BIO.B.1

Anchor Descriptor: Describe the three stages of the cell cycle: interphase, nuclear division, cytokinesis

Eligible Content: Compare the processes and outcomes of mitotic and meiotic nuclear division

Cell Cycle

1. **Interphase**: The cell functions normally while preparing for division (copying DNA and increasing in size)

2. Nuclear Division: The cell, ready to divide, separates the genetic information in the nucleus in preparation of the split.

3. Cytokinesis: The cell physically splits into two separate cells which immediately enter Interphase.

How often do cell divide?

- Skin cells- every 2 weeks
- Red blood cells- 4 months
- Liver cells- 300-500 days
- Intestine-internal lining- 3-4 days
- Intestine- muscle and other tissues- 16 years

During Interphase...

1. The cell is duplicating all of its DNA
   - two copies of DNA is necessary so that when the split does occur, each new cell will have all of the genetic information

2. The cell is using the DNA as the blueprint for how to build the proteins the cell needs to function
   - within nucleus, **transcription** occurs when DNA (which stays in the nucleus) is used to create RNA (which can carry the genetic information out of the nucleus)

   - RNA then goes to the ribosomes which, through the process of **translation**, use the RNA to build proteins from amino acids

Two Types of Nuclear Division

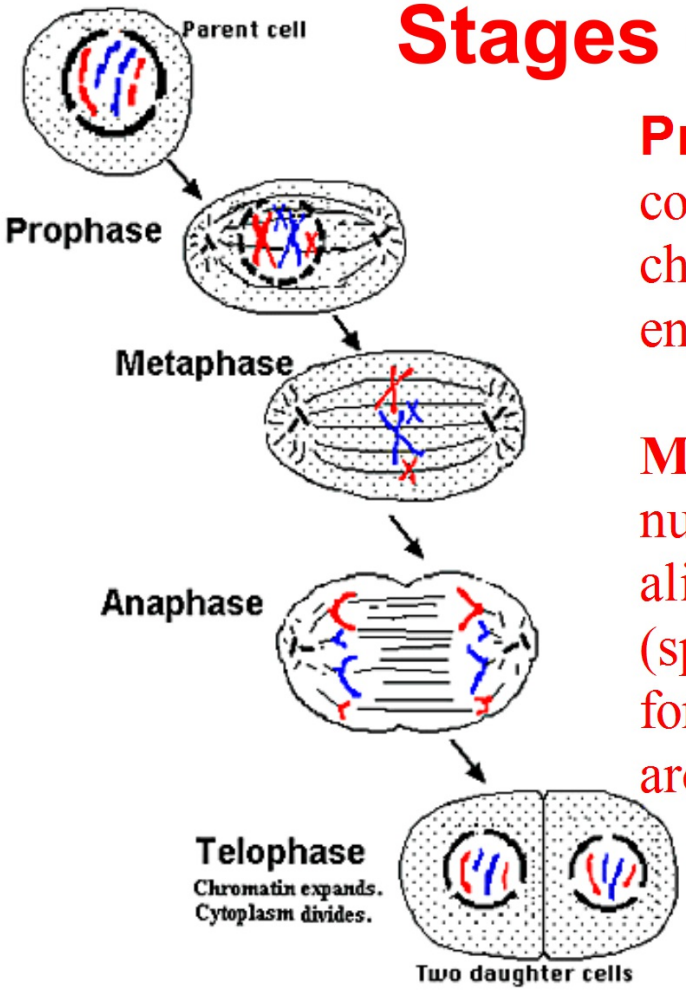
1. Mitosis

- forms two genetically identical cells
- occurs continuously in an organism
- has four stages
- how an organism creates new cells for itself
    - mistakes here cause problems for you (ex. cancer)

2 Meiosis

- forms four genetically unique cells
- occurs at particular times in organism's life
- has eight stages (with two separate splits)
- how an organism creates sex cells (gametes) to produce offspring (i.e. sperm and eggs)
    - mistakes here cause problems for your offspring

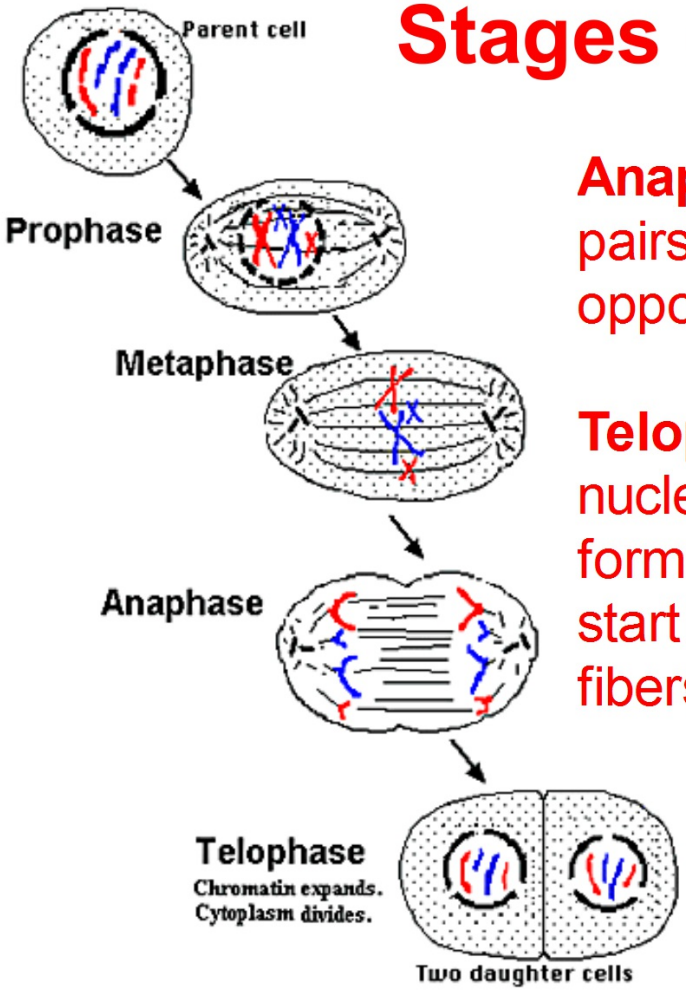
Stages of Mitosis



Prophase: DNA and proteins condense into tightly coiled chromosomes and the nuclear envelope starts to break down

