2. Organismal Biology

Structure & Function in Plants

1- Plant Organs
2- Water & Mineral Acquisition
3- Food Translocation & Storage

Plant Reproduction & Development

1- Alternation of Generations
2- Gamete Formation & Fertilization
3- Growth & Development
4- Tropisms & Photoperiodicity

Structure & Function in Animals

1- Major Systems
2- Homeostatic Mechanisms
3- Hormones in Homeostasis & Reproduction

Animal Reproduction & Development

1- Gamete Formation & Fertilization
2- Cleavage, Gastrulation, Germ Layers, Organ System Differentiation
3- Experimental Analysis of Vertebrate Development
4- Extraembryonic Membranes
5- Formation & Function of Mammalian Placenta
6- Blood Circulation in the Human Embryo

Principles of Heredity

1- Mendelian Inheritance
2- Chromosomal Basis of Inheritance
3- Linkage
4- Polygenic Inheritance

2.1 Structure & Function in Plants

Plant Structure & Function

2.1.1- Plant Organs
2.1.2- Water & Mineral Acquisition and Transport
2.1.3- Food Translocation & Storage

2.1.1

Plant Organs

- shoots
- leaves
- flowers
- fruits
- roots

2.1.2

Water & Mineral Acquisition and Transport

- vascular plants
- vascular tissues
- transport

2.1.3

Food Translocation & Storage

- phloem
- sugar movement
- food storage

2.1.1 Plant Organs

Major Plant Organs

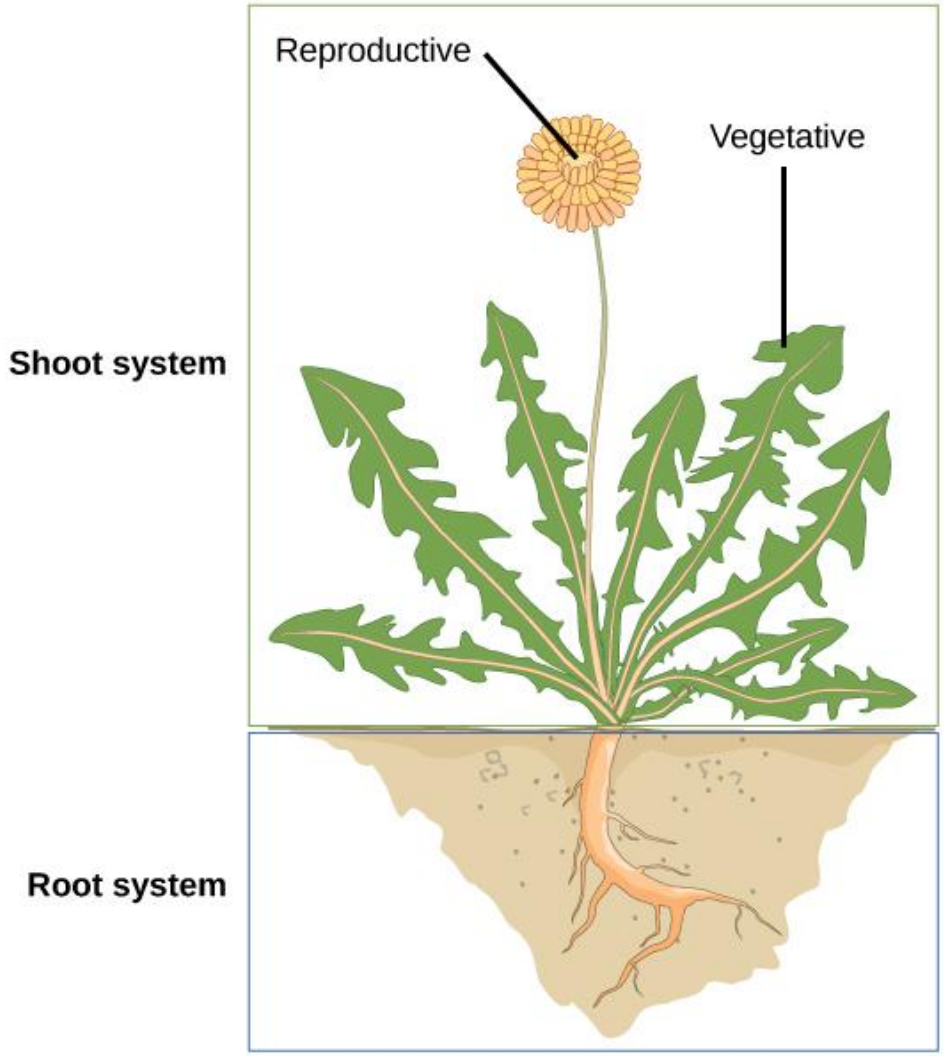
Shoots

Leaves

Flowers

Fruits

Roots



Shoot System

Usually above-ground part of plants

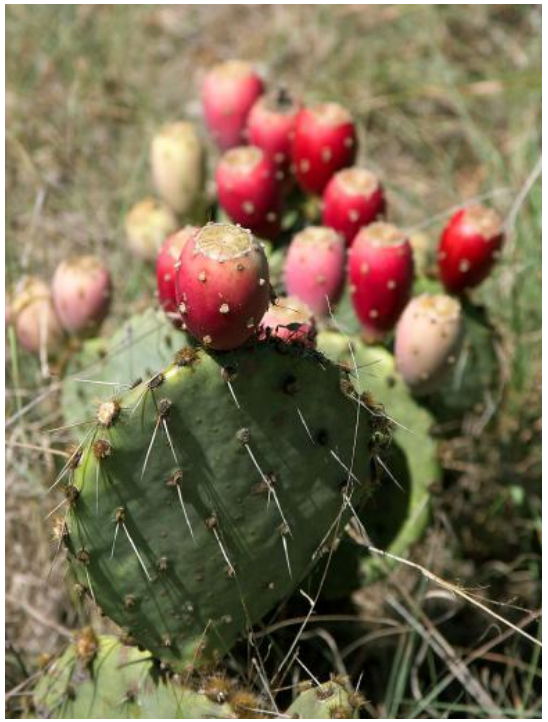
Sometimes has leaves, flowers, fruits

Gathers light & CO_2 for photosynthesis

Leaves

Gather light for photosynthesis

Sometimes modified or absent



Flowers

Only present in angiosperms

Attract pollinators, release pollen

Fruits

Mature reproductive organ

Contain seeds, sometimes tasty flesh

Roots

Absorb water & nutrients from soil

Below-ground organs

Sometimes store energy, water

2.1.2 Water & Mineral Acquisition and Transport

Vascular Plants

Non-vascular plants: no transport tissues; small & inconspicuous

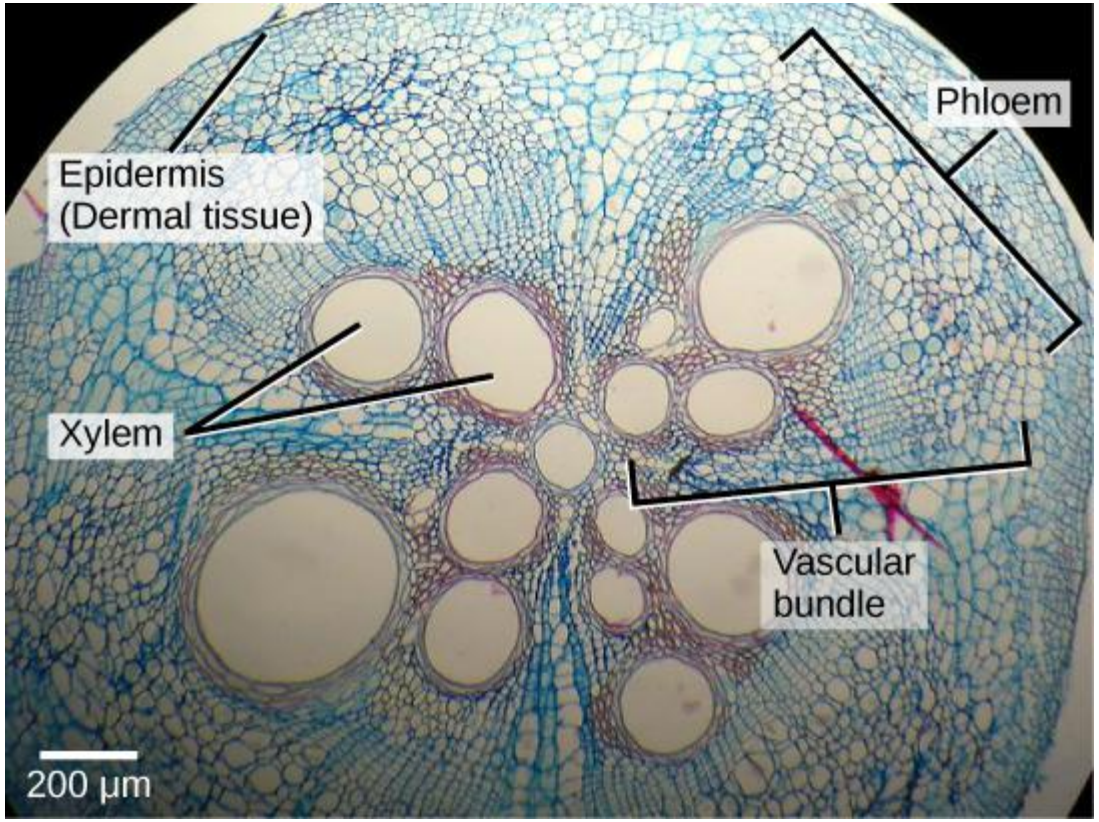
Vascular Plants: plants that have transport vessels for water, sugars, & minerals; most conspicuous plants

- **grasses**
- **trees**
- **cacti**
- **herbs...**

Vascular Tissues

Specifically for transport

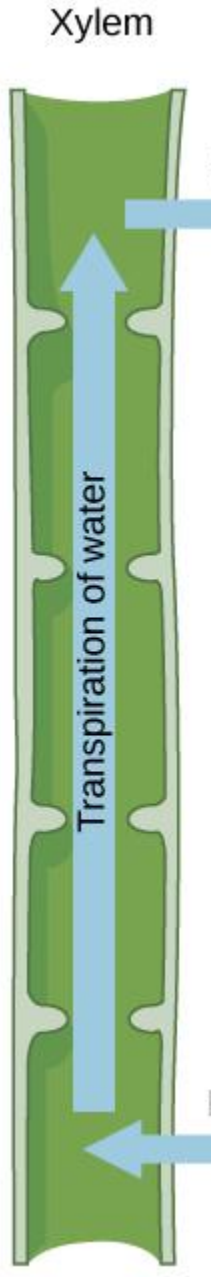
Xylem: transports water & minerals



Transport

Water & minerals diffuse into root cells

Cohesion-tension pulls water & minerals up through plant as water vapor is lost

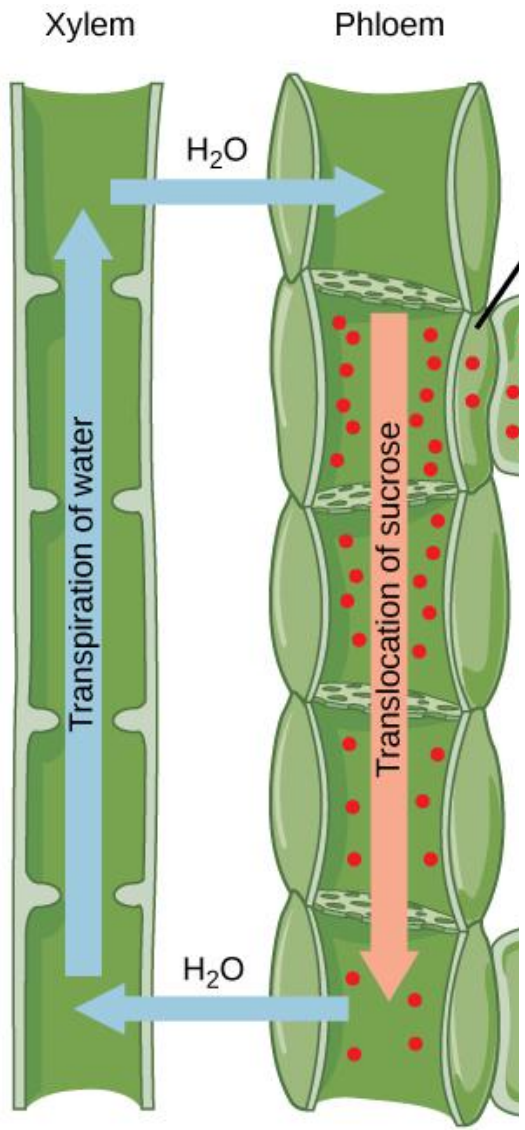


2.1.3 Food Translocation & Storage

Phloem

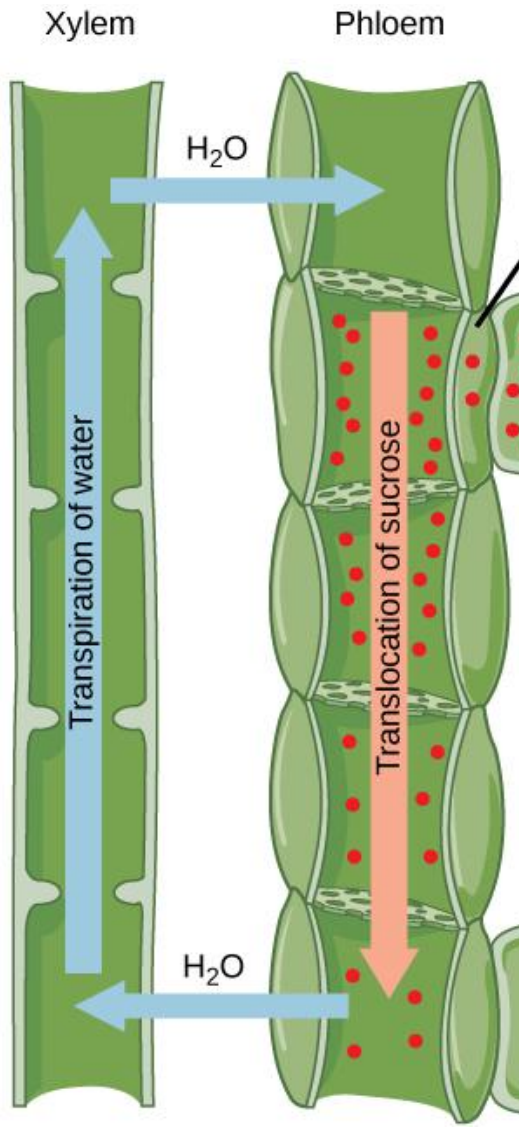
“Food” is sugars made via photosynthesis

Phloem: food transport tissues, shuttle sugars from leaves to rest of plant



Sugar Movement

Sugars build up in phloem, water diffuses in, sugar solution (sap) pushed throughout the plant



