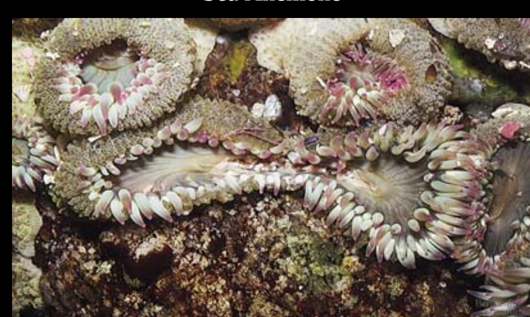
DNA fingerprint

Other examples of hermaphrodites:

• simultaneous:
  flatworms
  hydroids
  annelids
  barnacles
  pulmonate snails

• sequential:
  some reef fish

Asexual Reproduction
Sea Anemone



Asexual Reproduction
Benefits

1. Quick
2. Low risk
   - Successful genetic combinations maintained
   - No helpless juveniles
   - No parental care
3. Phenotype matches existing stable environment.
4. Minimal physiological resource cost.
5. Eliminate risk and cost of courtship behavior.
   - Finding mates
   - Exposure to predators
   - Sexual behavior consumes energy

Sexual Reproduction
Why Have Sex?

Sexual Reproduction
Why Have Sex?

- Sexual reproduction produces offspring with a <u>different</u> mix of alleles than their parents.
- The variation in traits among offspring increases the chances that <u>some members of a species will survive in a changing environment</u>.

Costs and Benefits for Sexual Reproduction

<u>Costs</u>:
- Cells that serve as gametes must be set aside and nurtured.
- Need specific reproductive structures.
- Mating may require specific behavior – can be very costly, especially for male.
- Requires synchronous timing of gamete formation, sexual readiness, parental behavior.
- Energy outlays for constructing and maintaining neural and hormonal controls.
- Reproduction is often limited to certain times of the year or month.
- Energy required to nourish developing individual – yolky eggs and the placenta.

Costs and Benefits for Sexual Reproduction

<u>Benefits</u>:
- Variation in traits is a selective advantage that offsets the biological costs associated with separate sexes and sexual reproduction.

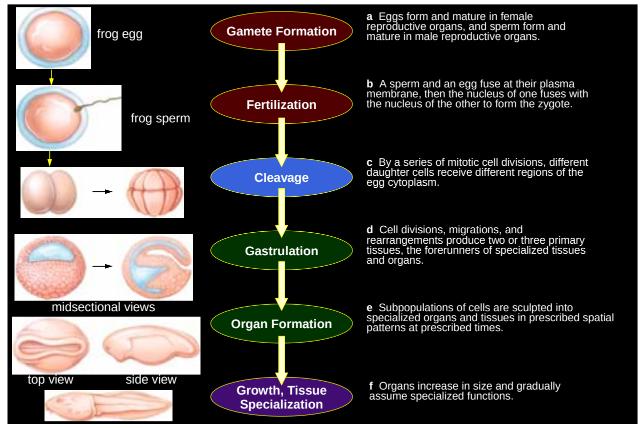
r vs K selection

<u>r-selection</u>:
- Up to 40,000,000 eggs released during spawning!
- No parental investment

<u>K-selection</u>:
- 1-few offspring
- Large parental investment

Stages of Development

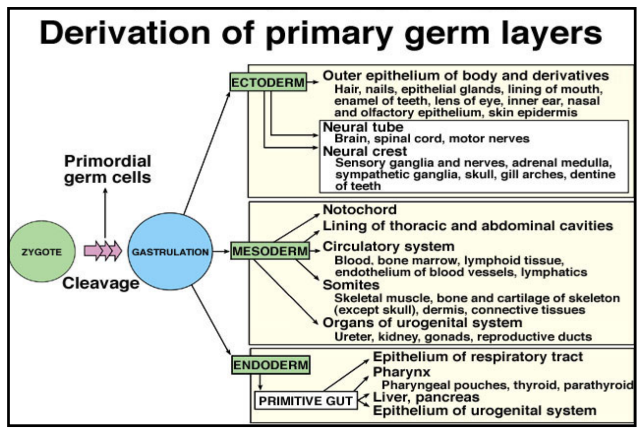
Gamete formation
Fertilization
Cleavage
Gastrulation
Organ formation
Growth, tissue specialization



