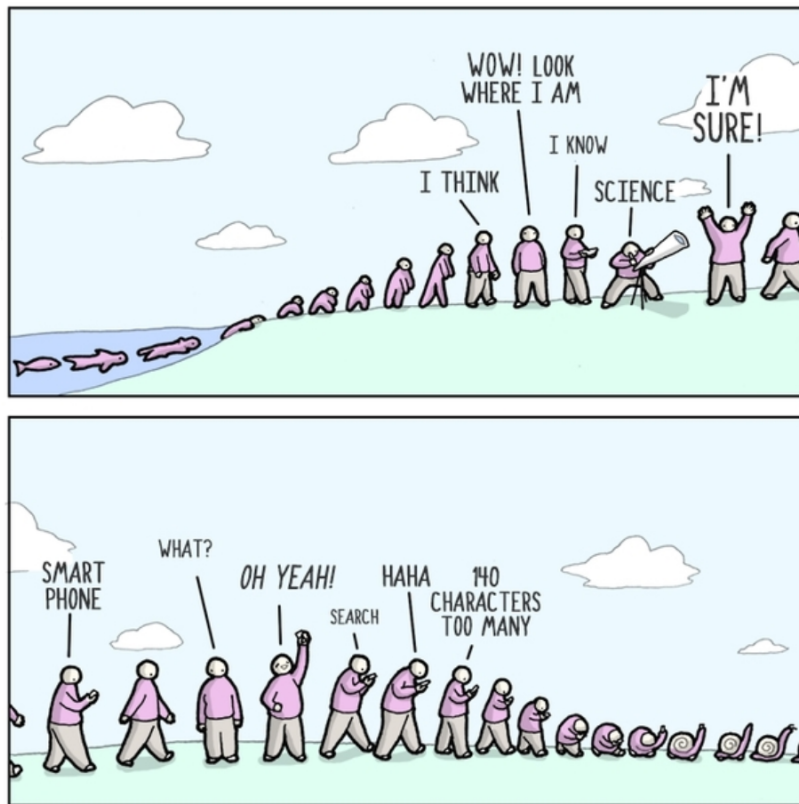# SCIENCE 10

UNIT 3: BIOLOGY

BOOK2: MUTATIONS & EVOLUTION

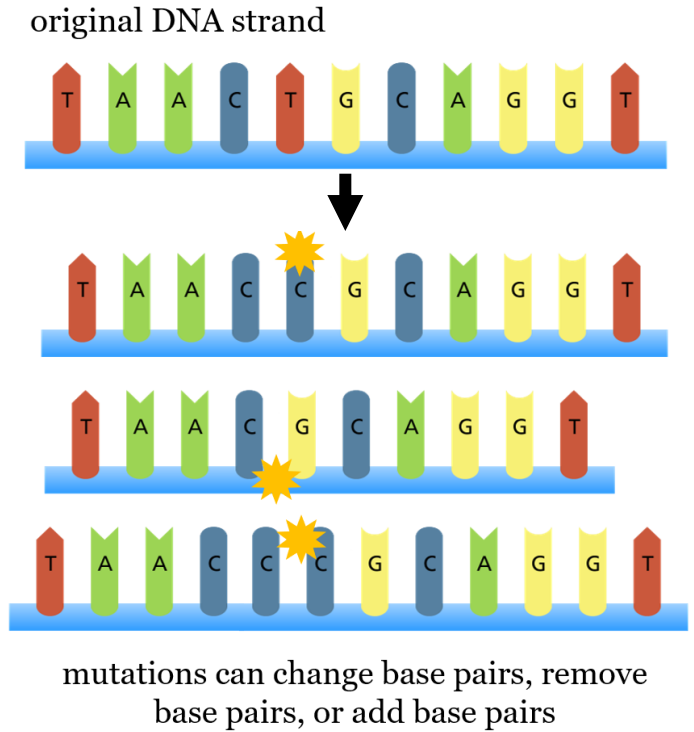NAME: _____   BLOCK:_____

Lesson 1.5 – Mutations

Mutations

☐ Up to this point, we have considered DNA molecules to be permanent structures, but in nature the DNA of organisms is

_____

☐ Any change to the sequence of bases in a DNA molecule is called a _____

☐ These changes can be small, such as

_____ _____,

_____ _____

or _____, or they can be large,

causing _____

and _____ as big as

_____

original DNA strand

mutations can change base pairs, remove base pairs, or add base pairs

☐ In most organisms the rate of mutation is extremely _____, perhaps as little as one or two changes per generation