Food Storage

Some plants store carbohydrates as starch in stems or roots

- potatoes
- beets
- turnips

2.2 Plant Reproduction & Development

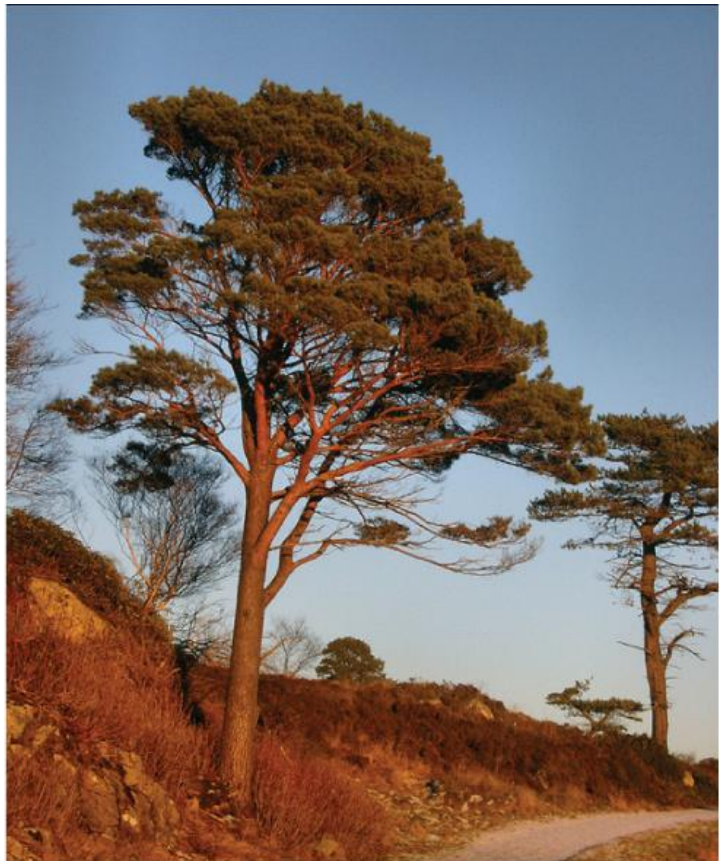
Plant Reproduction & Development

2.2.1- Alternation of Generations
2.2.2- Gamete Formation & Fertilization
2.2.3- Growth & Development
2.2.4- Tropisms & Photoperiodicity

2.2.1

Alternation of Generations

- alternation of phases
- diploid & haploid phases



2.2.2

Gamete Formation & Fertilization

- plant gametes
- plant sperm
- plant eggs
- fertilization in plants

2.2.3

Growth & Development

- plant hormones
- auxins
- cytokinins
- gibberellins
- abscisic acid
- ethylene

2.2.4

Tropisms & Photoperiodicity

- tropisms
- phototropism
- gravitropism
- thigmotropism
- photoperiodicity

2.2.1 Alternation of Generations

Alternation of Phases

The plant's life cycle is an alternation of haploid and diploid phases

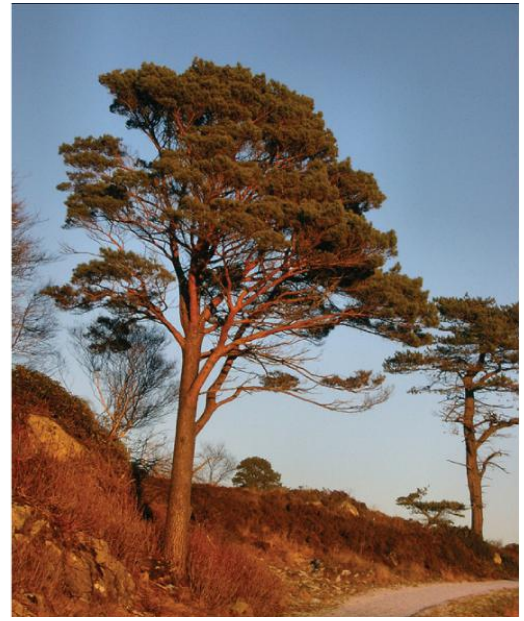
Both phases can undergo mitosis

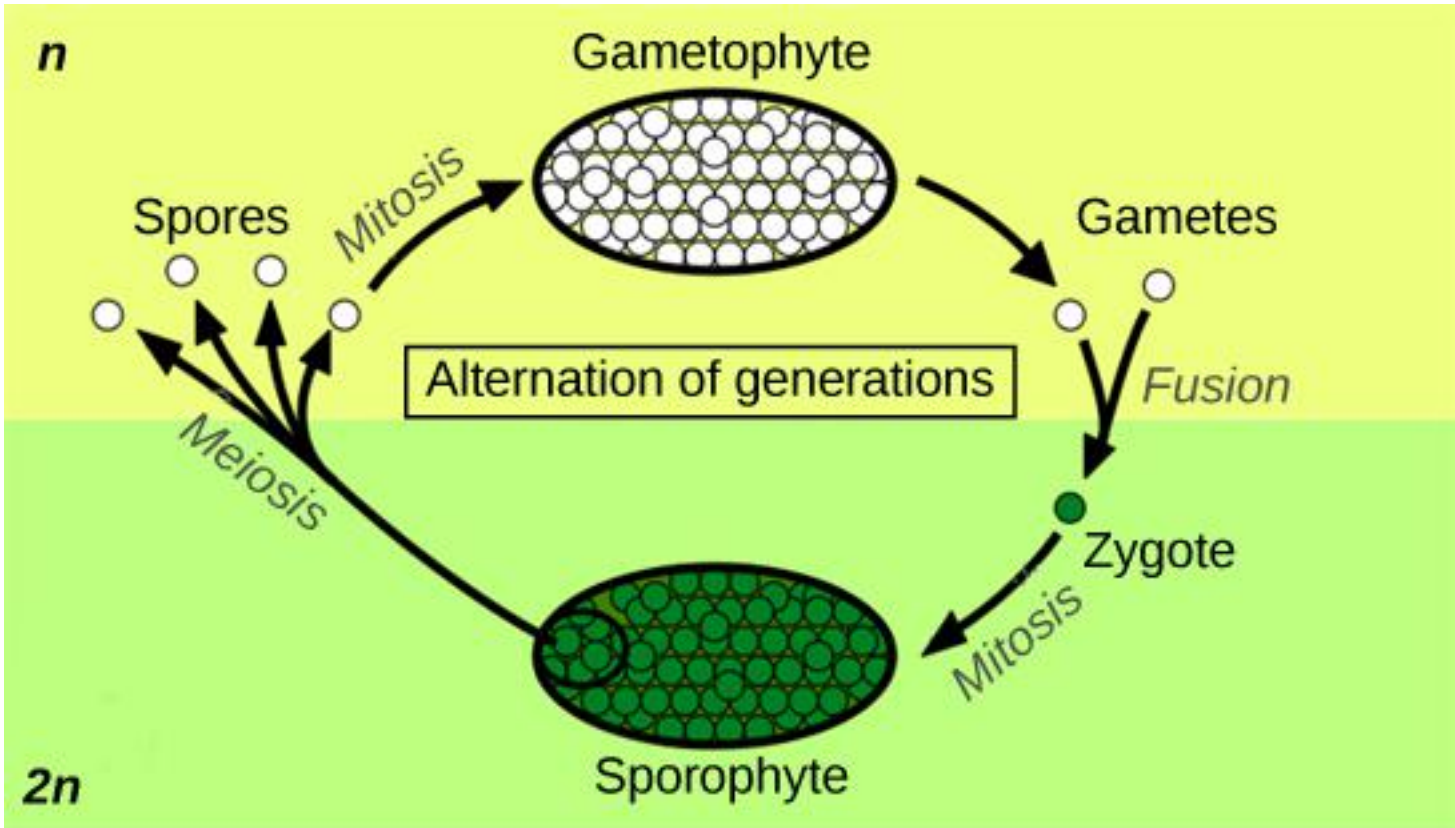
Sporophyte dominant in most plants, but depends on species

Diploid & Haploid Phases

Sporophyte (ex: pine tree): diploid phase, produces spores via meiosis, which grow into gametophytes via mitosis

Gametophyte (ex: inside pine cones): haploid phase, produces gametes via mitosis, which fuse to form new diploid individual (a sporophyte)




n
Gametophyte
Spores
Mitosis
Gametes
Alternation of generations
Fusion
Meiosis
Zygote
Mitosis
Sporophyte
2n

2.2.2 Gamete Formation & Fertilization

Plant Gametes

Gametes in plants are named like gametes in animals:

- male gamete: sperm
- female gamete: egg
- zygote: fused sperm & egg (fertilized egg)
- embryo: growing zygote (more than a few cells)

Plant Sperm

Formed by male gametophyte

Produced in large numbers, leave to join eggs

Transmittal depends on species:

- swimming in plants from wet areas
- non-swimming & packaged inside pollen grains in other plants

Plant Eggs

Formed by female gametophyte

Produced in small numbers, larger

Transmittal uncommon (they stay put)

Fertilization in Plants

Similar to fertilization in animals- male & female gametes fuse to form zygote

In seed plants (ex: pines, roses) sperm must grow through female plant tissue to reach ovaries w/ eggs

In seedless plants (ex: mosses, liverworts) it's simpler

2.2.3 Growth & Development

Plant Hormones

Function similarly to animal hormones, transported in vascular system

Control most aspects of growth & development

Often several interact

Auxins

Promote shoot elongation

Produced mostly in shoot tips; transported only from tip to base of shoot

Cytokinins

Stimulate cytokinesis

Produced in actively growing tissue: roots, embryos, fruits

Gibberellins

Affect cell division & elongation, fruit growth, seed germination

Young roots & leaves major sites of production

Abscisic Acid

Slows growth, often antagonizing actions of growth hormones

Ratio of ABA to growth hormones determines whether growth occurs

Ethylene

Produced in response to stresses...

- drought
- flood
- injury

And as part of normal life cycle

- fruit ripening
- programmed cell death

2.2.4 Tropisms & Photoperiodicity

Tropism

Any growth response that results in plants growing towards or away from stimuli

Phototropism

Response to light

Positive: plant organs grow toward light, most often seen in shoots

Negative: plant organs grow away from light, most often seen in roots

Gravitropism

Response to gravity

Roots display positive gravitropism

Shoots display negative gravitropism

Response occurs as soon as seed germinates & organs grow in appropriate direction no matter how seed is oriented when it lands

Thigmotropism

Response to touch

Comes in several forms

- trees in windy habitats grow short & thick
- plants that use objects for climbing
- plants that close when touched

Photoperiodicity

Physiological response to relative lengths of night & day

Affects growth & development

- **time of year for growing**
- **time of year for flowering**

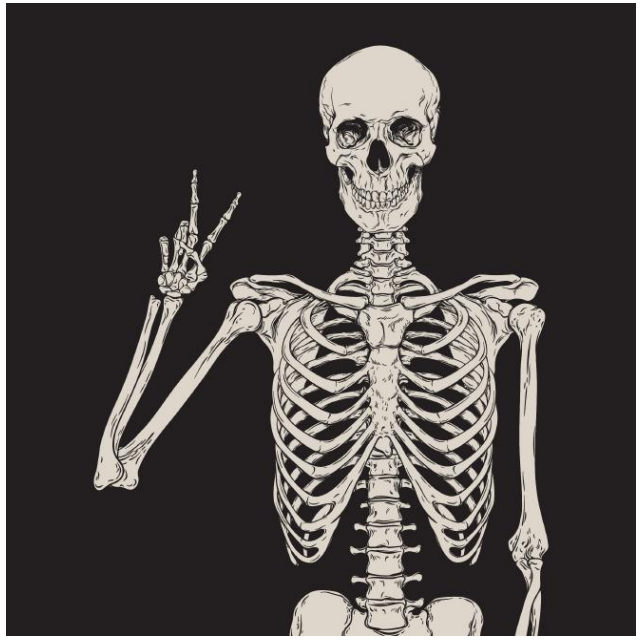
2.3 Structure & Function in Animals

Structure & Function in Animals

1- Major Systems
2- Homeostatic Mechanisms
3- Hormones in Homeostasis & Reproduction

Major Systems

- the animal body
- digestive
- respiratory
- circulatory
- musculoskeletal
- nervous
- excretory
- immune

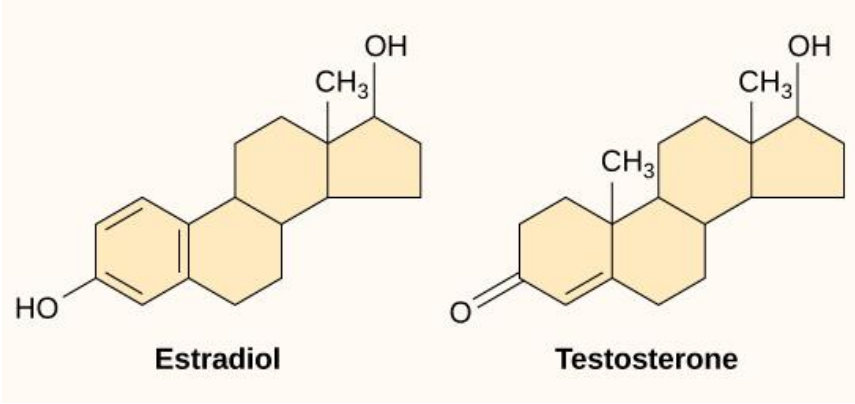


Homeostatic Mechanisms

- homeostasis
- homeostatic components
- feedback mechanisms
- thermoregulation

Hormones in Homeostasis & Reproduction

- endocrine system
- what is a hormone?
- endocrine glands
- hormones as signals
- hormones in reproduction

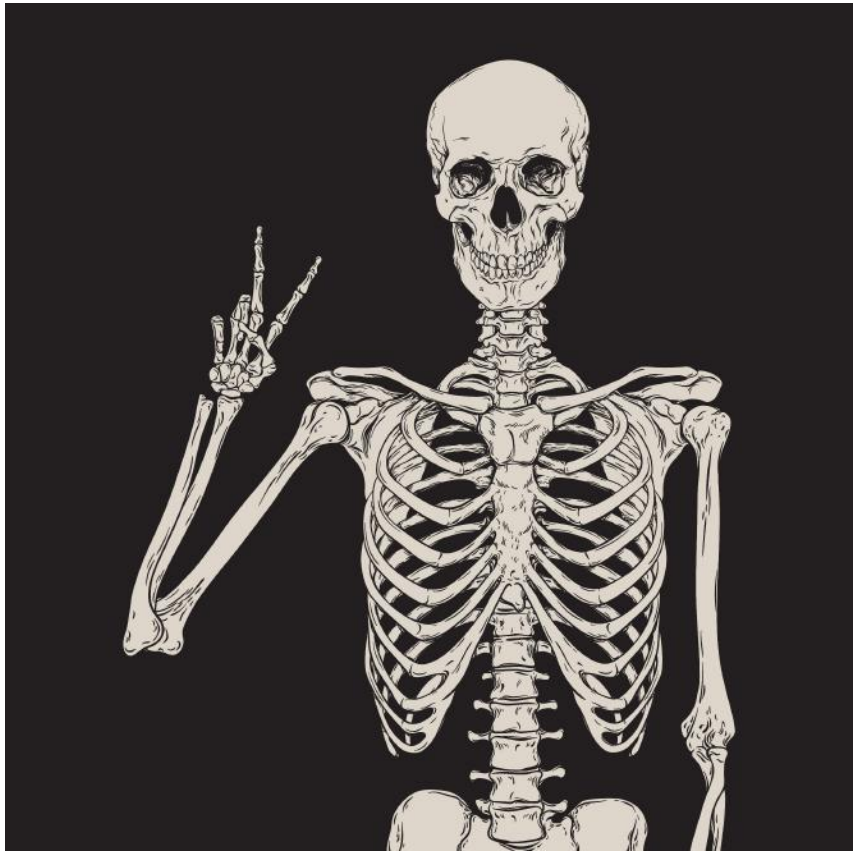


2.3.1 Major Systems

The Animal Body

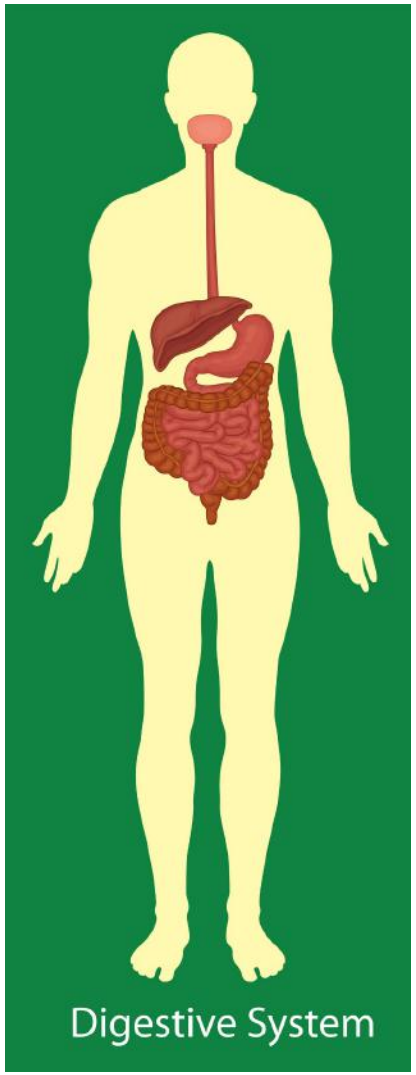
Highly complex “machine” with numerous processes occurring simultaneously & systems cooperating to maintain life