Stages of Development

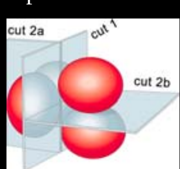
1. **Gamete Formation** – egg and sperm produced during meiosis.
2. **Fertilization** – sperm and egg fuse, then nuclear material fuses.
3. **Cleavage** – mitotic division; cells divide but do not grow.
4. **Gastrulation** – cell divisions, migrations, rearrangements produce 2 or 3 primary tissues:
   - Ectoderm – outermost layer; gives rise to nervous system and skin.
   - Mesoderm – intermediate layer; gives rise to muscles, skeleton, circulatory, reproductive, and excretory organs. Also forms connective tissues of gut and skin.
   - Endoderm – innermost layer; forms inner lining of gut and organs derived from the gut.
5. **Organ Formation** – groups of cells are organized into specialized organs and tissues in prescribed patterns.
6. **Growth, Tissue Specialization** – organs increase in size and assume specialized functions.

* Each step is critical for the next. Early developmental stages are the foundations for later differentiation.



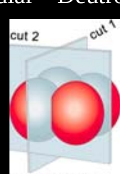
2 Types of developmental cleavage

1. Spiral – Protostomes



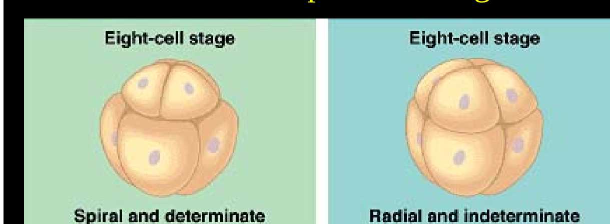
Rotational cleavage

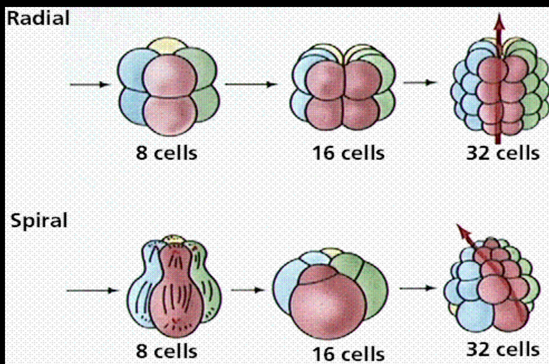
2. Radial – Deutrostomes



Radial cleavage

Radial and Spiral Cleavage





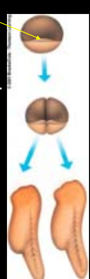
Maternal Instructions

1. The egg cytoplasm contains enzymes, mRNA transcripts, etc.
2. These materials are not randomly distributed throughout the egg
3. The egg also contains yolk, which will influence cleavage patterns

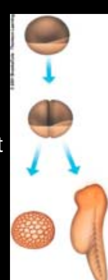
Experimental Evidence of Localized Differences

Gray crescent

Blastomeres separated after normal cleavage



Blastomeres separated so one cell gets all of gray crescent



Example of **regulative development**

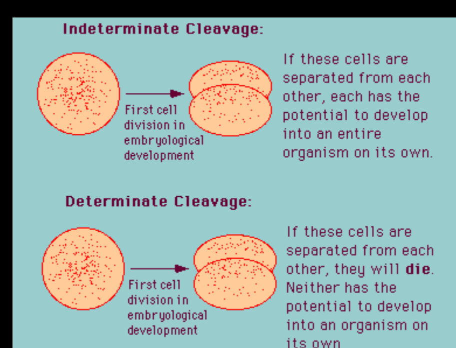
Regulative vs. Mosaic development

- **Regulative development** generally occurs in early gastrulation when cells are induced to form different structures according to the cell-cell signaling interactions in a specific area of the embryo that lead to the conditional specification of a cell's fate. A cell undergoing regulative development can be transplanted to another part of the embryo and form whatever structure belongs in that area instead of the structure that it would have originally formed because it is competent to receive the different signals from the new cells around it.