Metaphase: free from the nucleus, chromosomes start to align at the center of the cell (spindle fibers are responsible for moving chromosomes around)

Stages of Mitosis



Anaphase: Chromosome pairs split and separate to opposite sides

Telophase: cell splits, new nuclear membranes start to form as the chromosomes start to unravel and spindle fibers fall apart

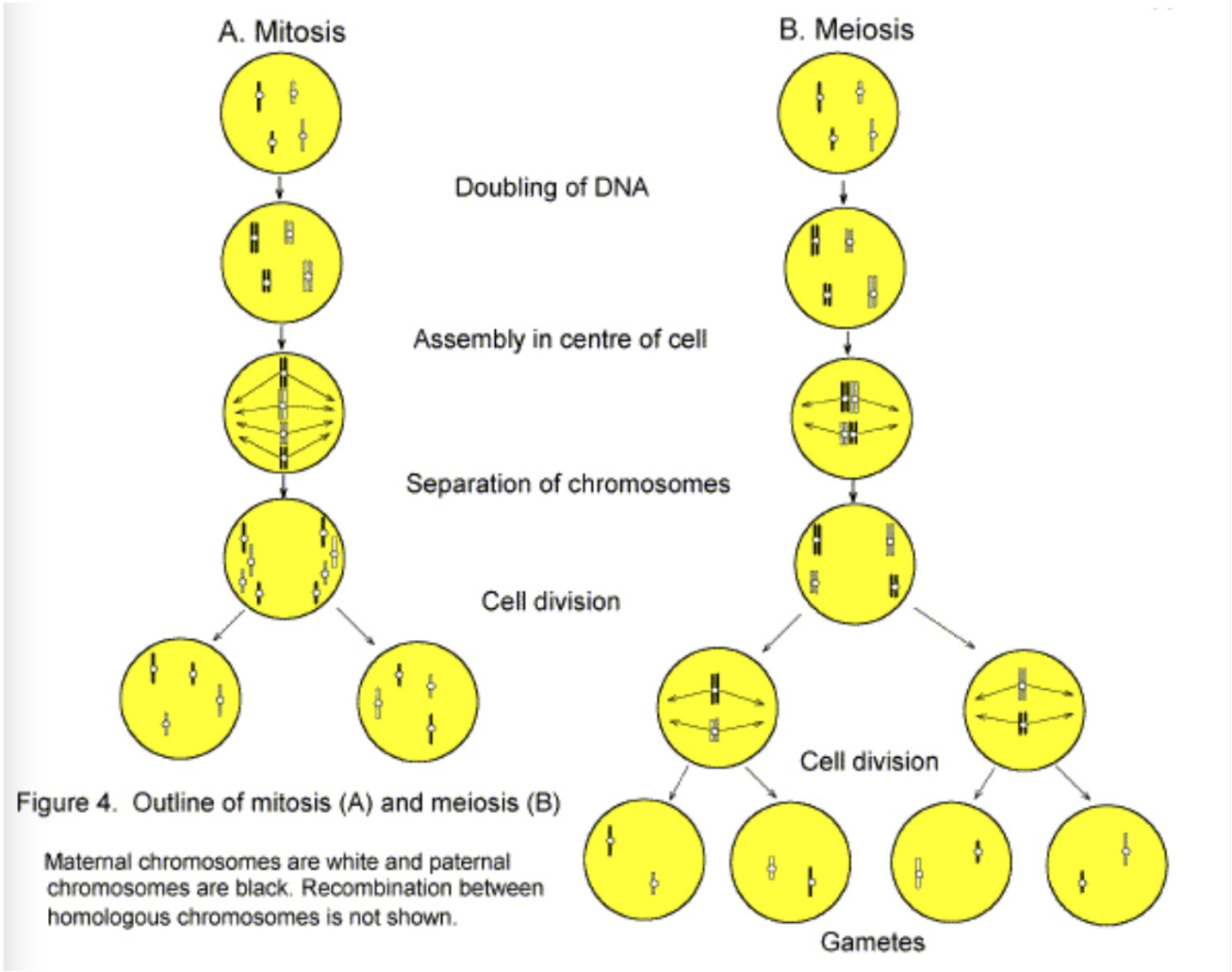
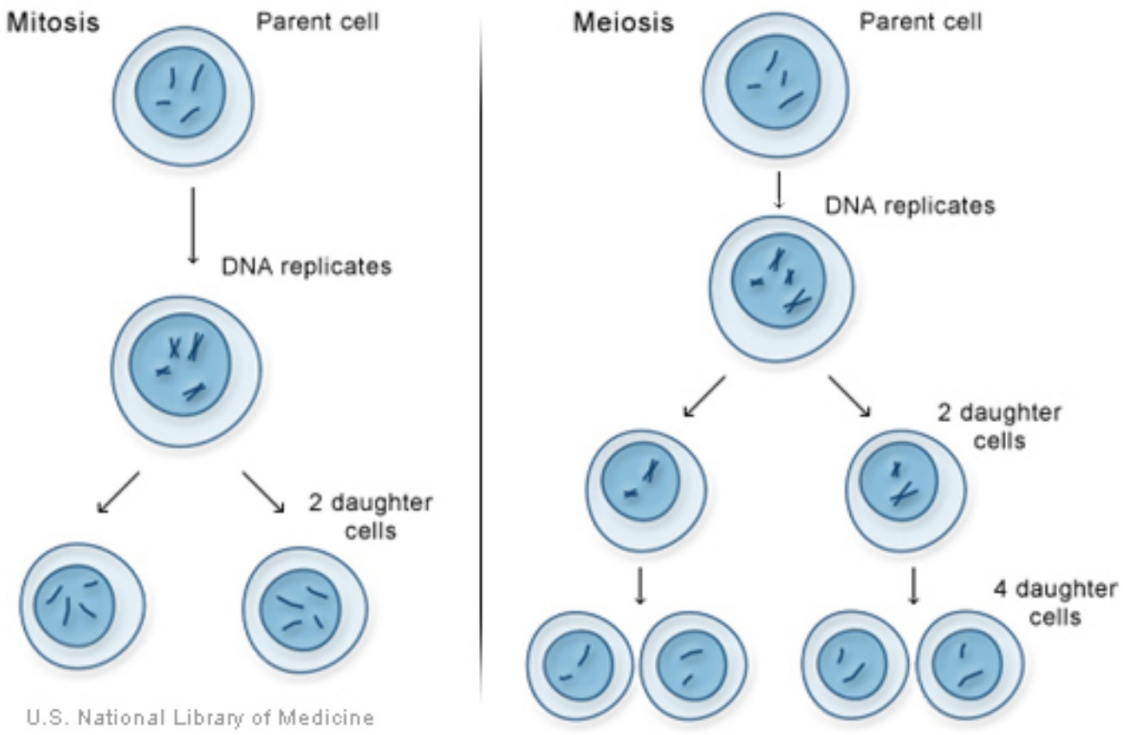