Mostly controlled by hormones, but affected by environment



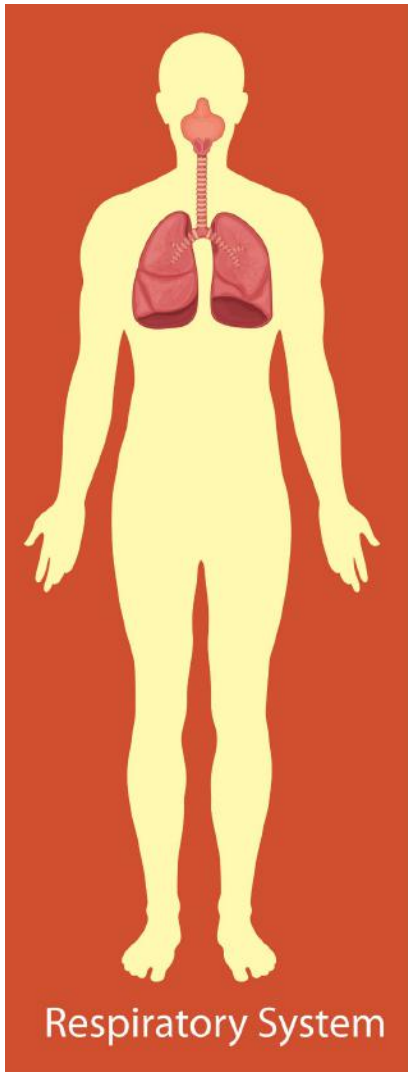
Digestive System

Processes ingested food & drink



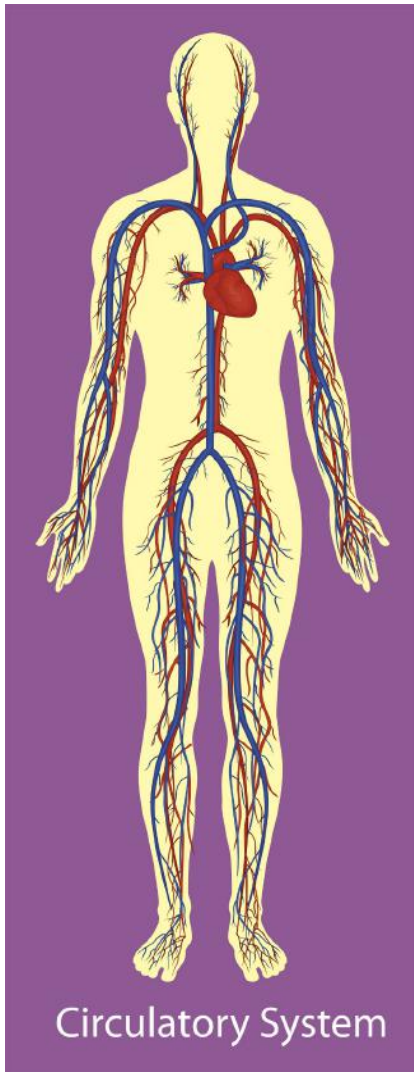
Respiratory System

Responsible for intake of essential gases, release of waste gases



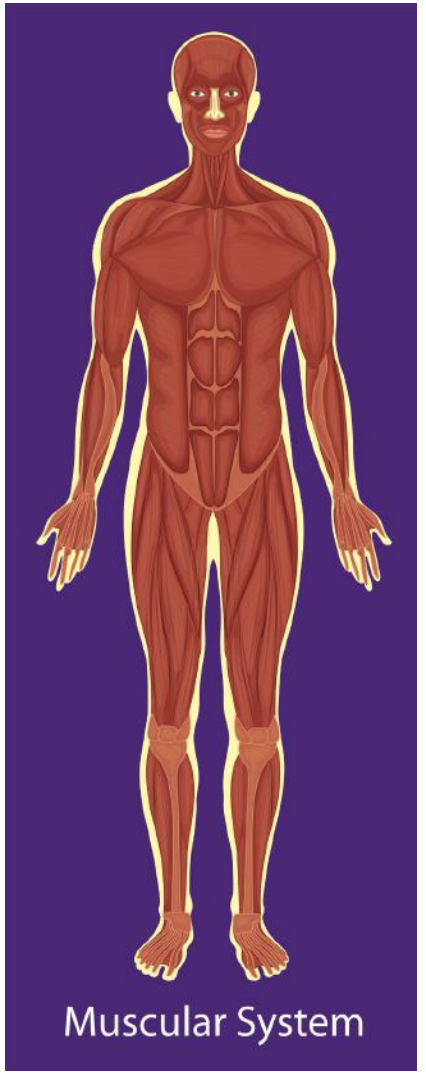
Circulatory System

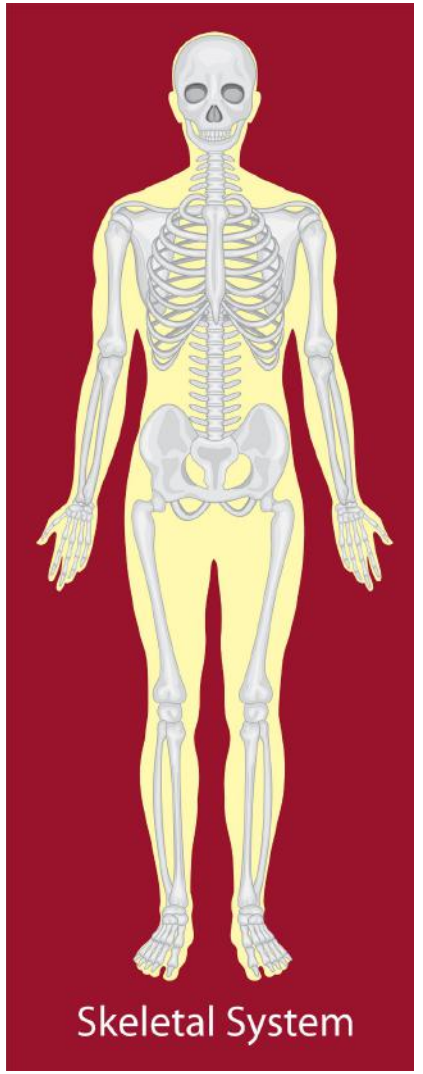
Moves gases, nutrients, hormones throughout body



Musculoskeletal System

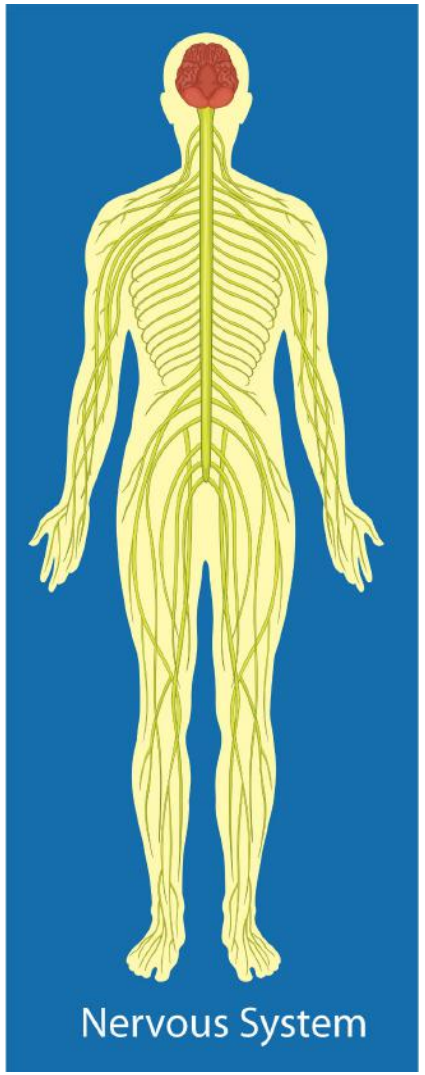
Muscles & skeleton work together to provide support, stability, movement





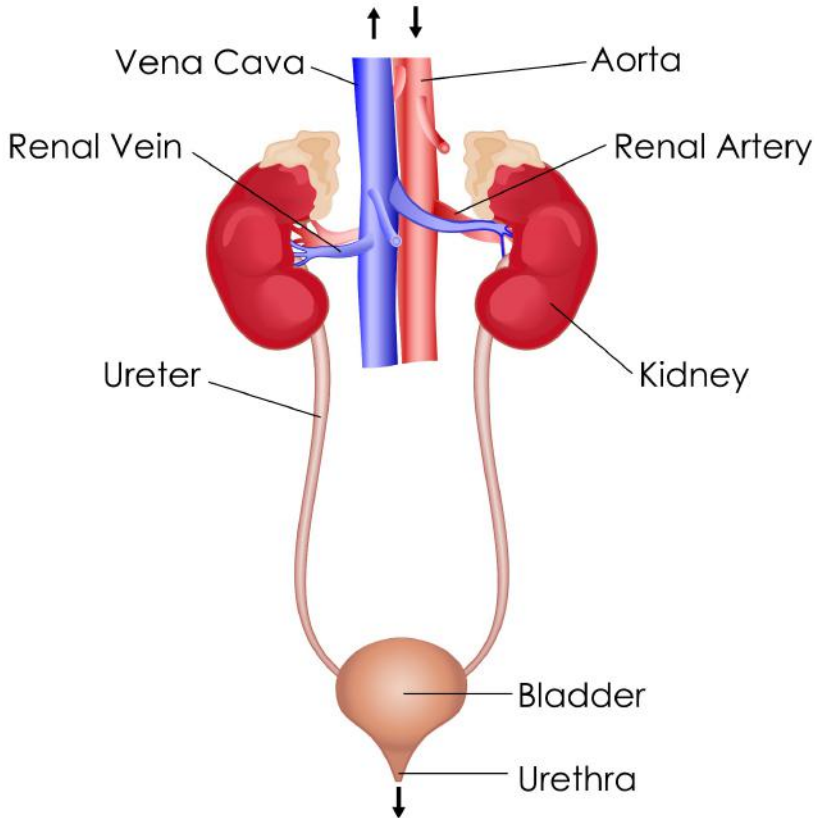
Nervous System

Passes messages between brain & body



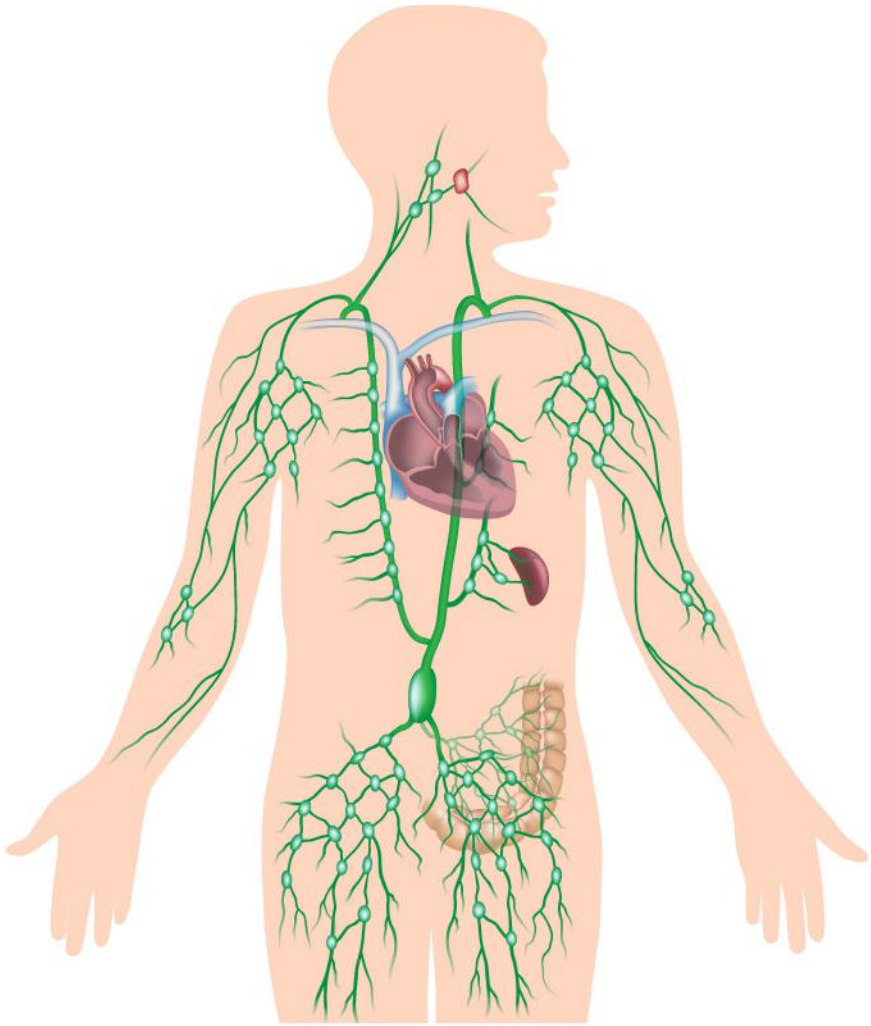
Excretory System

Filters wastes & excess water from blood, releases outside body



Immune/ Lymphatic System

Defense against invaders (bacteria, viruses, parasites...)