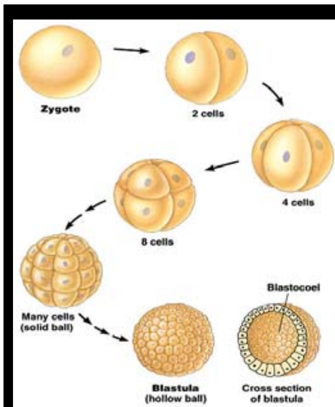
Regulative vs. Mosaic development

- **Mosaic development** results from the autonomous specification of a cell's fate. These cells, instead of depending on cell-cell interactions, are determined by cytoplasmic factors contained within the cell itself. These cells will form a given structure even if they are moved to a new location and are exposed to cell-cell interactions and signals that differ from their original position.

Indeterminate and Determinate Cleavage

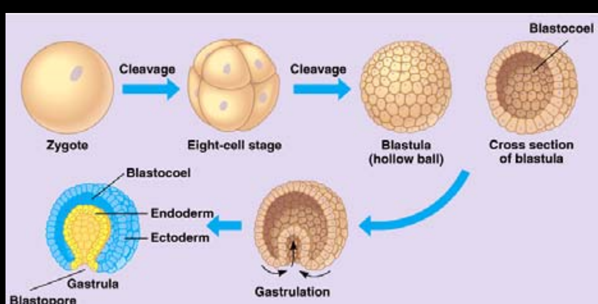


Developmental Characteristic	**Protostome**	**Deuterostome**
Cleavage	Spiral (Determinate or Mosaic Development)	Radial (Indeterminate or Regulative Development)
Coelom formed by	schizocoely	enterocoely
Blastopore becomes	mouth	anus
Examples:	annelids, molluscs, arthropods	echinoderms chordates