Figure 4. Outline of mitosis (A) and meiosis (B)

Maternal chromosomes are white and paternal chromosomes are black. Recombination between homologous chromosomes is not shown.

Mitosis vs Meiosis



Stages of Meiosis

- **Prophase I**: DNA organizes into chromosomes, nuclear membrane starts to break down (just like mitosis)
- **Metaphase I**: free from nucleus, chromosomes align in center (but different than mitosis)
- **Anaphase I:** the pairs of chromosomes split (unlike mitosis, chromosomes stay together)
- **Telophase I**: cells split apart nuclear membranes form again (just like mitosis)
- **Prophase II:** nuclear membrane break down again
- **Metaphase II:** chromosomes align at center
- **Anaphase II:** chromosomes pairs are pulled apart (like mitosis)
- **Telophase II:** cells split and form nuclear membrane

Mitosis/Meiosis Simulations

BIO.B.2

Anchor Descriptor: Compare Mendelian and non-Mendelian patterns of inheritance

Eligible Content: Describe and/or predict observed patterns of inheritance (i.e., dominant, recessive, co-dominance, incomplete dominance, sex-linked, polygenic, and multiple alleles).

Mendelian Patterns of Inheritance

(the simplified version)

key definitions

genome: all of an organism's genetic information

genotype: the genetic makeup of a specific set of genes which will determine a particular trait

phenotype: the actual trait the organism exhibits

allele: the alternate forms a particular gene might take

dominant allele: the allele that is expressed when two different alleles or two dominant alleles are present

recessive allele: the allele that is only expressed when two recessive alleles are present

Mendelian Patterns of Inheritance

(the simplified version)

example: determining eye color

Possible genotypes: BB, Bb, bb

- B: dominant allele (will lead to brown eyes)
- b: recessive allele (will lead to blue eyes)
- each genotype is made up of an allele from the mother and allele from the father
- the actual eye color the offspring has is its phenotype

Mendelian Patterns of Inheritance

(the simplified version)

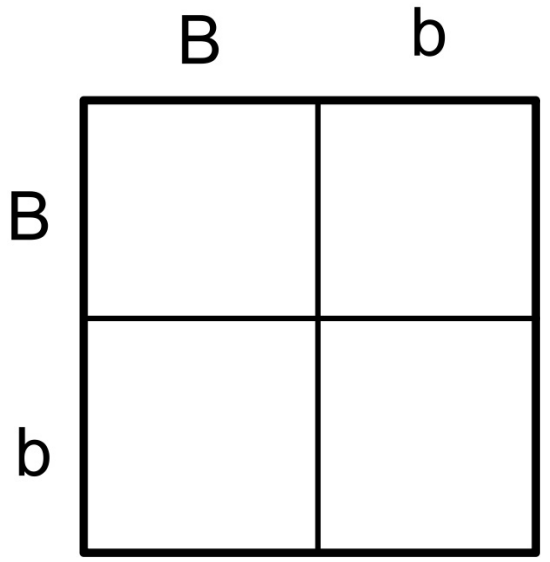
example: determining eye color

Father Genotype: Bb

- made up of an allele from paternal grandfather and an allele from paternal grandmother

Mother Genotype: Bb

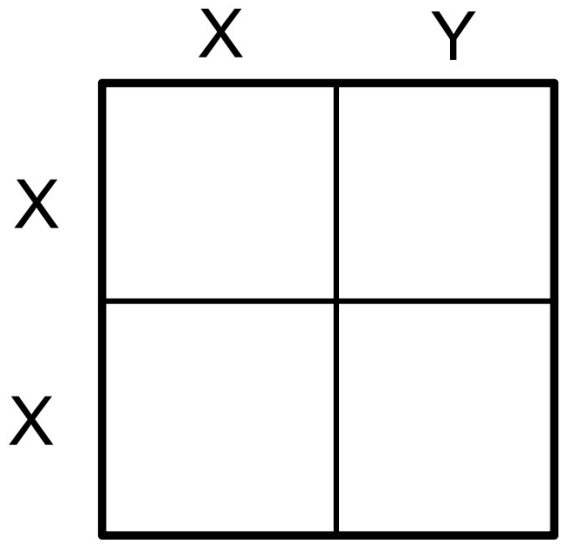
- made up of an allele from maternal grandfather and an allele from maternal grandmother



Punnett Square

Determining Gender

Male: XY
Female: XX



Non-Mendelian Patterns of Inheritance

(the complex, but more realistic, version)