☐ Mutation is incredibly important for evolution because it _____.
These are the building blocks for evolution!
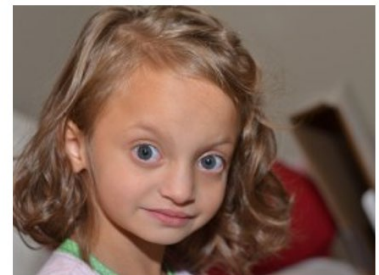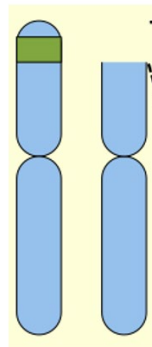
mutations can also add or change whole chromosomes: Wolf–Hirschhorn syndrome

Effects of Mutations

☐ **Positive Mutation** = any mutation that _____ the function of a gene by causing it to create a _____, and will give that organism an _____ over other members of its species

antibiotic resistance makes bacteria immune to an antibiotic, an example of a positive mutation

☐ **Negative Mutation** = any mutation that _____ the function of a gene by causing it to create a _____ or a protein that does not perform its job, and will give that organism a _____
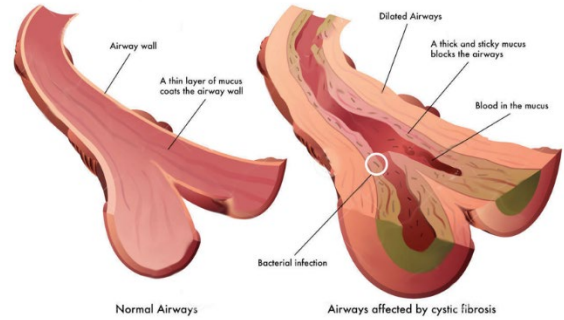
cystic fibrosis is caused by a mutation in gene CFTR, an example of a negative mutation

☐ **Neutral Mutation** = any mutation that _____ _____ the function of a gene by causing it to create a protein that is _____, provides its organism with _____

the 'Spirit Bear' is a mutant version of the black bear

An Analogy: If the gene was a sentence, and its function (meaning) was its protein: "The old dog sit."

☐ Positive mutation: _____. The sentence has improved function
☐ Negative mutation: _____. The sentence has reduced function
☐ Neutral mutation: _____. The sentence has identical function

Sources of Mutations

1. _____

☐ The protein that replicates DNA is _____: it only makes 1 base pairing mistake for every 100,000 base pairs it copies, but across all 46 chromosomes this creates _____

☐ The same protein that replicated DNA fixes _____ of these mistakes by proofreading the new DNA strand as it goes, _____

free nucleotides
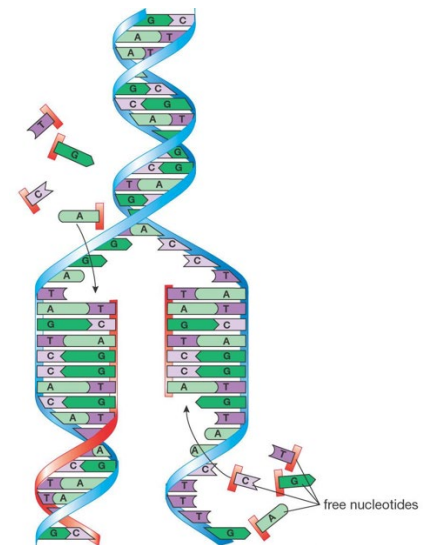
☐ Other proteins look for these mismatches and repair them, removing almost all of the remaining base pairing mistakes, but _____
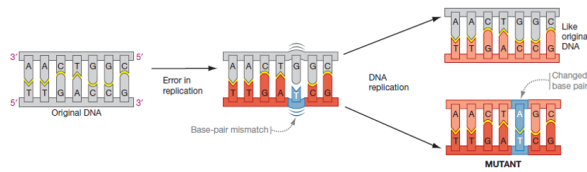
DNA replication results in base pairing errors – approximately 1,200 which each copy – that can become mutations

2. _____

    ☐ _____ and _____ agents that can cause mutations are called _____

    ☐ _____ (alpha particles, gamma rays) and _____ _____ (X-rays, ultraviolet light) _____ damage or _____