2.3.2 Homeostatic Mechanisms

Homeostasis

“Steady state,” refers to maintenance of internal balance

Examples:

- **temperature**
- **ion concentration**
- **blood oxygen**
- **blood glucose**

Homeostasis

Set point: animal maintains a variable at or near a particular value

Stimulus: fluctuations in a variable

Sensor: detects stimuli & sends signal to control center

Control center: generates output that triggers a physiological response to stimulus

Hormones are chemicals used as signals, important for homeostasis

Homeostasis

Relies largely on negative feedback cycles, which reduce stimulus

“Negative” feedback because stimulus results in events that decrease it

Example:

1. human body temperature set point= 98.6^{o}F
2. exercise produces heat that raises your body temperature (stimulus)
3. nervous system (sensor) sends message to control center (brain)
4. brain causes body to sweat (response)
5. Cooling from sweat decreases body temperature & sweating stops

Thermoregulation

Endothermy: internal temperature regulation through heat generated by metabolism; mammals, birds

Ectothermy: internal temperature regulated by external environment; amphibians, reptiles, most fish, most invertebrates

2.3.3 Hormones in Homeostasis & Reproduction

Endocrine System

Regulates body's 'set points'- temperature, heart rate, metabolism

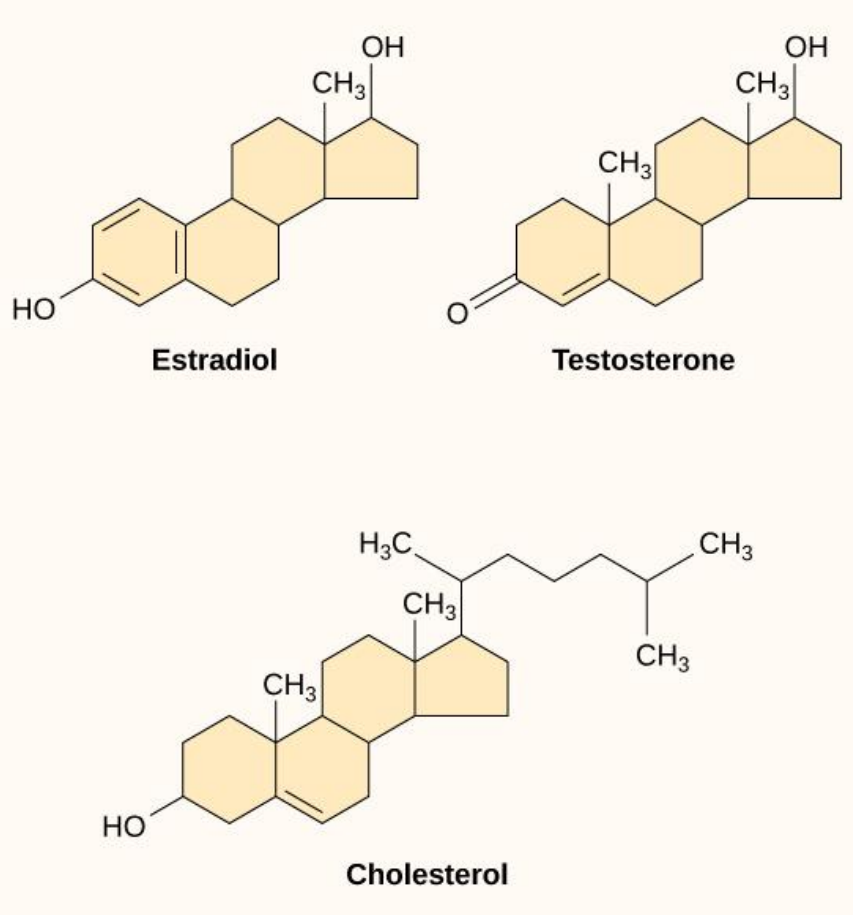
Triggers important physiological events- puberty, reproduction

Facilitates cell to cell communication- glucose uptake, antihistamine release

Hormone

A chemical secreted by an endocrine gland/organ into the blood for transport

Affects growth, metabolism, development, homeostasis



Endocrine Gland

A ductless gland or single cell that secretes a hormone, which travels through blood

Hormone targets the cells or organs that have receptors for the hormone

Food is consumed and digested, causing blood level glucose to rise.

In response to higher glucose levels, the pancreas secretes insulin into the blood.

In response to higher insulin levels, glucose is transported into cells and liver cells store glucose as glycogen. As a result, glucose levels drop.

In response to the lower concentration of glucose, the pancreas stops secreting insulin.

Hormones as Signals

Once released by the control center (usually the brain), hormones work as signals in one of two ways:

1. diffuse into cells' cytoplasm and join w/ receptor protein, which causes a response
2. join w/ receptor protein in cell membranes, which causes a response

Hormones in Reproduction

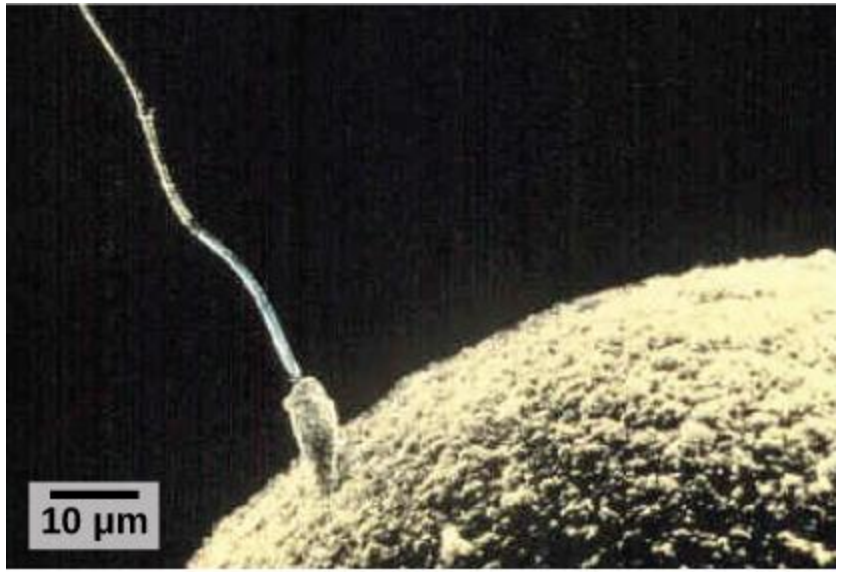
Hormones responsible for sexual maturation & cycling:

- development of gonads, which also release hormones
- development of sperm & eggs
- release of eggs
- development of embryos after fertilization
- contractions during labor or egg-laying
- lactation and other maternal behavior

2.4 Animal Reproduction & Development

Animal Reproduction & Development

1- Gamete Formation & Fertilization
2- Cleavage, Gastrulation, Germ Layers, Organ System Differentiation
3- Experimental Analysis of Vertebrate Development
4- Extraembryonic Membranes
5- Formation & Function of Mammalian Placenta
6- Blood Circulation in Human Embryo

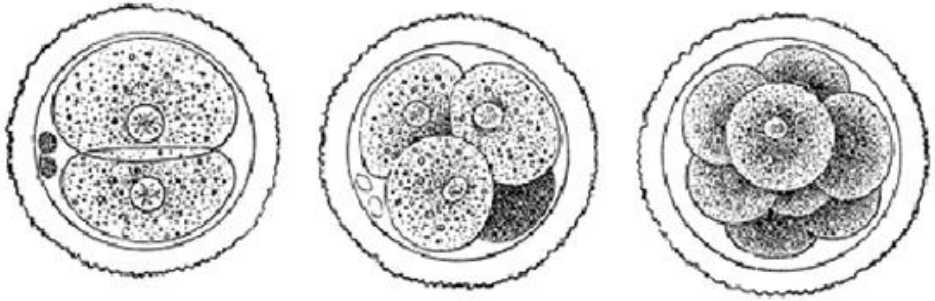


Gamete Formation & Fertilization

- reproduction
- gametogenesis
- spermatogenesis
- oogenesis
- fertilization

Cleavage, Gastrulation, Germ Layers, Organ System Differentiation

- the zygote
- cleavage
- developmental stages
- germ layers

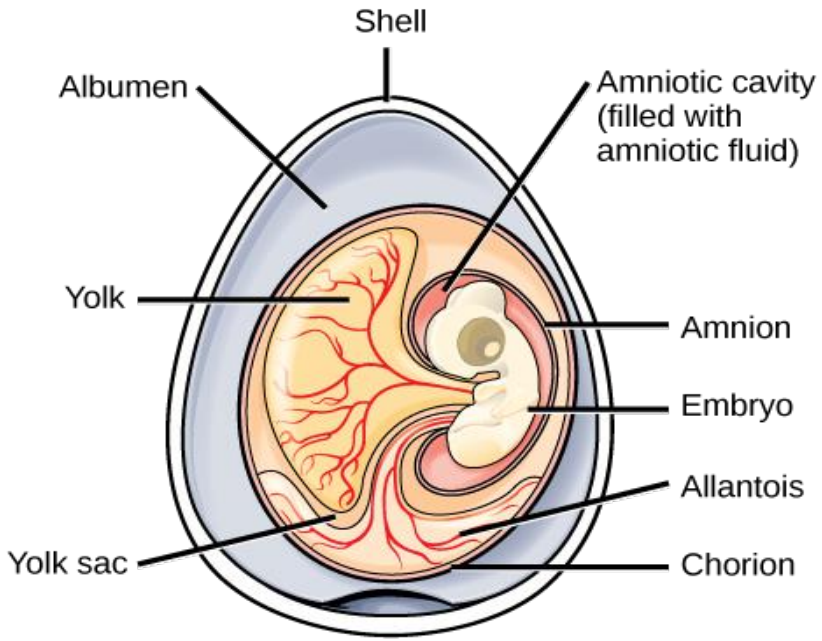


Experimental Analysis of Vertebrate Development

- Model Organisms
- Zebrafish
- Frogs
- Chicks
- Mice
- Fish in Space!

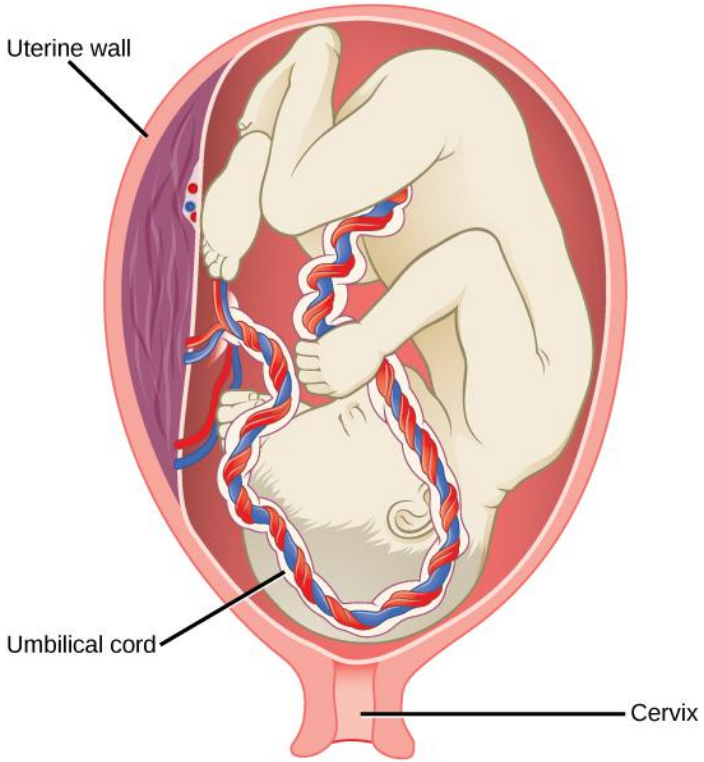
Extraembryonic Membranes

- extraembryonic membranes
- chorion
- amnion
- allantois
- yolk sac membrane



Formation & Function of Mammalian Placenta

- placental formation
- placental function



Blood Circulation in the Human Embryo

- embryonic blood vessels
- exchange with mother

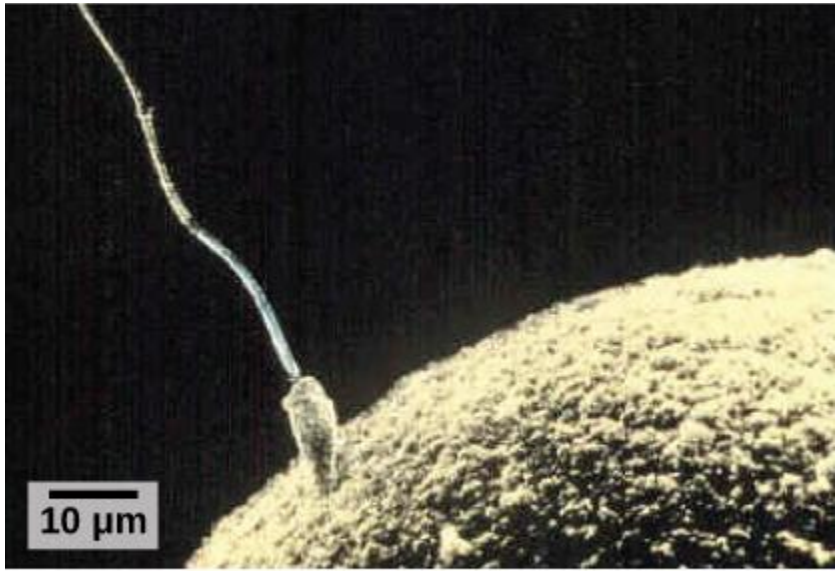
2.4.1 Gamete Formation & Fertilization

Reproduction

Reproduction is complicated for multicellular organisms

Two processes involved

1. **gametogenesis**
2. **fertilization**



Gametogenesis

“Making gametes”