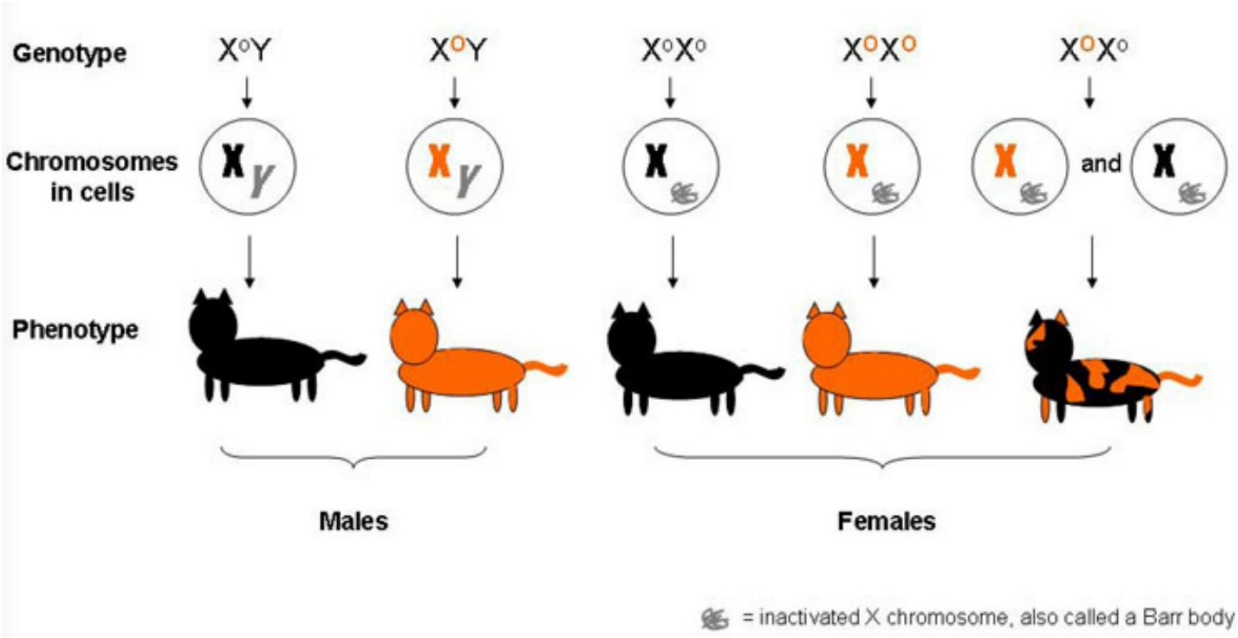
Sex-linked Genes

- some genes are only found on the X chromosome, so only one allele is present in males (because Y chromosome can't provide an allele)
- even in females (with two X chromosomes) only one allele is used to determine the phenotype (but which chromosome provides it may vary from cell to cell)

Non-Mendelian Patterns of Inheritance

(the complex, but more realistic, version)

Sex-linked Genes



Non-Mendelian Patterns of Inheritance

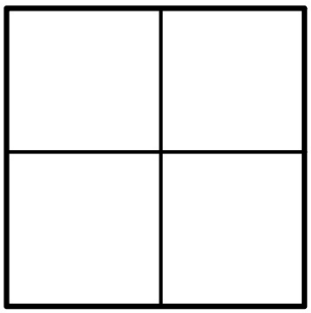
(the complex, but more realistic, version)

Incomplete Dominance

- when heterozygous phenotype (genotype has two different alleles) is somewhere in between the homozygous phenotypes (genotypes have the same alleles)

Example

<u>Flower Color</u>
RR = Red
WW = White
RW = Pink



Non-Mendelian Patterns of Inheritance

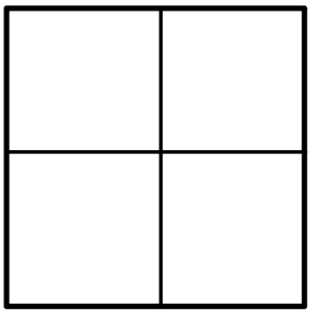
(the complex, but more realistic, version)

Codominance

- when neither allele is dominant nor recessive so both traits are fully and separately expressed.

Example

<u>Flower Color</u>
RR = Red
WW = White
RW = some red area and some white area



Non-Mendelian Patterns of Inheritance

(the complex, but more realistic, version)

Polygenic Traits

- when more than one gene interact to form a trait
- example in humans: eye color
    - note: our brown eyes vs. blue eyes example from early was oversimplified

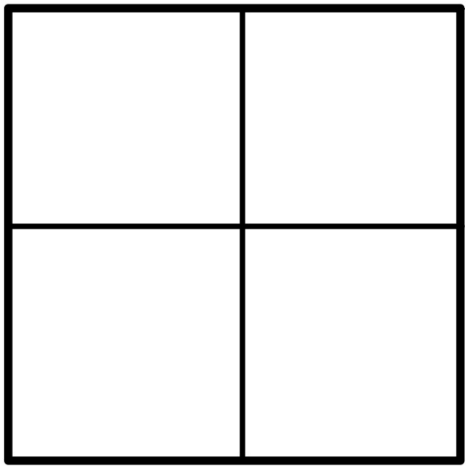
Multiple Alleles

- more than two alleles are present in a population, but each individual organism still only has two alleles (one from each parent)
- example in humans: blood type (I^A, I^B, I^o)

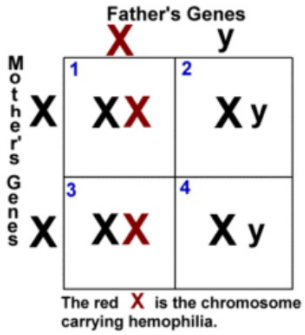
Blood Types (example of multiple alleles)

I^AI^o = Type A
I^AI^A = Type A
I^BI^o = Type B
I^BI^B = Type B
I^AI^B = Type AB
I^oI^o = Type 0

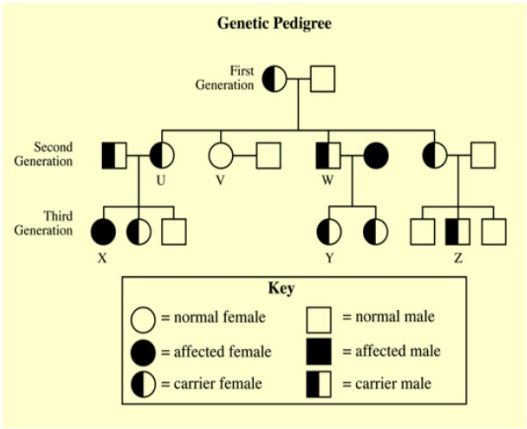
What if...