Measuring Radiation's Effects

Activity	Millirems
Typical yearly dose, all sources	360.00
Full set of dental X-rays	40.00
Chest X-ray	8.00
Flying round-trip from D.C. To Los Angeles	5.00
Living outside nuclear power plant for a year	0.10

Health risk	Expected life lost
Smoking a pack of cigarettes a day	6 years
Being 15 percent overweight	2 years
Working in construction	227 days
Working in nuclear plant (1,000 mrem/yr)	51 days
Typical annual background radiation dose (360 mrem/yr)	18 days

    ☐ _____ such as benzene attach themselves to DNA and _____ _____
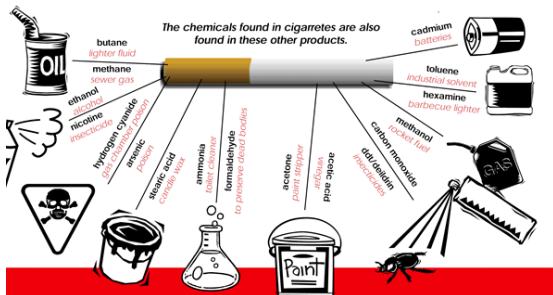
benzopyrene from cigarettes inserted into the DNA double helix
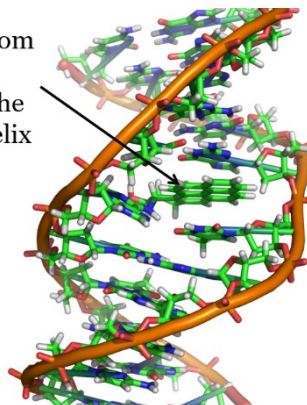
☐ Heavy metals such as _____ also damage DNA and interfere with DNA repair

☐ Some _____ insert themselves into the DNA of the host cell, interrupting genes

Mutations and Cancer

☐ While some cancers are _____, almost all of them are caused by _____ _____ that alter a cell's identity and affect _____

☐ Agents that cause cancer, called _____, are thus mostly mutagens

☐ Cancer mutations result in _____ that can _____
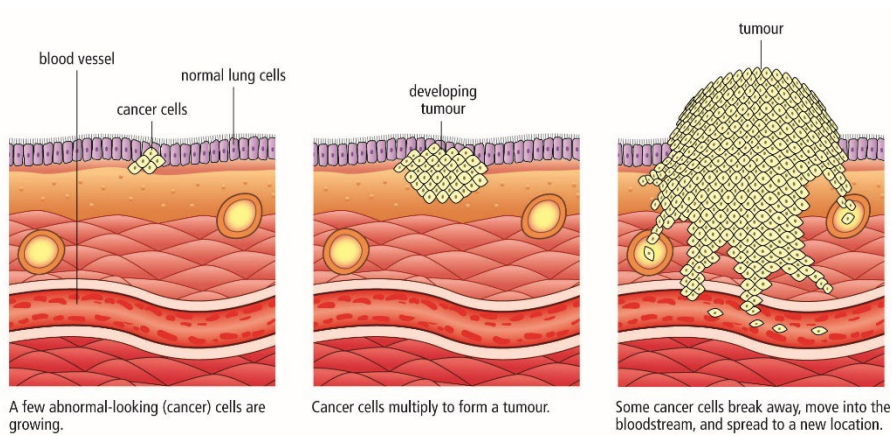
A few abnormal-looking (cancer) cells are growing.

Cancer cells multiply to form a tumour.

Some cancer cells break away, move into the bloodstream, and spread to a new location.

1. Identify each of the following examples as a positive, negative, or neutral mutation:

<table>
<tr><th>Example</th><th>Type of Mutation</th></tr>
<tr><td>a. Some plants carry a mutated gene that protects them from a fungus parasite called powdery mildew.</td><td>_____</td></tr>
<tr><td>b. Some people are born with a mutated gene that prevents the cells in their throat and lungs from making normal mucus, as a result the thick mucus accumulates and clogs the lungs (cystic fibrosis).</td><td>_____</td></tr>
<tr><td>c. The Spirit Bears of coastal British Columbia have a mutation that makes their fur white instead of black, but does not affect their survival.</td><td>_____</td></tr>
<tr><td>d. Some people have a mutation that prevents the virus HIV from infecting their cells.</td><td>_____</td></tr>
<tr><td>e. Some people have a mutation which causes blood protein involved in clotting to have a different shape, as a result they have internal and external bleeding (haemophilia).</td><td>_____</td></tr>
</table>

2. Which of the following can result from a DNA mutation?

   A. The protein will no longer function.
   B. The protein will have reduced function.
   C. The protein will have improved function.
   D. All of the above can occur.