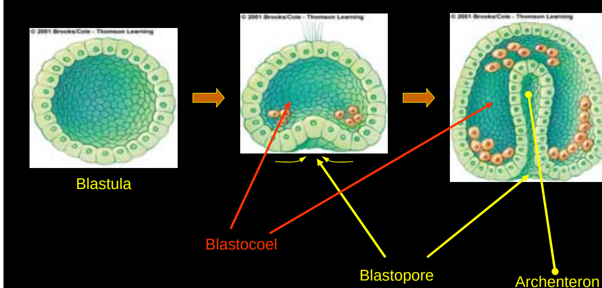


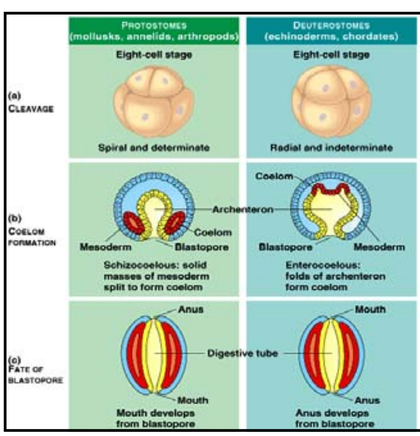
Development to the Blastula

Development to the Gastrula



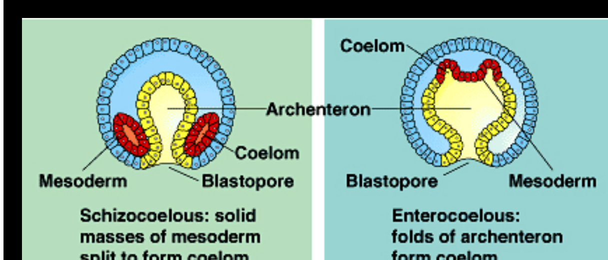
Gastrulation



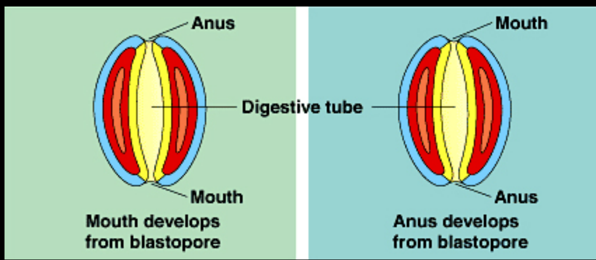


Developmental Differences Between Protostomes and Deuterostomes

Coelom Formation



Blastopore Formation



Cell Differentiation

1. Certain groups of genes are activated in some cells but not in others.
2. Genes are not lost, just inactivated.
3. In early 70's Gurdon showed frog intestinal cell still had all the genes needed to make a new individual. First successful vertebrate clone.

Morphogenesis

1. Orderly changes result in specialized tissues and early organs.
2. Cells migrate.
3. Whole sheets of cells expand and fold.
4. Programmed cell death sculpts body parts.

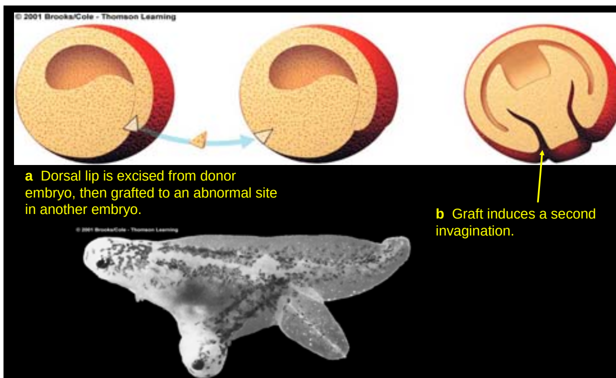
Cell migration

Embryonic Induction

1. Development fate of embryonic cell lineages changes upon exposure to gene products from adjacent tissues.
2. Cells behave as if they have positional memory.
3. Demonstrated experimentally by transplanting embryonic cells.

Morphogens

1. Dorsal lip (embryonic signaling center).
2. Influence's other cells by producing a morphogen.
3. Diffusion of morphogen creates gradient that influences differentiation; influences which genes are turned on or off.



a Dorsal lip is excised from donor embryo, then grafted to an abnormal site in another embryo.

b Graft induces a second invagination.

c Gastrula develops into a double embryo. Most of its tissues originated from the host embryo.

Fig. 38.12, p. 654

Pattern Formation

This specialization of tissues and organs in specific regions and in particular order is known as Pattern Formation.

Spatial and temporal components.

Pattern Formation

1. Starts with cytoplasmic localization.
   - Cell to cell contact
   - Chemical gradients induce diff responses at diff distances.
2. Classes of master genes activated in sequence.
3. Interactions among master genes are guided by regulatory proteins.
4. Gene products are spatially organized in the embryo.

Similar Master Genes

1. Diverse animals use similar or the same master genes to govern development.
2. May help explain why there are so few body plans.
3. The relatively small number of master genes constrains variation.

Identical Twins (Monozygotic)

arise from a single fertilized egg

Example of indeterminate cell division

Identical Twins (Monozygotic)

arise from a single fertilized egg

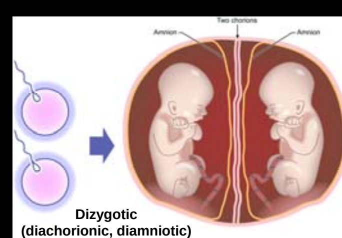
Depending on the stage at which the zygote divides:

Monoamniotic - share the same **amnion**
- Monochorionic - share the same **placenta** ⟶ Identical

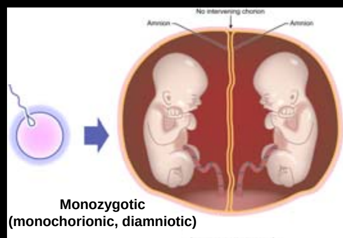
Diamniotic – Have their own **amnion**
- Monochorionic - share the same **placenta** ⟶ Identical
- Dichorionic – have their own **placenta** ⟶ Identical/fraternal

note that any monochorionic or monoamniotic twins are identical twins. This condition does not occur in fraternal twins.