Punnett Squares and Pedigree



Blood Type	Genotype		Can Receive Blood From:
A	$i^A i$ $i^A i^A$	AA AO	A or O
B	$i^B i$ $i^B i^B$	BB BO	B or O
AB	$i^A i^B$	AB	A, B, AB, O
O	$i\,i$	OO	O



	O	O
A	AO	AO
B	BO	BO

	A	B
A	AA	AB
B	BA	BB

BIO.B.3

Anchor Descriptor: Analyze the sources of evidence for biological evolution.

Eligible Content: Interpret evidence supporting the theory of evolution (i.e., fossil, anatomical, physiological, embryological, biochemical, and universal genetic code).

Theory of Evolution

Organisms evolve from simpler organisms through the process of natural selection.

Natural Selection: The process by which organisms with traits that allow them to thrive are able to reproduce more successfully than other organisms with different traits. This process leads to the creation of new species and the extinction of others creating the diversity of life.

Theory vs. Law

Theory: an explanation

Law: a description

It will never be called the Law of Evolution. That does not mean there is not solid evidence in support of it.

Evidence in Support of Evolution

1. We can see it happening...

The Peppered Moth

Peppered Moths can have two colors as seen above. When majority of the trees were clean (i.e. light in color), the population of the white moths was significantly higher.

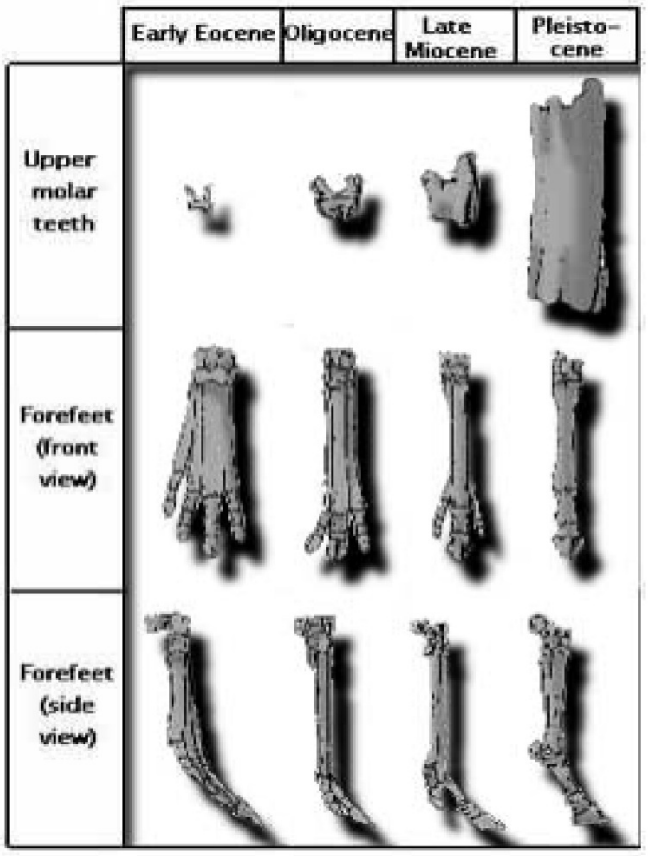
Evidence in Support of Evolution

But... the pollution caused by the Industrial Revolution in Great Britain turned trees dark, consequently, the population of white Peppered Moths dropped dramatically, while the population of black Peppered Moths increased dramatically.

Evidence in Support of Evolution

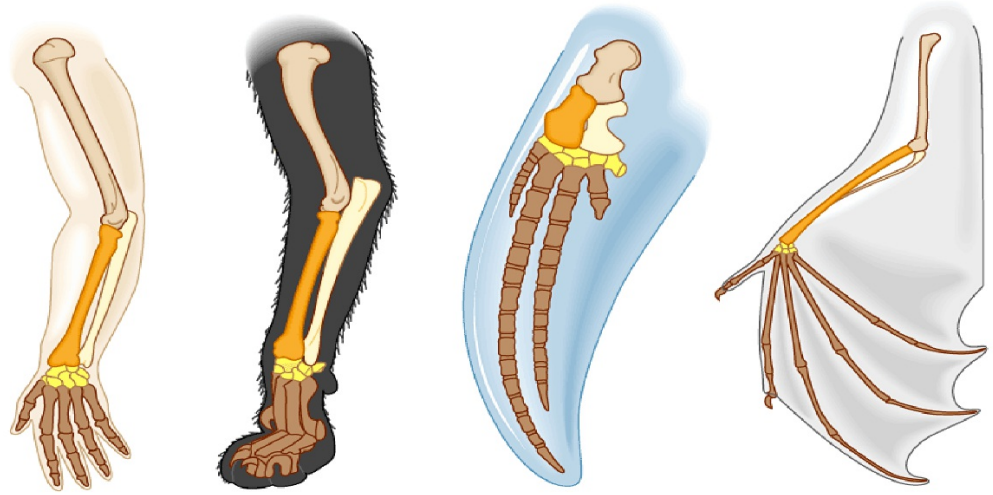
2. Fossil Record

- Succession of form over time
- Transitional Links
- Vertebrate Descent



Evidence in Support of Evolution

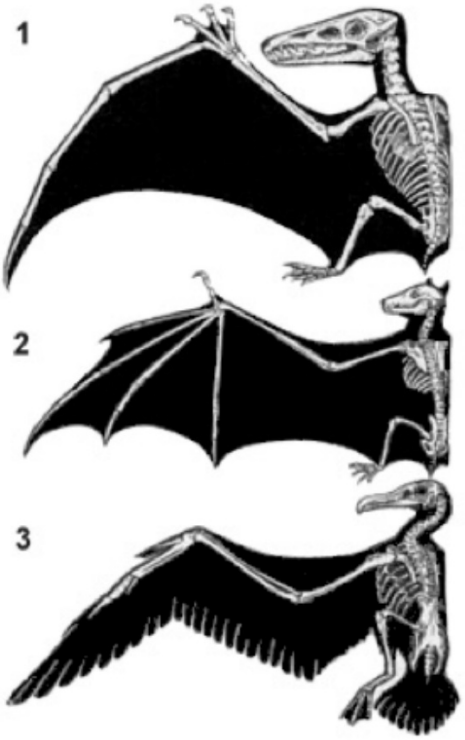
3. Homologous Structures vs. Analogous Structures