3. Which of the following correctly describes a mutation?

   A. a change in the base pair sequence of a DNA molecule
   B. a change in the proteins that wrap around the DNA molecule
   C. a change in the order of sugars and phosphates in a protein
   D. a change in the structure of a protein

4. A man is sitting outside of a restaurant on a park bench smoking a cigarette, reading the newspaper. Which of the following is a mutagen that he is exposing himself to?

   A. the newspaper
   B. the cigarette
   C. the oxygen he is breathing
   D. the park bench

5. The three kinds of mutations are called:

   A. neutral, negative, and carcinogenic
   B. positive, negative, and neutral
   C. mutagens, carcinogens, and mutations
   D. complete, incomplete, co-mutant

6. A woman breaks her arm riding motocross. After checking into the hospital, she waits in the emergency room and drinks a glass of water. Eventually the doctor identifies the break with an X-ray and casts the arm. Which of the following is a mutagen that she is exposing herself to?

    A. the glass of water
    B. the hospital waiting room
    C. the chair she sits on
    D. the X-ray exam

7. Cancer results when mutations cause body cells to lose their identity and divide uncontrollably. Cancer is an example of

    A. a negative mutation.
    B. a positive mutation.
    C. a neutral mutation.

8. A mutation in a gene that creates proteins which carry fat in blood was discovered in people living in a small village in northern Italy. Blood fat can accumulate inside the walls of blood vessels, blocking blood flow and causing heart attacks and strokes. The mutation greatly reduces the accumulation of fat inside the walls of blood vessels, and so is an example of

    A. a neutral mutation.
    B. a negative mutation.
    C. a positive mutation.

9. A mutation which does not affect the function of the protein is called a

    A. positive mutation.
    B. negative mutation.
    C. neutral mutation.

10. Cats in the American Curl breed have ears that curl upwards at the tips. This does not appear to affect their hearing in any way. This mutation is an example of

    A. a neutral mutation.
    B. a positive mutation.
    C. a negative mutation.

11. The Huntingtin gene creates a protein which is found in many different body cells. In humans there is a mutant allele of this gene which results in a protein that kills many types of cells, especially brain cells. This mutation is an example of

    A. a negative mutation.
    B. a neutral mutation.
    C. a positive mutation.

12. Identify the type of mutation below (substitution, addition, or deletion). Fill in the table.

Original DNA Sequence:	TACACCTTGGCGACGACT	Type of Mutation
Mutated DNA Sequence #1:	TACATCTTGGCGACGACT	
Mutated DNA Sequence #2:	TACGACCTTGGCGACGACT	
Mutated DNA Sequence #3:	TACACCTTAGCGACGACT	
Mutated DNA Sequence #4:	TACACCTTGGCGACTACT	
Mutated DNA Sequence #5:	TACACCTTGGGACGACT	

13. Look at the following sequence: THE FAT CAT ATE THE RAT. Delete the first H and regroup the letters in groups of three- write out the new groups of three. Does the sentence still make sense? What type of mutation is this an example of?

Lesson 1.6 – Darwin, Wallace, and Natural Selection

A Tale of Two Very Different Scientists

☐   Darwin (1809-1882) was born into a _____ family, studying _____ and religion at Cambridge

☐   At _____ he was hired to join the _____ as it travelled around the world, _____ _____ specimens

☐ Alfred Wallace (1823-1913) was from a _____ family, and after a few failed careers, inspired by Darwin, he became an _____ in Brazil and southeast Asia

☐ Wallace collected _____, including thousands of _____, and began to think about _____ _____
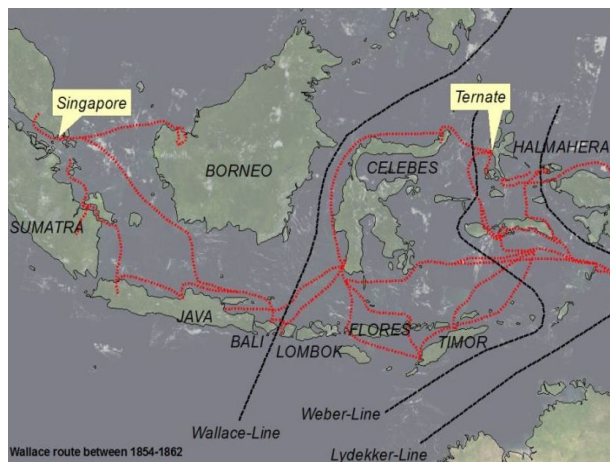
Darwin and Wallace's Observations (Reached Independently)