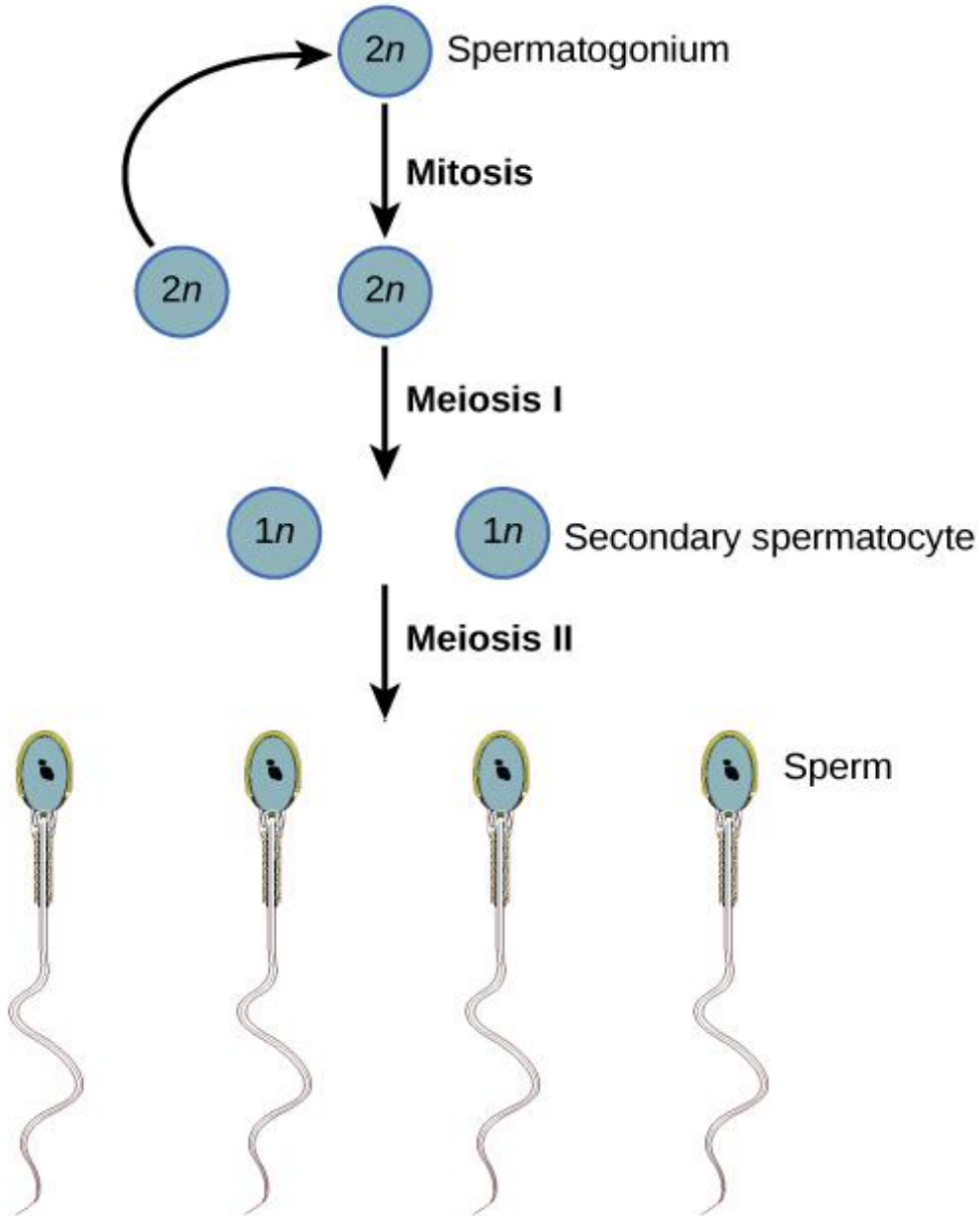
- **sperm**
- **eggs**

Spermatogenesis

Formation of sperm

Occurs in spermatogonia- cells in testes

1. **Primary spermatocytes (2n) formed**
2. **Secondary spermatocytes (1n) formed from primary, via Meiosis 1**
3. **Sperm cells (1n) formed from secondary spermatocytes via Meiosis II**

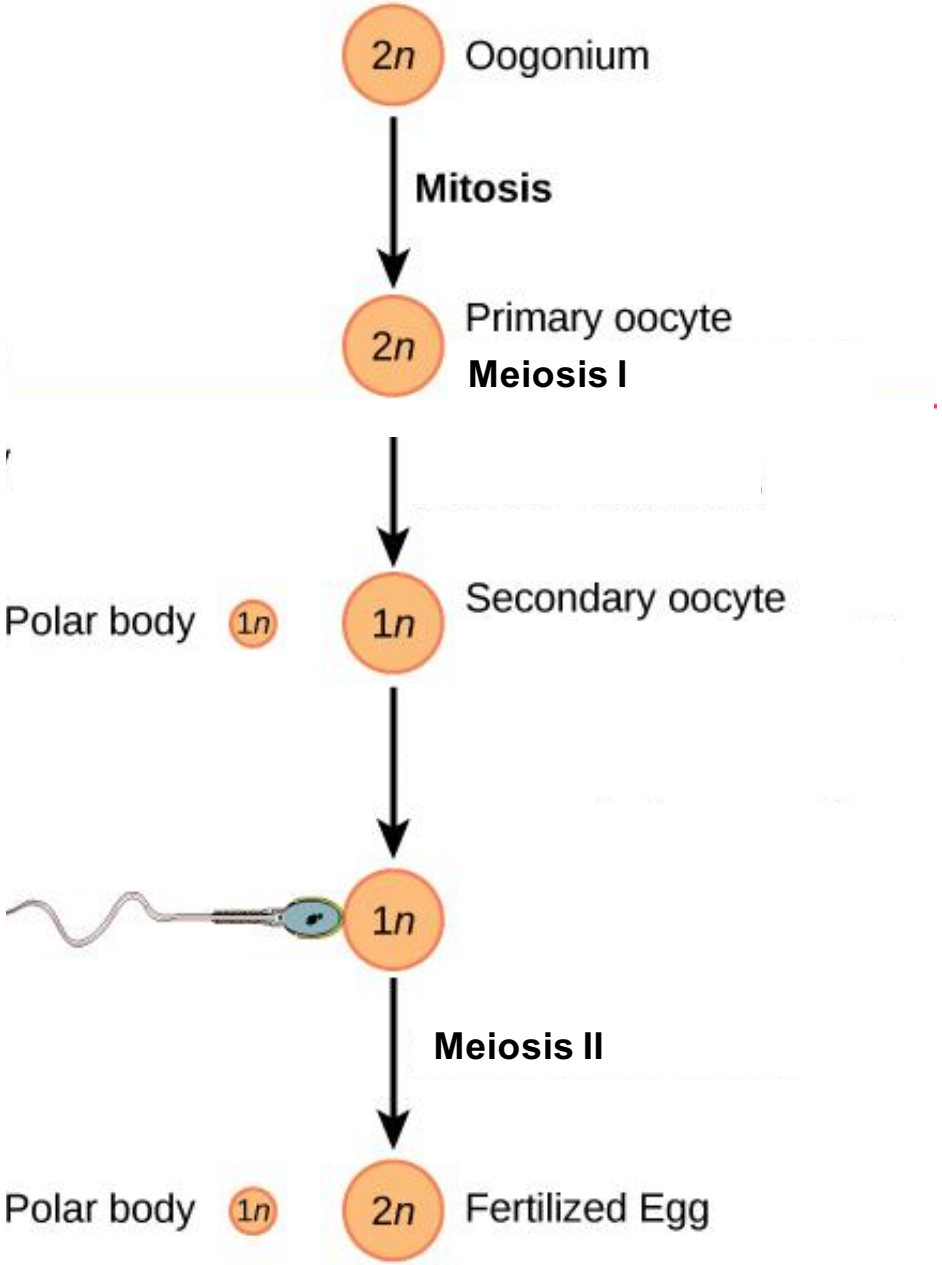

2n
Spermatogonium
Mitosis
2n
2n
Meiosis I
1n
1n
Secondary spermatocyte
Meiosis II
Sperm

Oogenesis

Formation of eggs

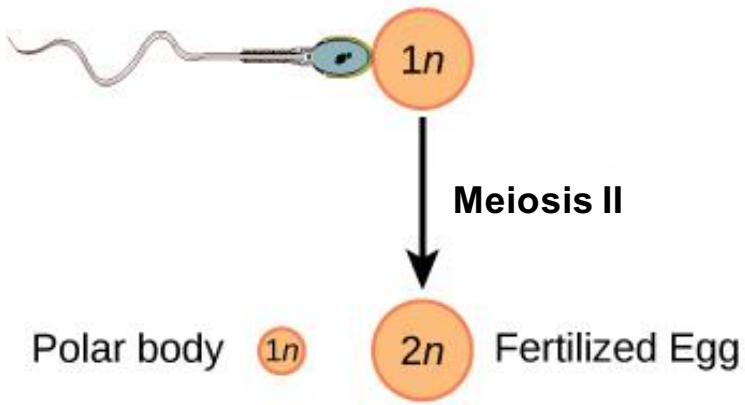
Occurs in oogonia- cells in ovaries

1. **Primary oocyte (2n) present in ovaries from birth**
2. **Secondary oocytes (1n) formed from primary, via Meiosis 1; polar body also formed**
3. **Egg cells and polar bodies (1n) formed from secondary oocytes via Meiosis II**
4. **Polar bodies recycled**


2n
Oogonium
Mitosis
2n
Primary oocyte
Meiosis I
Polar body
1n
1n
Secondary oocyte
1n
Meiosis II
Polar body
1n
2n
Fertilized Egg

Fertilization

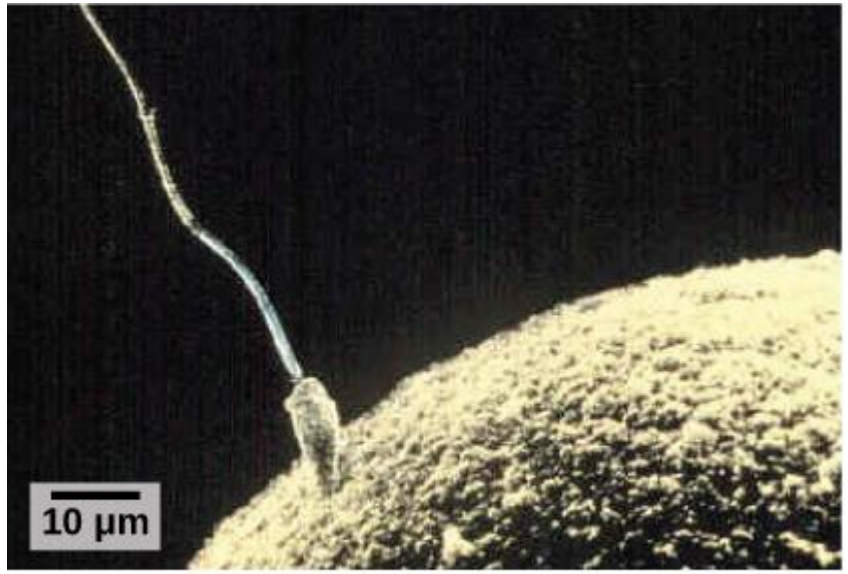
Sperm and egg join to form zygote



2.4.2 Cleavage, Gastrulation, Germ Layers, Organ System Differentiation

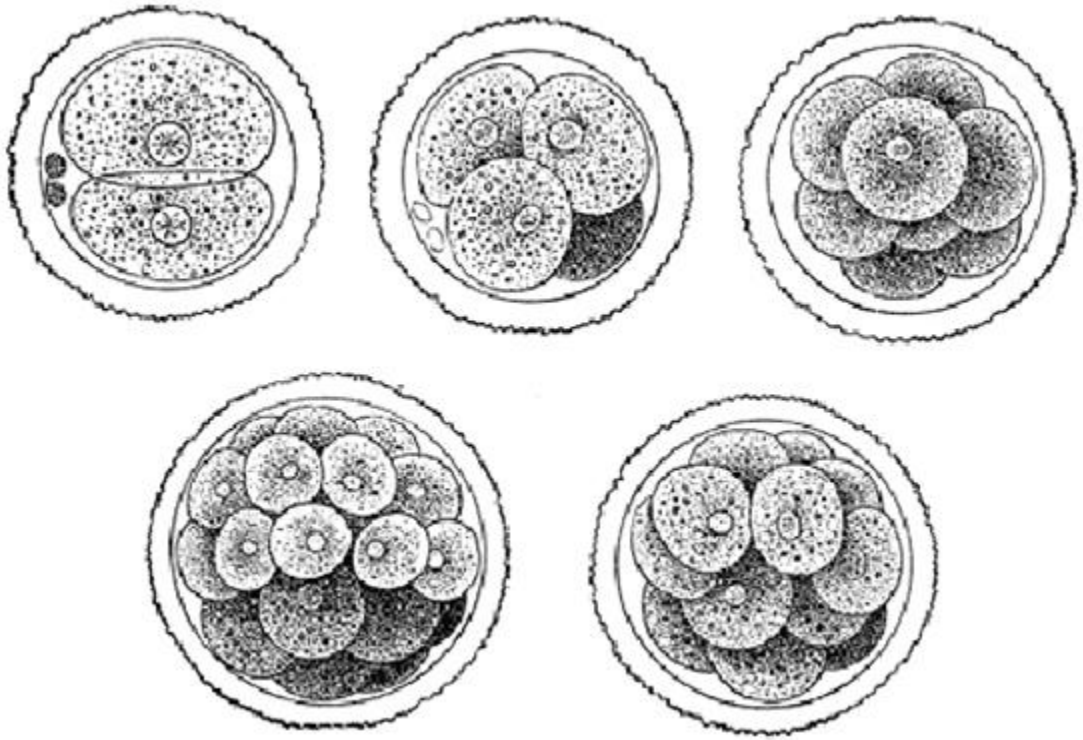
The Zygote

All sexually-reproducing multicellular organisms start life as a zygote (fertilized egg)



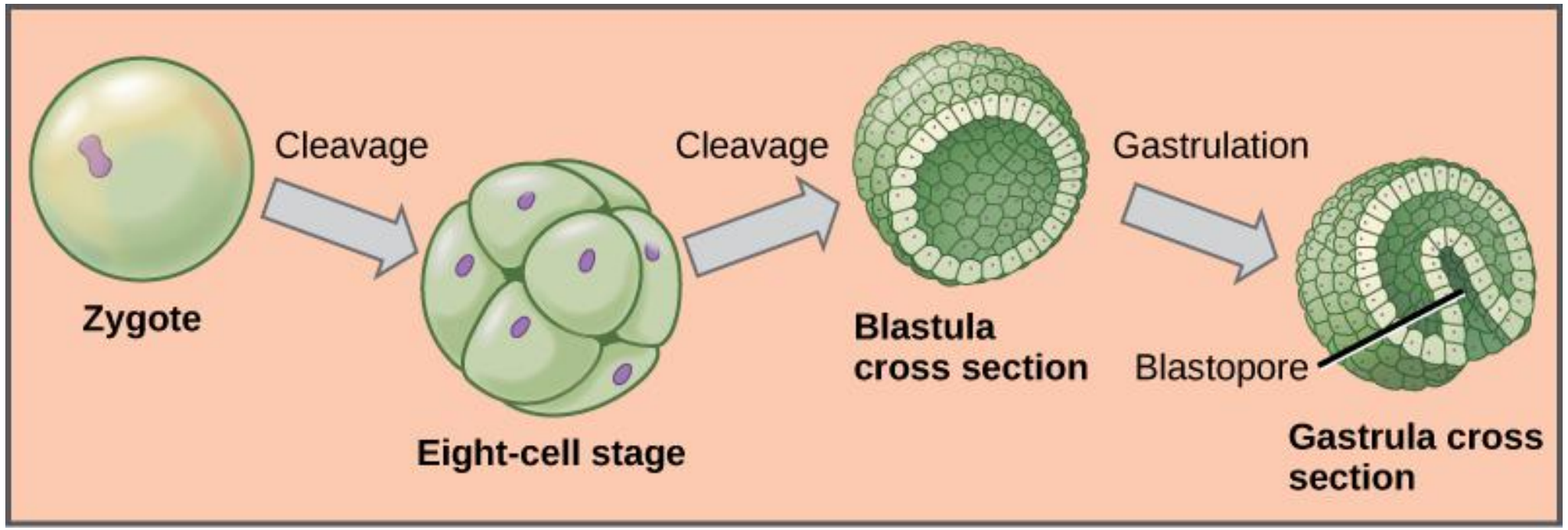
Cleavage

Zygote divides several times via mitosis, without changing size



Developmental Stages

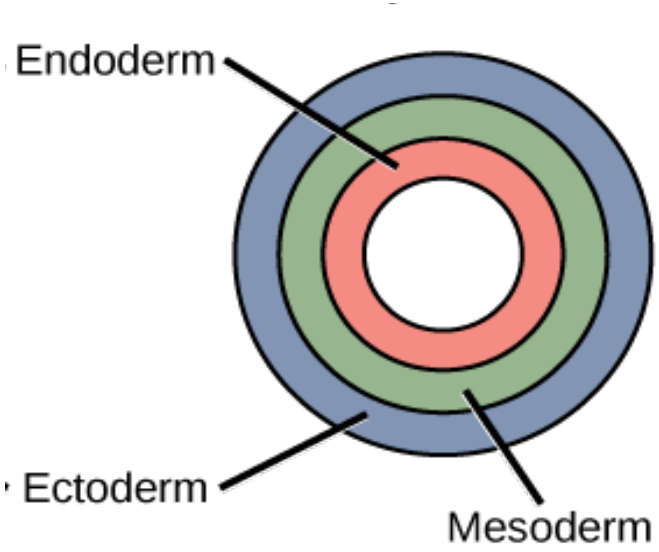
1. Morula- solid ball of cells
2. Blastula- hollow sphere of cells
3. Gastrula (gastrulation)- hollow sphere of cells w/ tube through center that forms digestive canal