Homologous Structure: May perform the same or different function, but have the same evolution origin

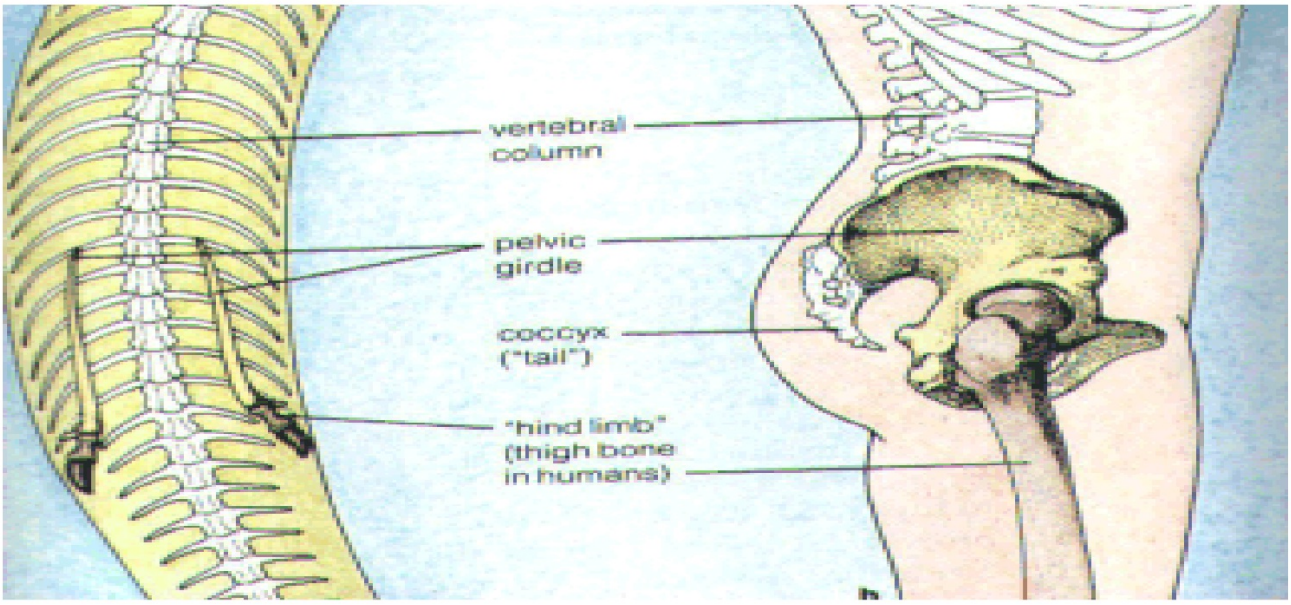
Evidence in Support of Evolution

3. Homologous Structures vs. Analogous Structures



Analogous Structure: Perform the same function, but completely different structure and evolution origin

Evidence in Support of Evolution

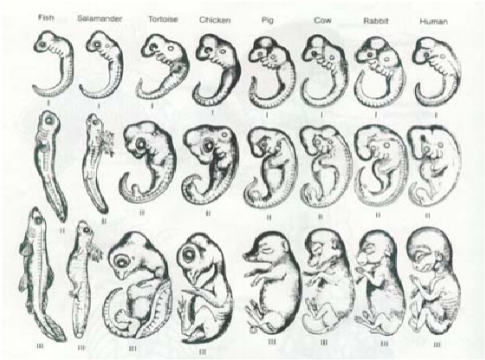


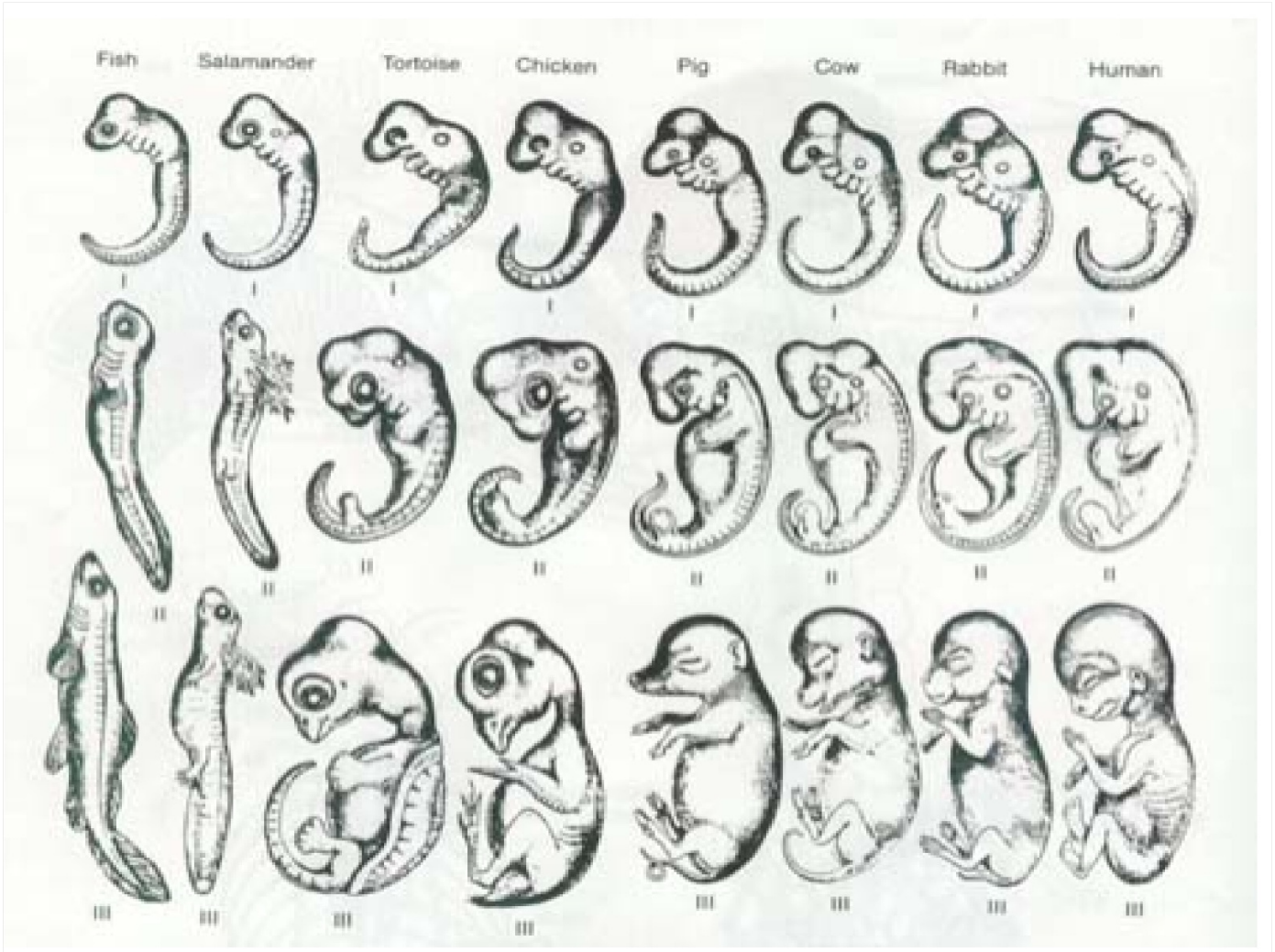
Vestigial Structure: Organs useless to their present owner, structure that serve no important function