1. Organisms _____ and _____
   (sadly they did not yet know about Mendel's work)

2. Within every population there is _____
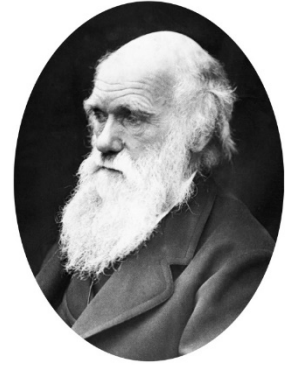   _____ of that population (caused by
   mutations creating new alleles)

3. Some variations affect an organism's _____:
   successful variations _____ their chance of survival,
   and unsuccessful variations _____ survival

4. Successful organisms _____ and _____,
   _____
   _____

The Theory of Natural Selection

☐ Wallace wrote to Darwin, and it turned out that Darwin had come to the _____
   _____: a theory they named _____

☐ Nature 'selects' – by allowing them to live and _____ – organisms with
   _____, and those alleles become _____
   _____ in the population over time

☐ It is often thought of as "_____" but this ignores the
   important role of _____ and _____

☐ Natural selection is an important driving force of _____
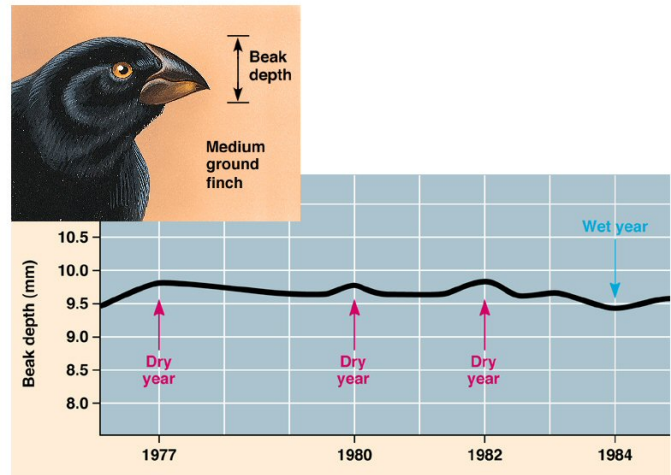
©1999 Addison Wesley Longman, Inc.

Selection Pressures on Natural Populations

- ☐ The 'forces' that drive natural selection, called _____, include anything that affects the _____:
    - ○ _____ between organisms of the _____ for _____ (food, habitat, and reproductive partners)
    - ○ _____ between _____
    - ○ Seasonal and long-term availability of _____
    - ○ Organisms introduced from other environments, called _____, _____ or _____ _____

typical morph   melanic morph

Two different traits in a natural population of peppered moths

typical form was more common and better camouflaged against pale tree trunks

VS

Manchester at the end of the 19th century

melanic form was better camouflaged against sooty tree trunks and became more common in the late 19th century
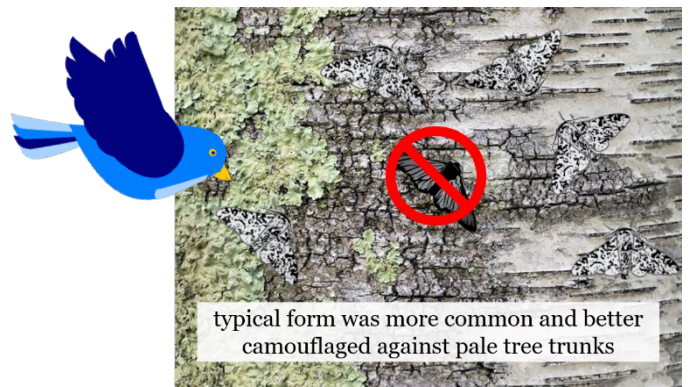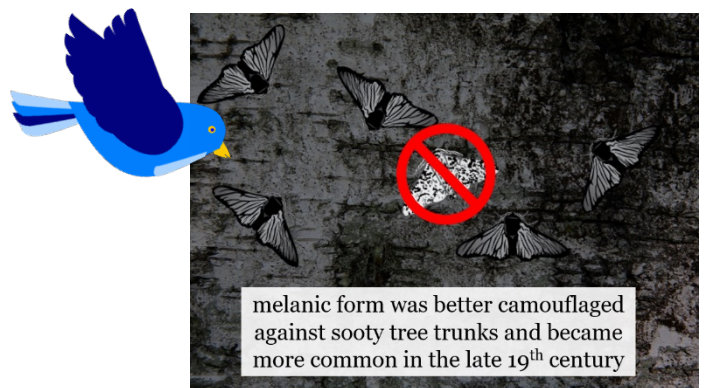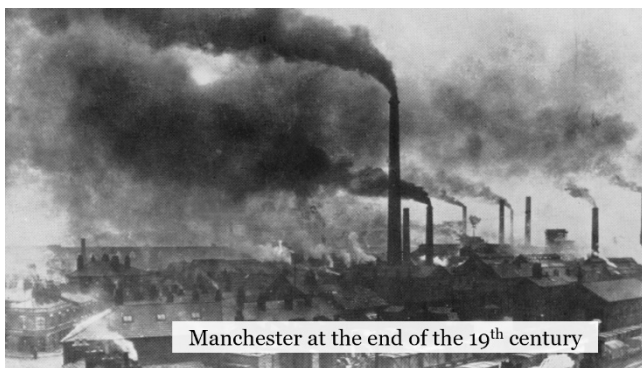
Adaptation