Zygote
Cleavage
Eight-cell stage
Cleavage
Blastula
cross section
Gastrulation
Blastopore
Gastrula cross
section

Germ Layers

Layers of tissue in developing organism

1. Endoderm- inside, forms alimentary canal
2. Mesoderm- in middle, forms muscles, bones, circulatory system, reproductive system
3. Ectoderm- outside, forms skin, nervous system



2.4.3 Experimental Analysis of Vertebrate Development

Model Organisms

Model organisms are used to learn about generalities in vertebrate development

The majority of what we know about development has come from these models

Zebrafish

Zebrafish embryos have been used to explore:

- **effects of inhibitors**
- **effects of alcohol**
- **stages of development**

Frogs

Frog embryos have been used to investigate:

- blastula formation
- causes of two-headedness
- control of spinal formation

Chicks

Chicken embryos are used to learn about:

- **formation of limbs**
- **signaling molecules**

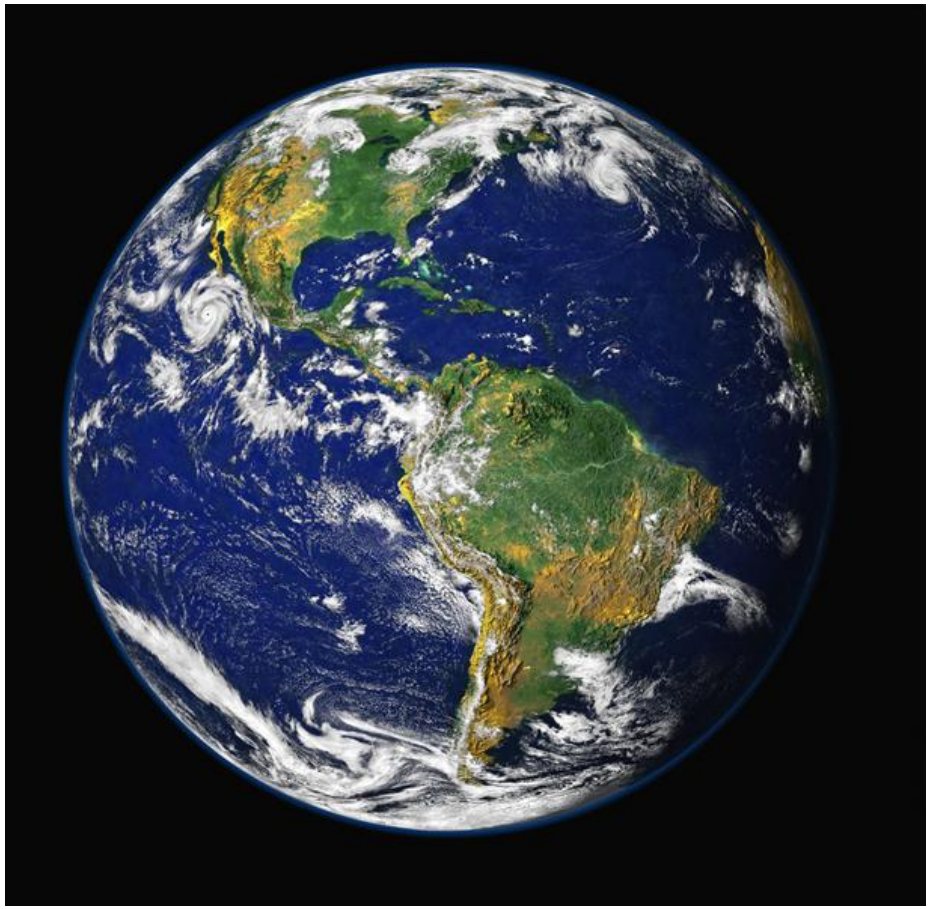
Mice

Study of mouse embryos have helped us understand:

- **toe formation & separation**
- **cell fate determinants**

Fish in Space!

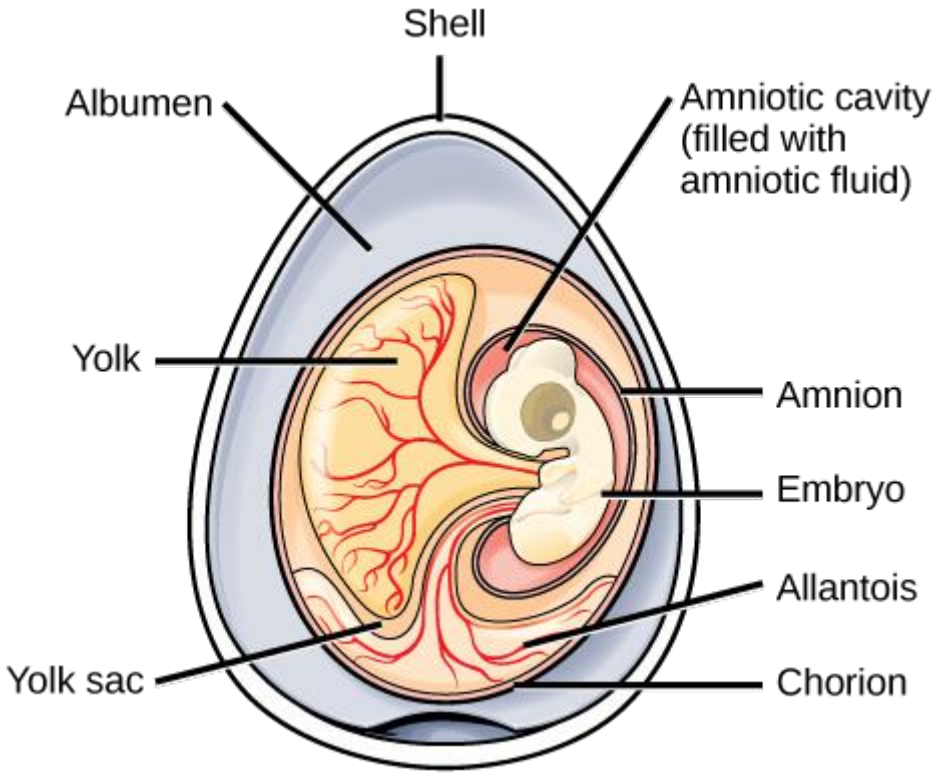
The medaka, and Asian relative of the zebrafish, is being used to study the effects of low gravity on vertebrate embryo development



2.4.4 Extraembryonic Membranes

Extraembryonic Membranes

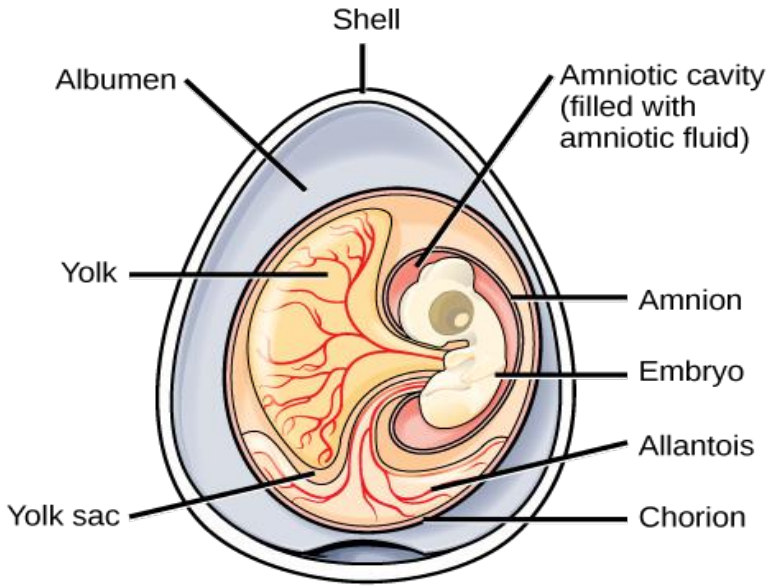
Membranes outside the embryo, surrounding embryo during development



Chorion

Regulates water, gases, nutrients, wastes

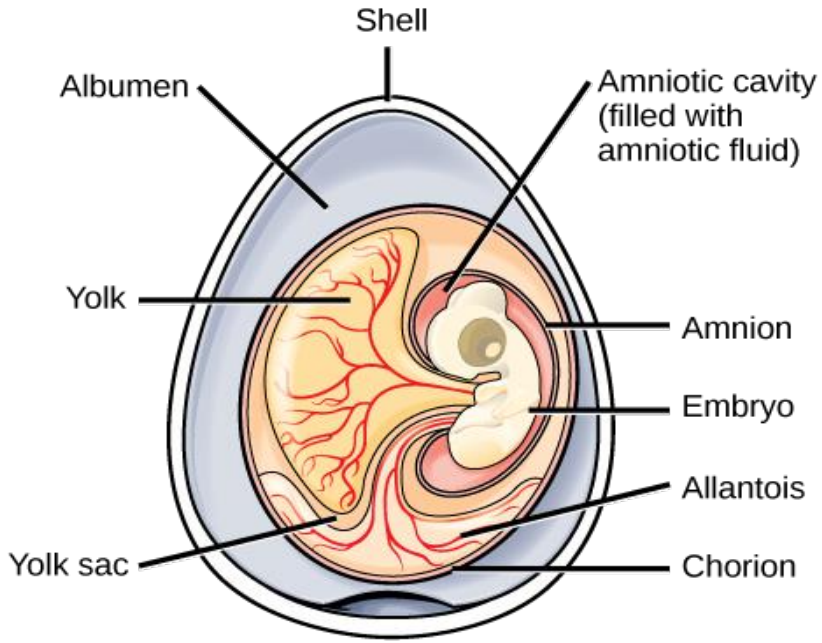
- **In egg-layers, in contact with inner shell surface**
- **In others, in contact with uterus**



Amnion

Fluid-filled sac around embryo

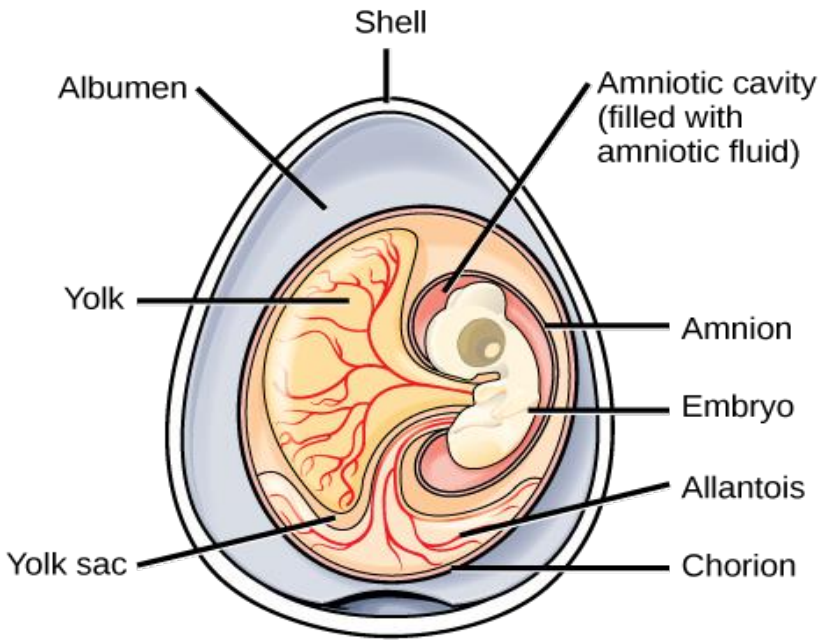
- **cushioning**
- **temperature regulation**



Allantois

Comes from developing digestive tract, gas & nutrient exchange

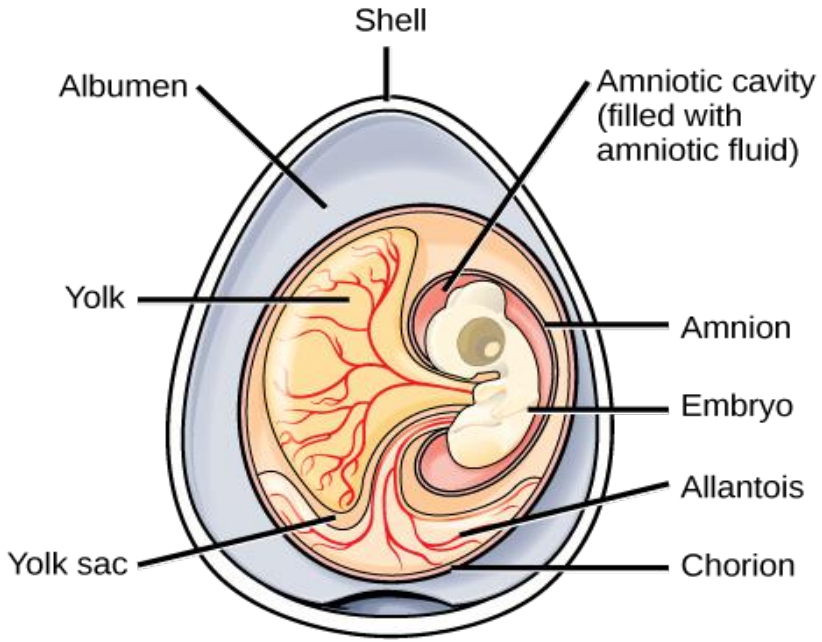
- becomes umbilical cord in non-egg layers
- waste storage in egg-layers



Yolk Sac Membrane

Comes from developing digestive tract, encloses yolk sac that stores nutrients

- **becomes part of umbilical cord in non-egg layers**
- **larger in non-egg layers**