Evidence in Support of Evolution

4. Comparative Embryology

Similarities can be seen between the early stages of development in related organisms




Fish
Salamander
Tortoise
Chicken
Pig
Cow
Rabbit
Human
I
II
III

Evidence in Support of Evolution

5. Molecular Biology

- Similarities in DNA, proteins, genes, and gene products

- Common genetic code

Evidence in Support of Evolution

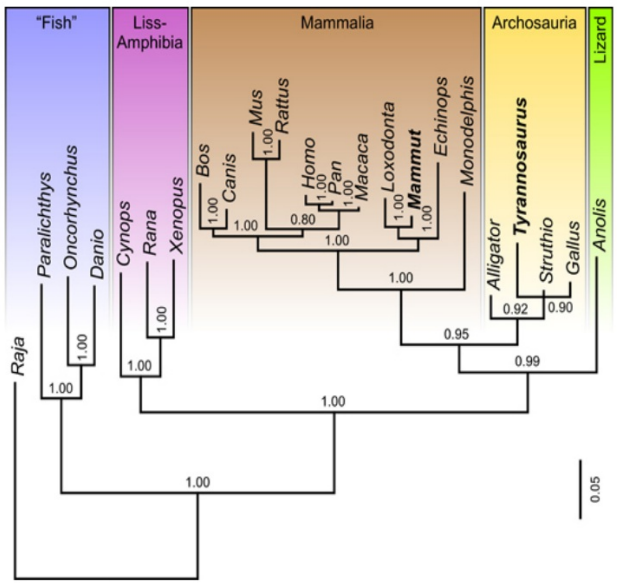
Table 22.1 Molecular Data and the Evolutionary Relationships of Vertebrates

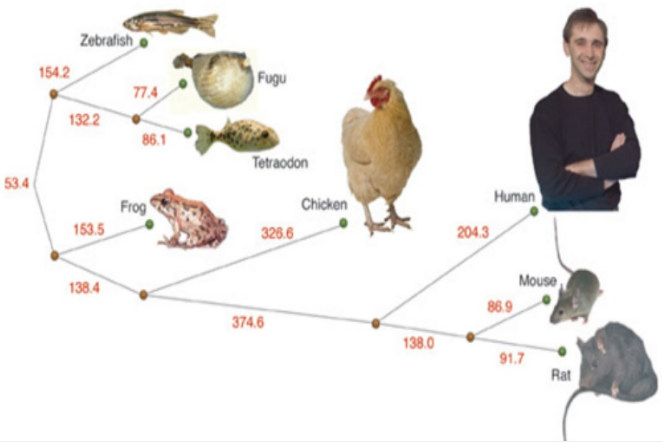
Species	Number of Amino Acids That Differ from a Human Hemoglobin Polypeptide (Total Chain Length = 146 Amino Acids)
Human 	0
Rhesus monkey 	8
Mouse 	27
Chicken 	45
Frog 	67
Lamprey 	125

Species that have few differences are closely related.

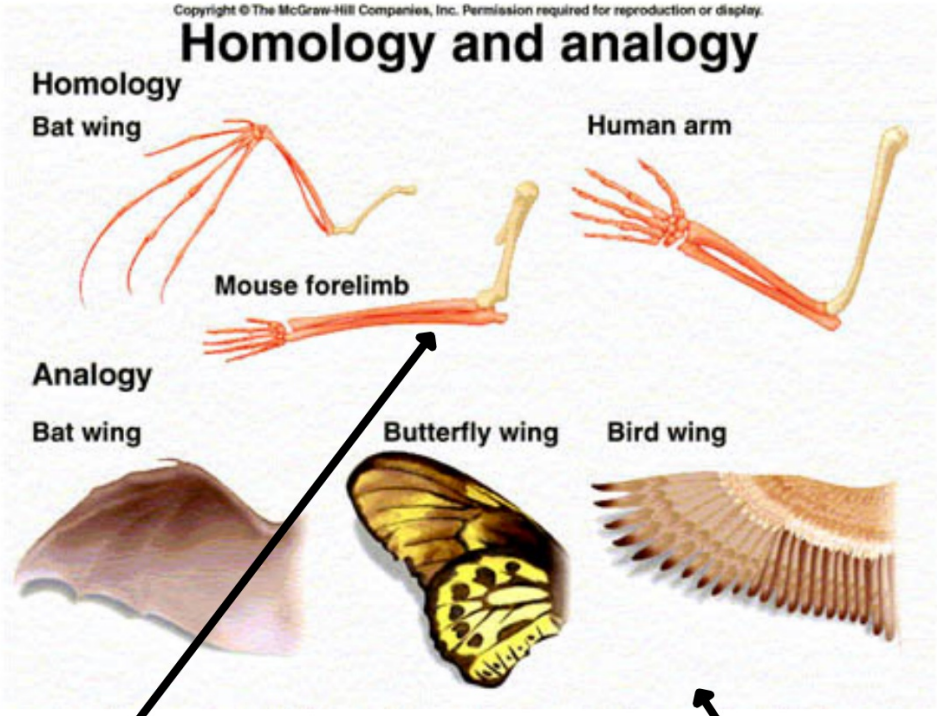
Species that have many differences diverged from each other further in the past.