- ☐ Every organism has a 'job' in its environment, which biologists call its _____
- ☐ Natural selection leads to organisms _____ in their niche, a process called _____
- ☐ Adaptations that allow organisms to be successful include _____ inside of cells (_____), _____ to cells or organs (_____), and _____ _____ in an organism's response to its environment

structural adaptation: prehensile tail and grasping hands

physiological adaptation: blood 'antifreeze' to protect from freezing

behavioural adaptation: migration

- ☐ A special kind of adaptation occurs when a _____ _____: the species evolves into _____ to fill a _____ in what is called an _____ _____
  - ☐ Example: 300 species of cichlid fish evolved from single ancestor that entered Lake Victoria, Africa, evolving to feed in different parts of the lake

Haplochromis chilotes (feeds on insects)

Haplochromis macrognathus (feeds on other fish)

Astatotilapia elegans (generalized bottom feeder)

Macropleurodus bicolor (feeds on snails and other molluscs)
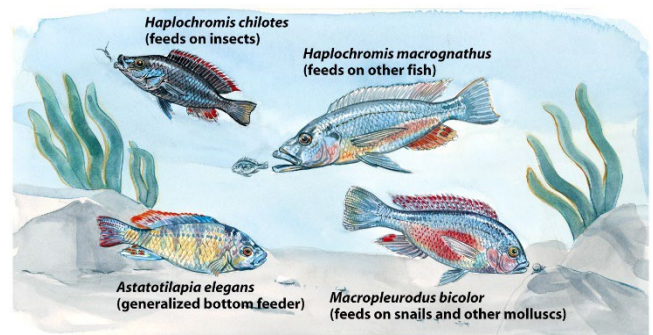
Environmental Changes

- ☐ Natural selection and adaptation are _____ processes because environments _____: mutations introduce _____, _____, and _____
- ☐ Natural selection is a remorseless process, organisms which cannot adapt to their environment for any reason face _____: the _____ of a species

Charles Darwin developed the theory of evolution through a process called natural selection. This process of natural selction has 5 main principles:

1. Population has variations.
2. Some variations are favorable.
3. More offspring are produced than can survive.
4. Those that survive have favorable traits.
5. A population will change over time.

Read the following situations below and identify the 5 points of Darwin's natural selection in **complete sentences**.

1)

There are 2 types of worms: worms that eat at night (nocturnal) and worms that eat during the day (diurnal). The birds eat during the day and seem to be eating ONLY the diurnal worms. The nocturnal worms are in their burrows during this time. Each spring when the worms reproduce, they have about 500 babies but only 100 of these 500 ever become old enough to reproduce.

a. What worm has natural selection selected AGAINST? _____ FOR? _____

b. Darwin's 5 points: Identify the 5 points in the scenario above.