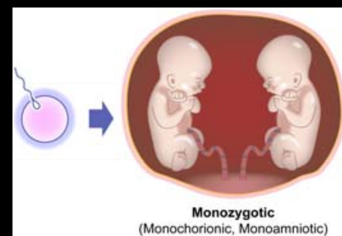
Fraternal twins



Identical twins



Identical twins



Identical Twins (Monozygotic)

"Mirror twins"

Some monozygotic twins are known as "**mirror twins**" or *mirror image twins*. These are identical twins with opposite features, that is, one may be right-handed and the other may be left-handed; hair will whorl in the opposite direction, and so on.

One mirror may or may not have situs inversus. This is where some or all of the organs will be on the opposite side of the body, such as the heart being on the right (dextrocardia).

This results from a late split of the fertilized egg at around 9-12 days.

Identical Twins (Monozygotic)

Conjoined twins

Conjoined twins are monozygotic twins, whose bodies are joined together at birth. This occurs where the single zygote of identical twins fails to separate completely.

This usually occurs after a fertilized egg splits after 12 days.

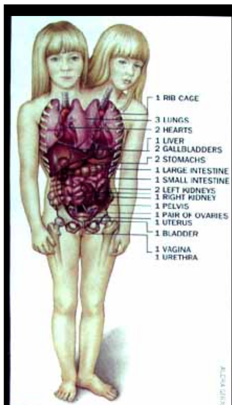
This condition occurs in about 1 in 100,000 pregnancies.

Conjoined Twins

Chang and Eng

"Siamese" Twins

1811-1874



Conjoined Twins

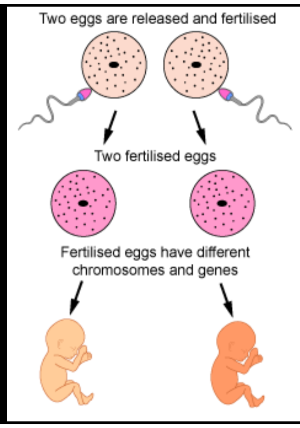
Normally, identical twins form when a zygote splits, early in development. When the zygote does not completely split, the twins are left conjoined.

Abigail and Brittany Hensel
Born in Minnesota in 1990

Conjoined Twins

Fraternal Twins (Dizygotic)

arise from two fertilized eggs



Rare fraternal twins heteropaternal superfecundation

fraternal twins with different fathers:

This can occur when a second egg is fertilized after the first has already begun to develop. This can happen within a single menstrual cycle (superfecundation) or in very rare cases, later in pregnancy (superfetation).

*Often realized when twins of different races are born.

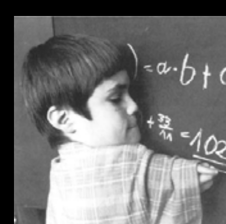
Birth Defects

- Genetic
- Chemical:
  - Alcohol – Fetal Alcohol Syndrome
  - Smoking – Low Birth Weight
  - Drugs – Accutane (for acne), Tegison (for psoriasis), Soriatane (for psoriasis), Thalidomide (nausea), Captopril (reduces blood pressure), Enalapril (reduces blood pressure, and street drugs
- Congenital Infections – when mother is infected
- Food – mercury in certain fishes, raw fishes/shellfish

Teratogenic Effects

Between 1956-1961 thalidomide was prescribed to alleviate morning sickness in pregnant women.

>10,000 children were born without normal arms and legs.



Attending school in the 1960's, this German boy reached the blackboard with a stub arm and gripped the chalk with distorted fingers. Many children that were exposed to thalidomide in utero were born will malformed limbs but normal intelligence. They often learned to adapt to their handicaps.

External Fertilization – Aquatic Organisms

Broadcast spawning – typical of many marine invertebrates and fishes where millions of eggs and sperm are released into the surrounding seawater. Example: peak of spawning for corals on the Great Barrier Reef occurs three days after a full moon in November. Energy allocated to reproduction is used to produce *many* small gametes.