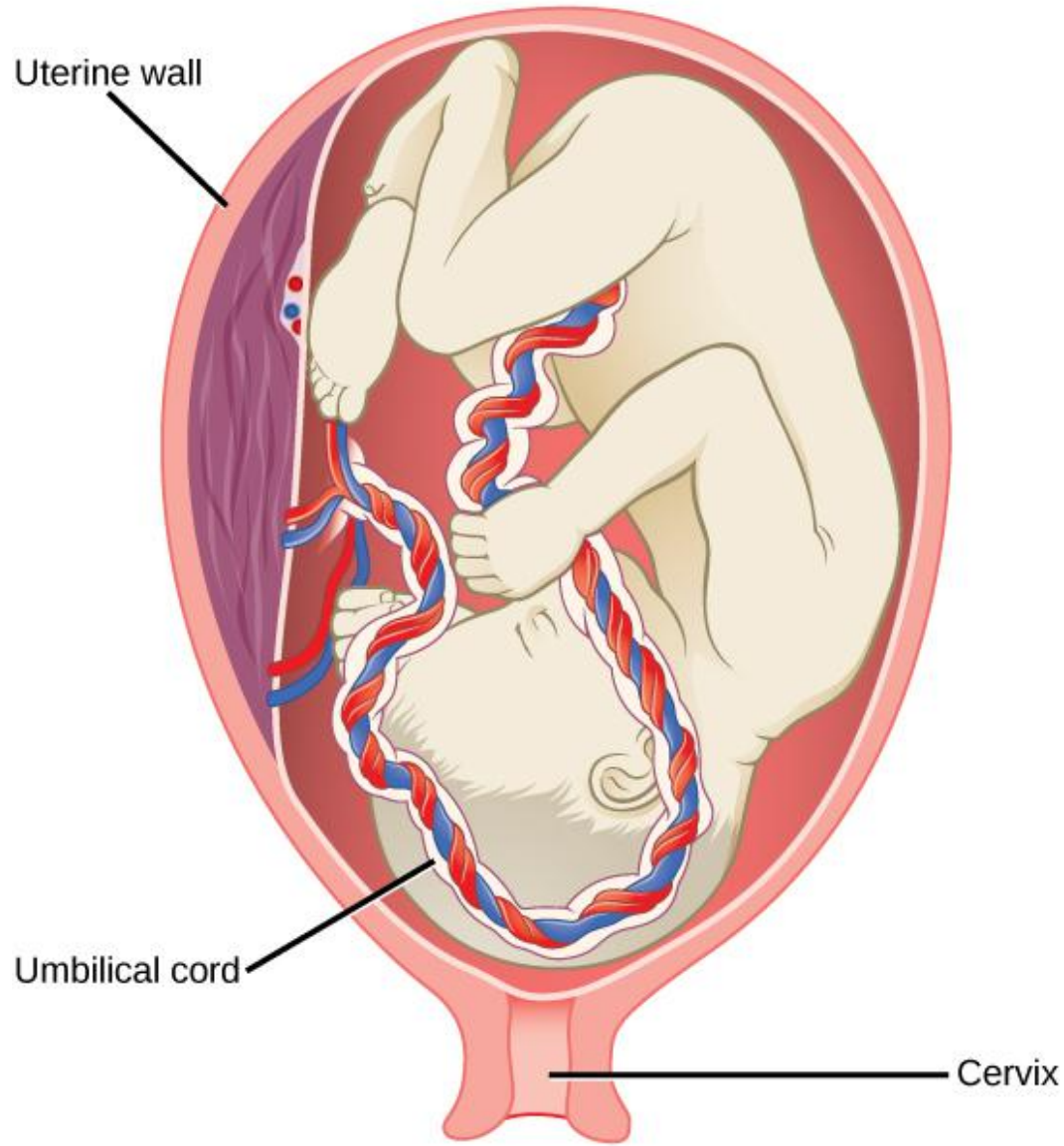


2.4.5 Formation & Function of Mammalian Placenta

Placental Formation

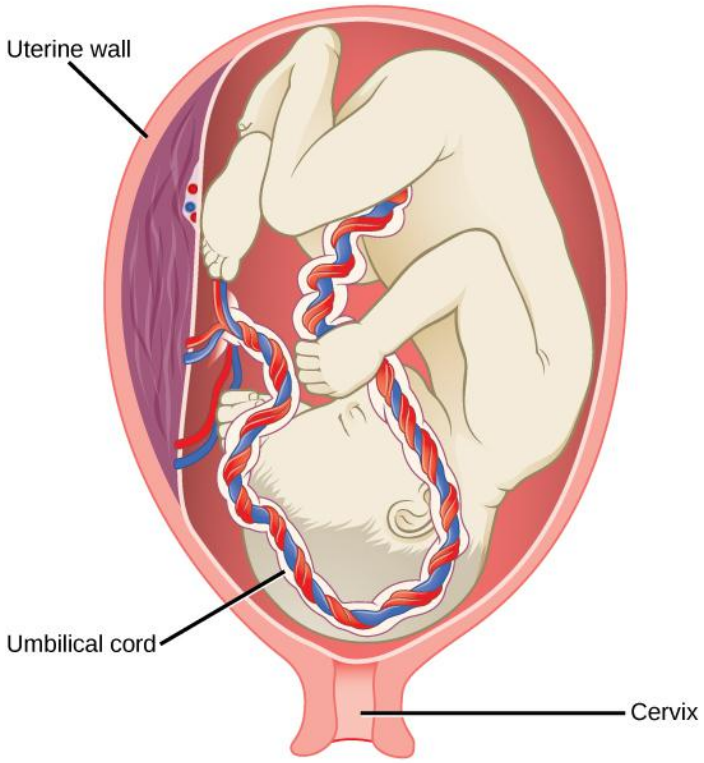
Formed from outer cells of embryo and inner cells of uterus

Connection between mother & embryo


Uterine wall
Umbilical cord
Cervix

Placental Function

Function: transfer nutrients, water, wastes between mother & embryo



2.4.6 Blood Circulation in Human Embryo

Human embryos develop their own blood vessels

Embryo's blood vessels next to mothers, and molecules exchanged via diffusion:

- **from mother to embryo- nutrients, water, oxygen**
- **from embryo to mother- carbon dioxide & waste**

2.5 Principles of Heredity

Principles of Heredity

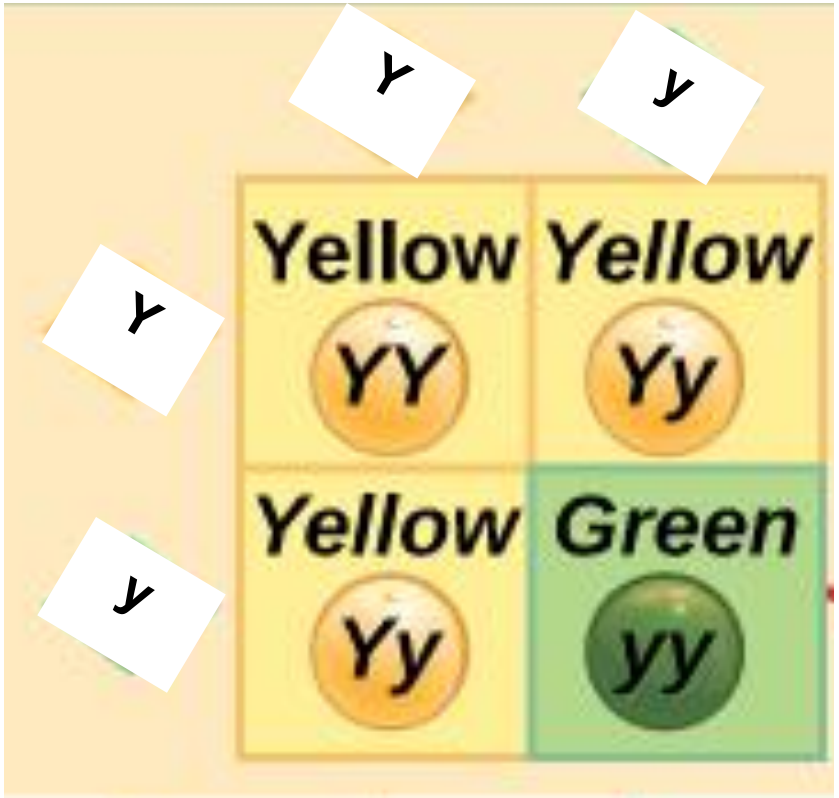
1- Mendelian Inheritance
2- Chromosomal Basis of Inheritance
3- Linkage
4- Polygenic Inheritance

Mendelian Inheritance

- Gregor Mendel
- terminology

Chromosomal Basis of Inheritance

- Mendel's Laws
- probability
- Punnett square



Linkage

- Non-Mendelian genetics
- sex linkage
- cat coat color
- other Linkage

Polygenic Inheritance

- multiple genes
- disease

2.5.1 Mendelian Inheritance

Gregor Mendel

Inheritance: characteristics passed from one generation to another, in form of genes

Mendel: Austrian monk who studied pea plant inheritance ~1865

First to quantify genetic tests

Terminology

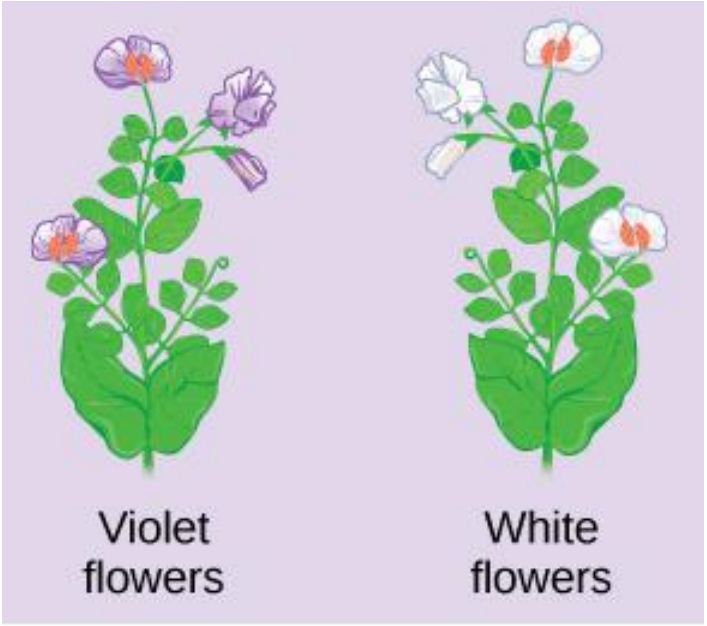
Mendel's ideas still accurate for simple systems

Mendel coined several terms still used:

1. **Allele: alternate form of gene, everyone has 2 alleles for each gene, represented by a letter (R, r)**
2. **Homozygous: two copies of same allele (RR or rr)**
3. **Heterozygous: one copy of each allele (Rr)**

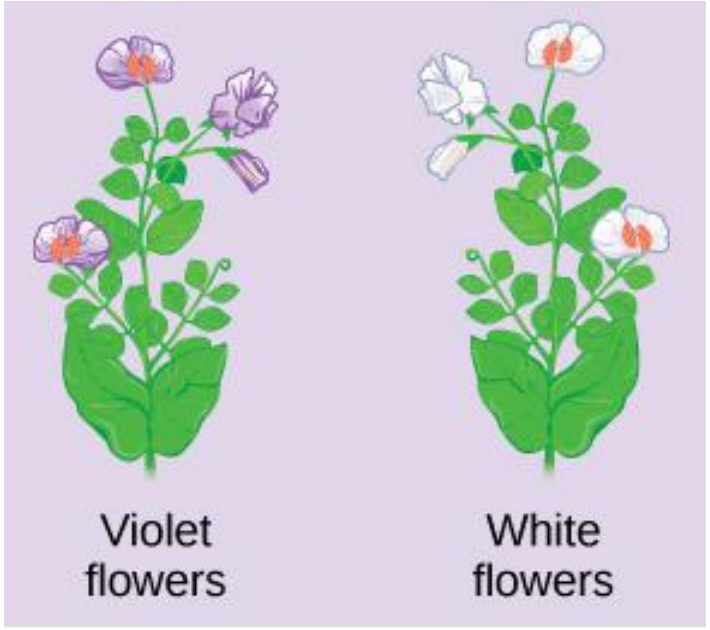
Terminology

4. **Dominant allele: always expressed when present, shown by capital letter (R, G, N)**
5. **Recessive allele: masked when dominant allele present, shown by lowercase letter (r, g, n)**



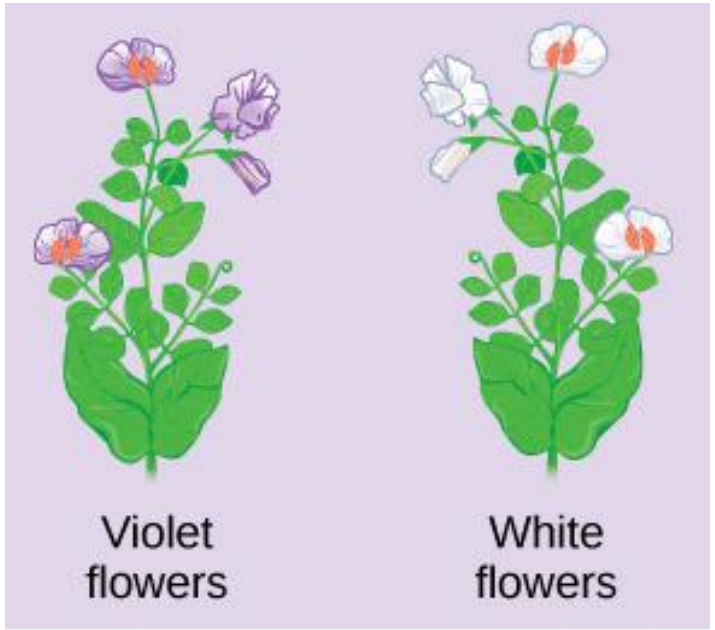
Terminology

6. **Genotype: alleles carried by individual**
7. **Phenotype: appearance of individual**
8. **Cross: sexual reproduction between different individuals**



Terminology

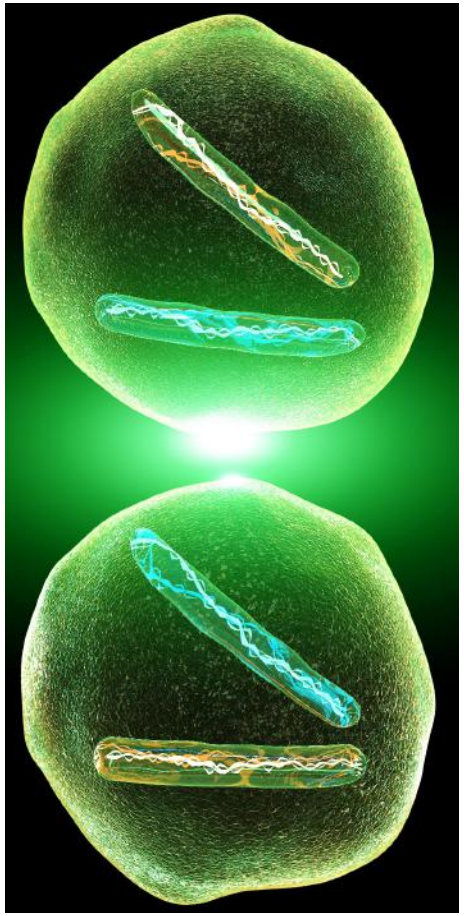
9. **Character: a feature, like hair color or plant height**
10. **Trait: the genotype or phenotype of an individual for a given character (red hair or dwarf plants)**