1. Population has variations. _____
2. Some variations are favorable. _____

_____
3. More offspring are produced than survive. _____
4. Those that survive have favorable traits. _____

_____
5. A population will change over time. _____

_____

2) There are 3 types of polar bears: ones with thick coats, ones with thin coats and ones with medium coats. It is fall, soon to be winter. The temperatures are dropping rapidly and the bears must be kept warm, or they will freeze to death. Many of the bears have had ~2 cubs each but due to the extreme temperatures, many mothers only have one cub left.

a. What bear has natural selection selected AGAINST? _____ FOR? _____

b. Darwin's 5 points: Identify the 5 points in the scenario above.

1. Population has variations. _____
2. Some variations are favorable. _____
_____
3. More offspring are produced than survive. _____
4. Those that survive have favorable traits. _____
_____
5. A population will change over time. _____
_____

3)

In ostriches, there are 2 types: ones that run fast and those that run slowly. The fast birds can reach up to 40 miles an hour. Jackals love to eat ostrich, and they can reach speeds of up to 35-40 miles per hour. A flock of ostrich will lay ~ 10 eggs (each mother only lays 1), but many rodents break into the eggs and eat the fetus before they hatch.

a. Which ostrich has natural selection selected AGAINST? _____ FOR? _____

b. Darwin's 5 points: Identify the 5 points in the scenario above.

1. Population has variations. _____
2. Some variations are favorable. _____
_____
3. More offspring are produced than survive. _____
4. Those that survive have favorable traits. _____
_____
5. A population will change over time. _____
_____

4) There are two types of rabbits: those that strictly eat grass and those that strictly eat berries and flowers. A drought occurs one year, and the plants have difficulty producing any extras (flowers, berries, etc.). They can only try and keep themselves green. The rabbits have had babies all year long but many are eaten by foxes or hawks Due to the drought, many have starved to death.
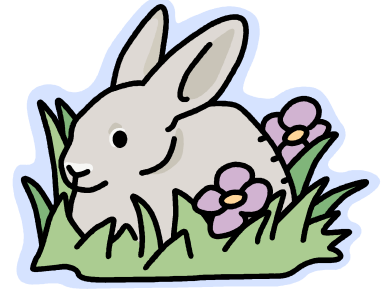
a. What rabbit has natural selection selected AGAINST? _____ FOR? _____

b. Darwin's 5 points: Identify the 5 points in the scenario above.

1. Population has variations. _____

2. Some variations are favorable. _____

_____

3. More offspring are produced than survive. _____

4. Those that survive have favorable traits. _____

_____

5. A population will change over time. _____

_____

Lesson 1.7 – Artificial Selection

Darwin and Pigeons

☐ Darwin was aware of how _____ for their own purposes because he was interested in _____

☐ Pigeon breeders had selectively bred the _____ (pigeon) into _____, some for racing, some for appearance, and some for meat

☐ They had done so by _____ they were _____, such as the _____ of their feathers, and only breeding together the pigeons that _____

many breeds of pigeon had been created

first generation

second generation

third generation

this was accomplished by breeding together parents with the traits that they were interested in

within a few generations of this process the offspring are genetically different from the original population

Artificial Selection

☐ The process of _____ in _____ _____ by _____ which organisms _____ together is now called _____

☐ Artificial selection is **similar** to natural selection in that it is _____ and _____ of organisms which _____ in the population

☐ Artificial selection also causes the alleles that are selected to become _____ in the population over time, causing the _____

☐ The important **difference** between the two is that the selection pressures in artificial selection are
_____ (i.e. they are artificial)