Coral Spawning

Aquatic Release of Eggs and Sperm

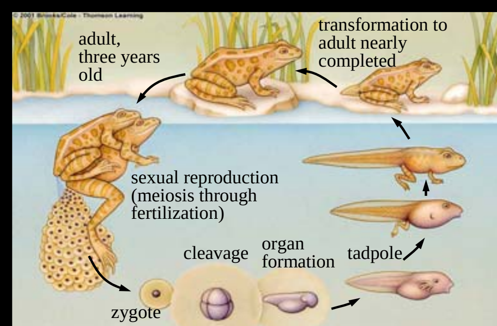
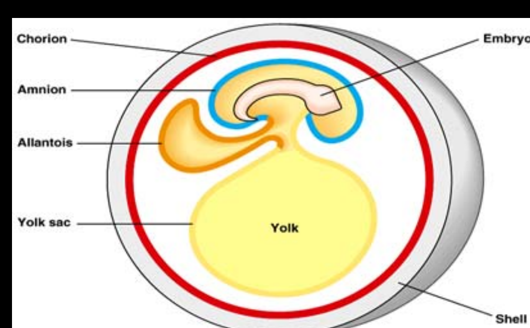


Fig. 39.1a, p. 645

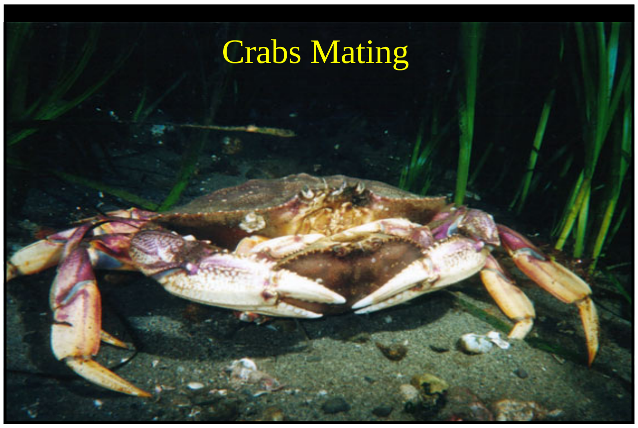
Internal Fertilization

- Energetically expensive to make different sexes with separate reproductive organs.
- Allocate reproductive energy in provisioning eggs with yolk that nourish the young.
- Internal fertilization ensures a high likelihood of sperm and eggs contacting each other.
- Amniotic egg allowed organisms to spend their entire lives in a desiccating terrestrial environment.
- Sperm must contact the egg before the shell develops.
- Sperm swim in water and internal fertilization was necessary for nonaquatic organisms.
- Usually involves copulation where a penis is inserted in the female.

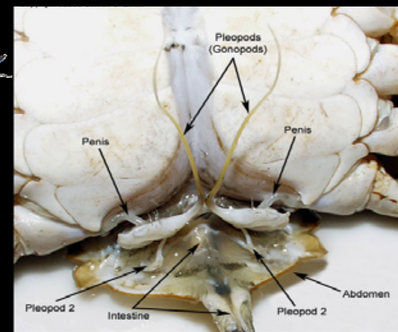
Amniotic Egg



Crabs Mating

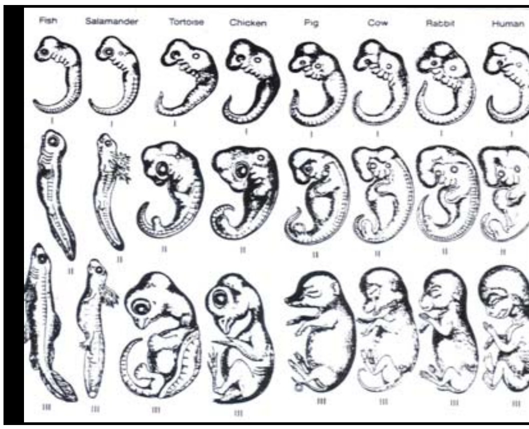


Male Crab with two penises



Barnacles Mating

Vertebrate Development



Grasshoppers Mating

Tortoises Mating

Oystercatchers Mating

Wolves after mating

Camels at the Oakland Zoo

Male Post-coitus