Phylogenic Trees





The Mulan program can generate a phylogenetic tree that depicts the evolutionary relationships between species based on the similarities of their genomes. The red circles represent common ancestors, and the numbers represent nucleotide substitutions per 1 kilobase of genomic sequence.



Different function but evolved from the same structure (shows genetic relation)

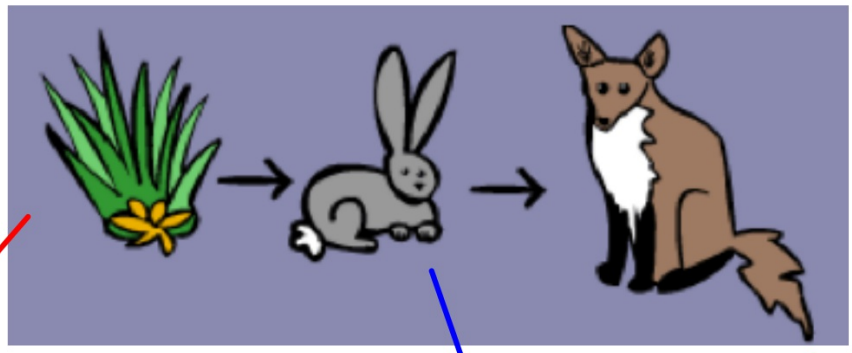
Same function but evolved from different structures (does not show genetic relation)

BIO.B.4

Anchor Descriptor: Describe interactions and relationships in an ecosystem

Eligible Content: Describes the effects of limiting factors on population dynamics and potential species extinction

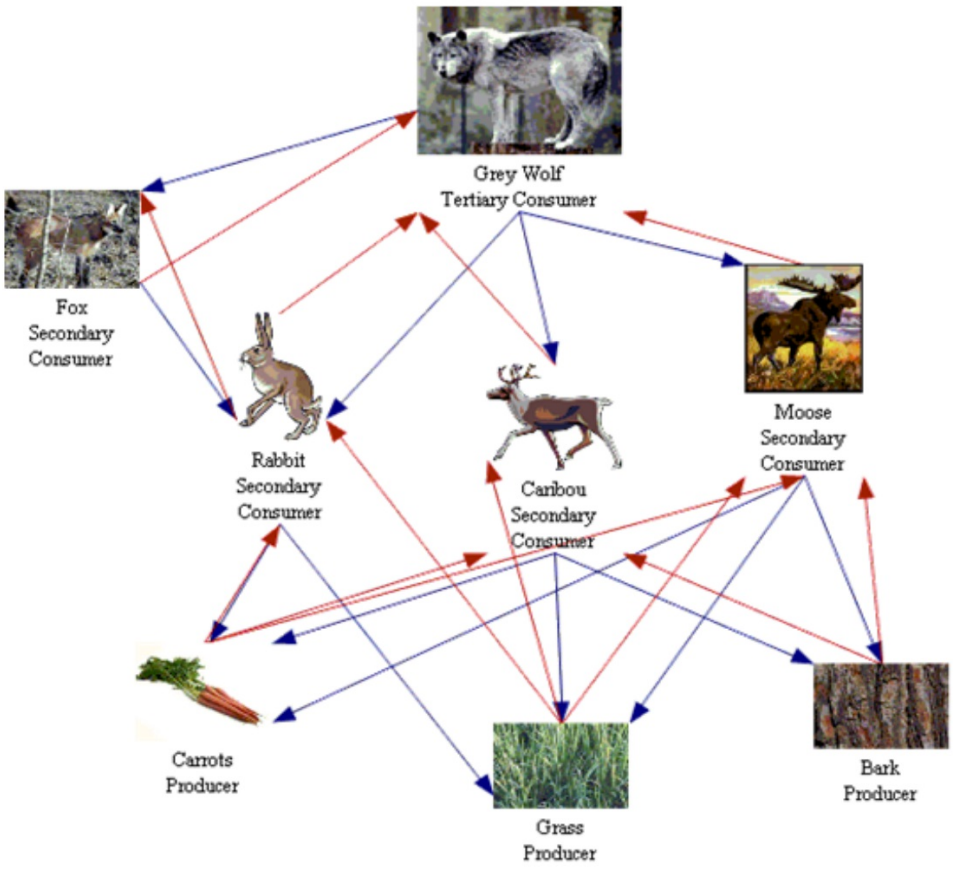
The Food Chain



Producers
get energy from photosynthesis

Primary Consumer
eat producers, get energy from producers, who got it from photosynthesis

Secondary Consumer
eat primary consumer, get energy from primary consumer, who got it from producer, who got it from photosynthesis


Grey Wolf
Tertiary Consumer
Fox
Secondary
Consumer
Rabbit
Secondary
Consumer
Caribou
Secondary
Consumer
Moose
Secondary
Consumer
Carrots
Producer
Grass
Producer
Bark
Producer

Species Relationships

1. **Predator/Prey:** one species eats another

2. **Competition:** two species compete for the same resource

3. **Symbiotic:** a close and prolonged relationship between two species
   a. Mutualism: both species benefit
   b. Commensalism: one species benefit, other is unaffected
   c. Parasitism: one species benefits, other is harmed

Ecology

The scientific study of the relationships that living organisms have with each other and their natural environment

Because all organisms in an environment affect each other and the environment itself, changes to the environment or any individual species in the ecosystem can have dramatic effects on the rest of the system.