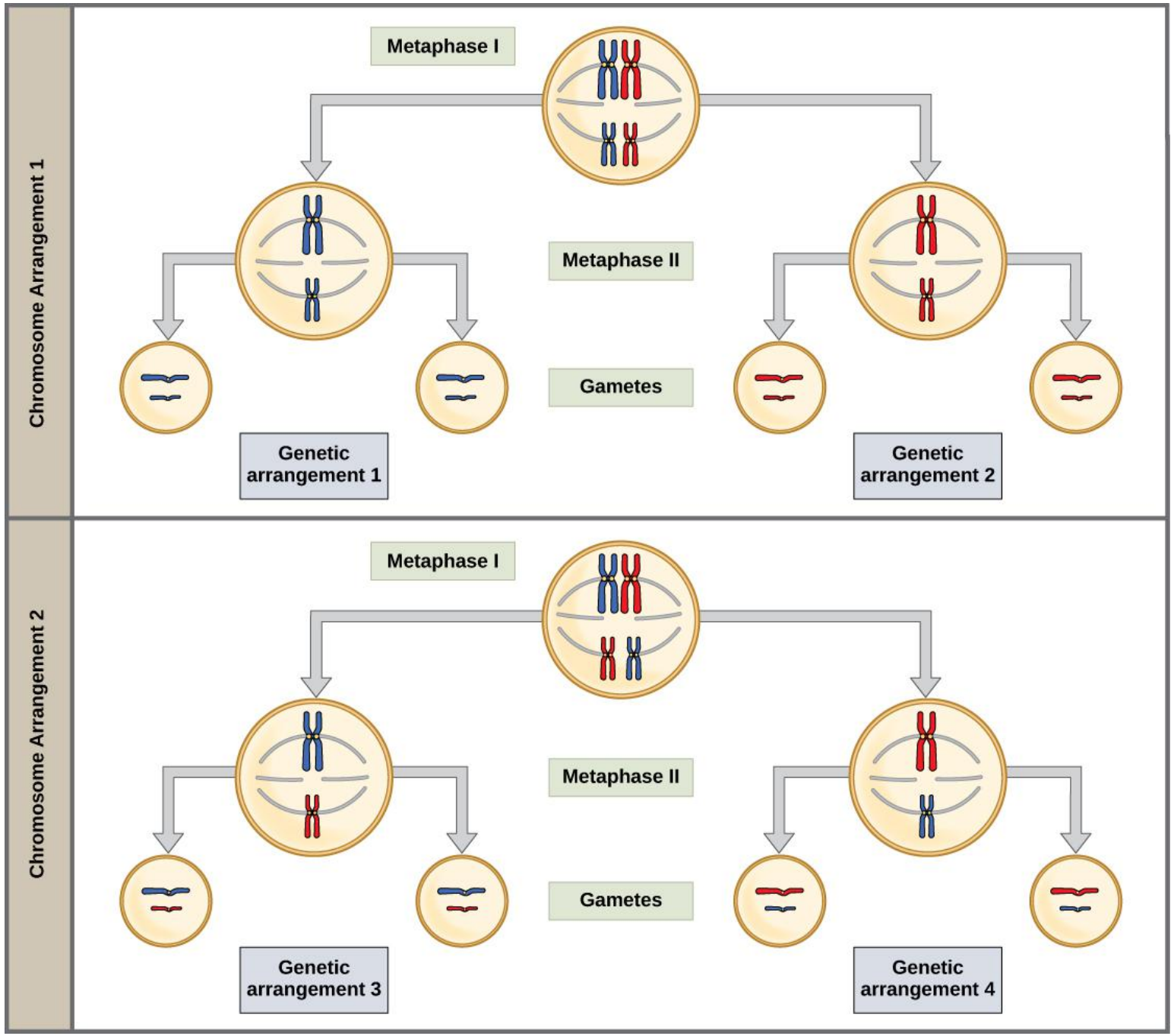


2.5.2 Chromosomal Basis of Inheritance

Mendel's Laws

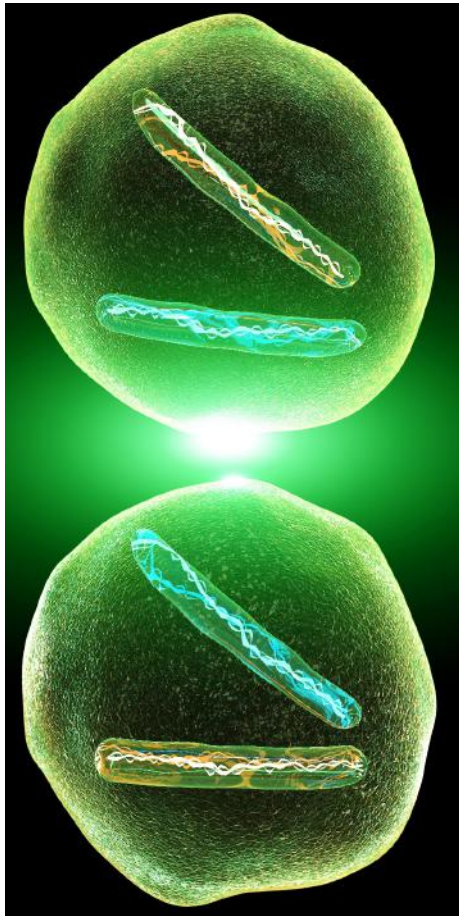
Law of Independent Assortment: Every possible combination of alleles is equally likely for each gamete




Chromosome Arrangement 1
Metaphase I
Metaphase II
Gametes
Genetic arrangement 1
Genetic arrangement 2
Chromosome Arrangement 2
Metaphase I
Metaphase II
Gametes
Genetic arrangement 3
Genetic arrangement 4

Mendel’s Laws

Law of Segregation: Paired genes separate and randomly recombine in gametes, so offspring have an equal likelihood of inheriting either



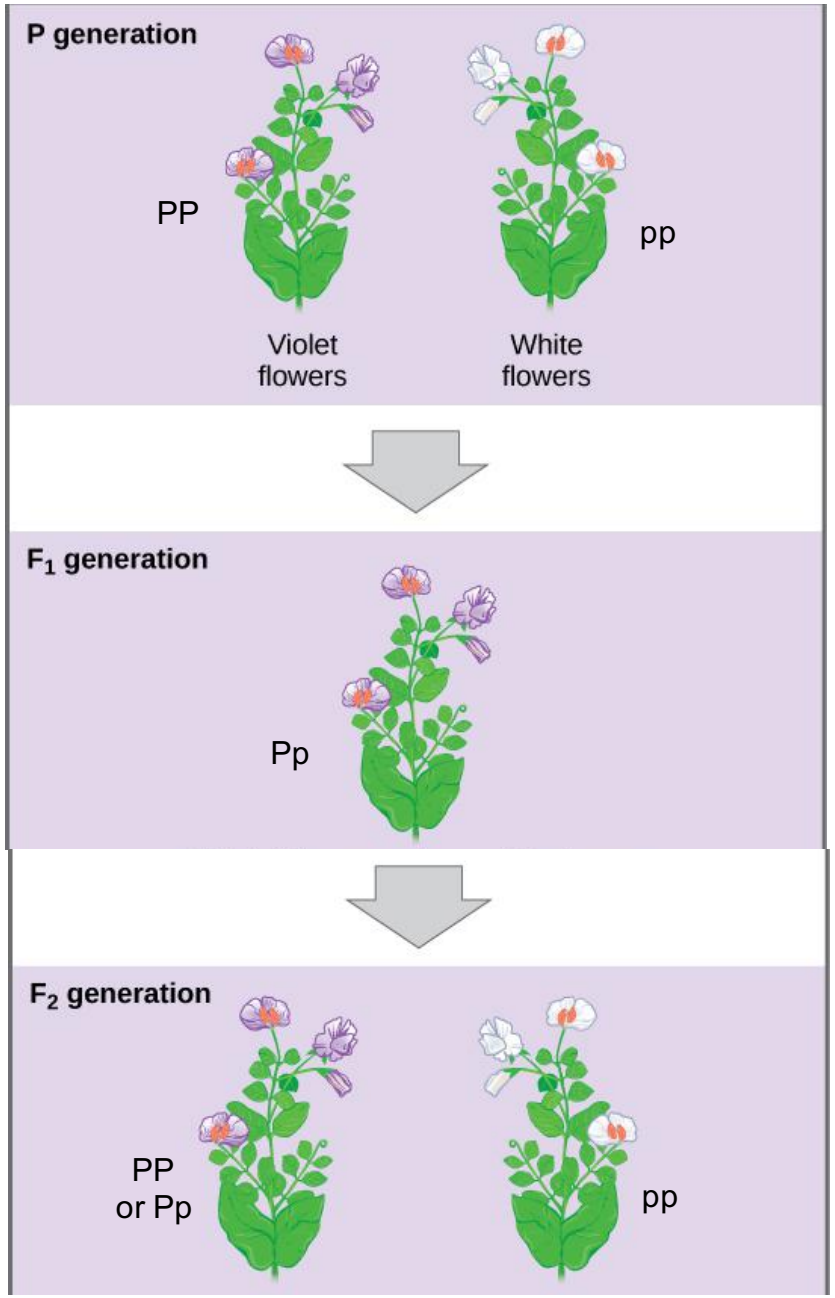
Probability

If independent assortment is occurring, laws of probability predict genotypes of offspring from crosses

Parental generation (P): the parents of a cross b/w two individuals

First Filial generation (F_1): offspring of P

Second Filial generation (F_2): offspring from cross b/w two F_1 individuals

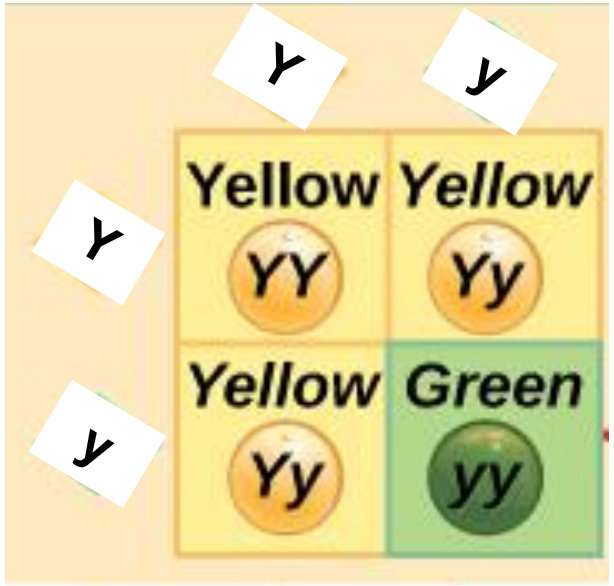

P generation
PP
pp
Violet flowers
White flowers
F1 generation
Pp
F2 generation
PP or Pp
pp

Punnett Square

Method of predicting offspring genotypes, using probability

Use gametes possible from each parent to see predicted offspring genotypes & phenotype ratios

P: Yy x Yy
F_1: ¼ YY, ½ Yy, ¼ yy



2.5.3 Linkage

Non-Mendelian Genetics

Since Mendel's time, we've discovered that his Law of Independent Assortment isn't always true.

- **Some genes only on sex chromosomes**
- **Some genes always inherited together**

Sex Linkage

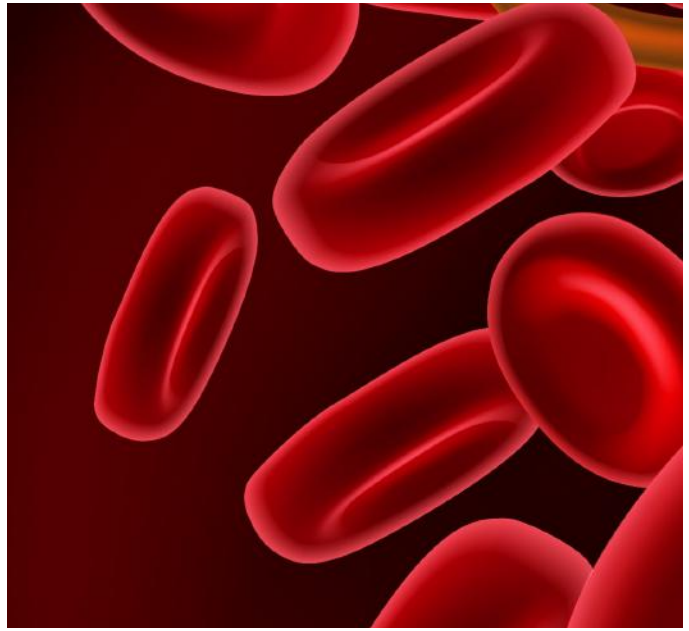
Sex-linked genes: those located on either sex chromosome

Y-linked genes usually harmless because so small

Sex Linkage

X-linked genes are responsible for several human genetic conditions

- color-blindness in men
- Duschene muscular dystrophy in men
- hemophilia



Cat Coat Color

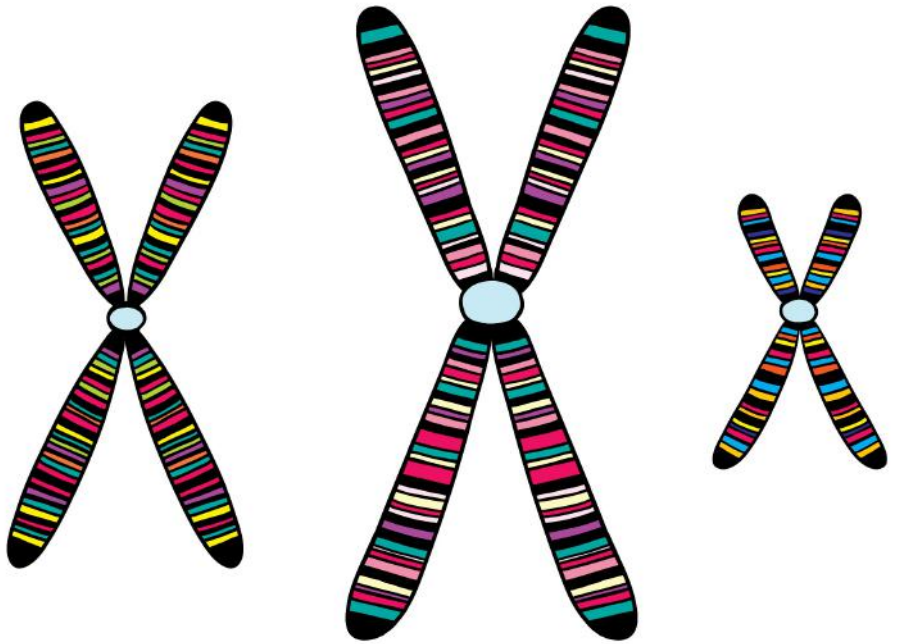
Tortoiseshell coat coloration the result of X-linked genes

- genes for orange and black coat color are both on the X chromosome
- males (Xy) express the color on their one X
- females (XX) express both colors, causing tortoise-shell patterning if black & orange
- only males with XXy genotype can be tortoiseshell or calico

Other Linkage

Linkage: autosomal genes inherited together during meiosis if close together

As distance between genes increases, likelihood of linkage decreases



2.5.4 Polygenic Inheritance

Multiple Genes

Polygenic inheritance: two or more genes affect the same phenotypic character

- **Human height**
- **Human eye & skin color**

Disease

Polygenic traits hard to predict, but can contribute to many illnesses

- **diabetes**
- **heart disease**
- **hypertension**