rather than by the _____
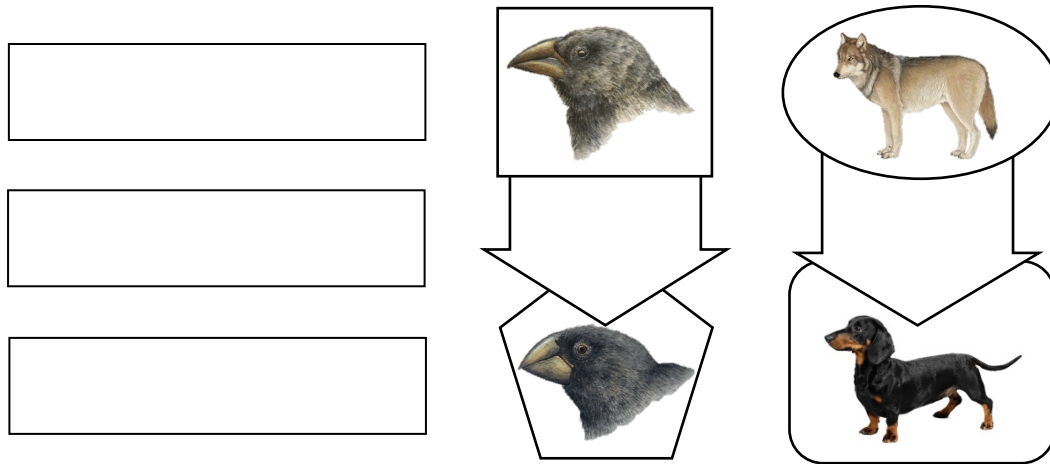
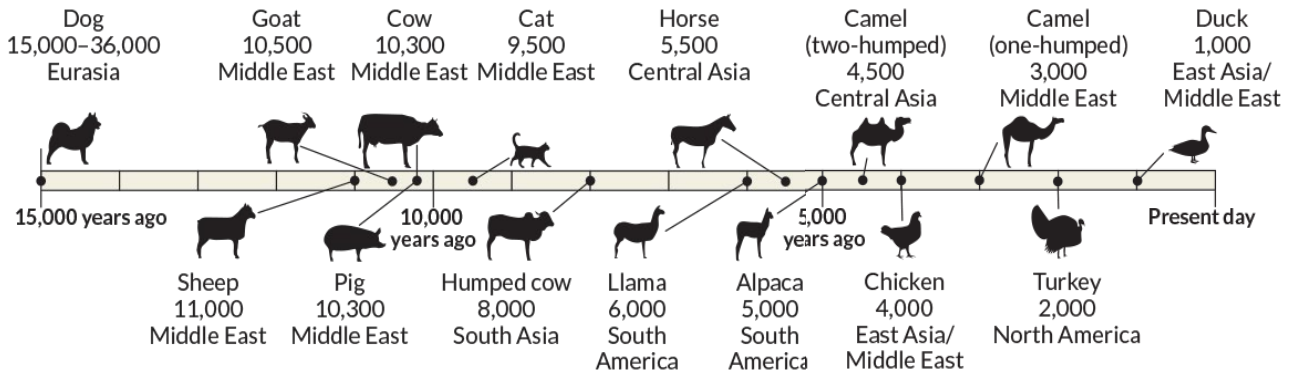## Animal Breeding

☐ All domesticated animals – such as dogs, cats, sheep, horses, and cows – are the products of
_____ of artificial selection by _____

☐ _____ were the first organism to be artificially selected by humans, perhaps as early as
36,000 years ago, using a population of Eurasian gray _____ that is now extinct

Gray wolf
(Common ancestor)

| Europe | North America | China | India |
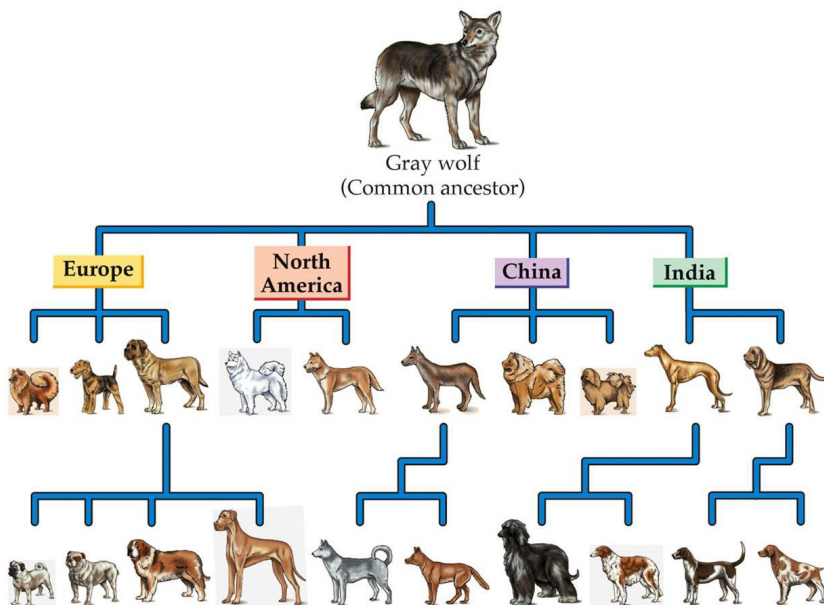
☐ Since that time we have domesticated other animal species for meat (_____), milk (_____), and physical labour (_____)

| Dog 15,000–36,000 Eurasia | Goat 10,500 Middle East | Cow 10,300 Middle East | Cat 9,500 Middle East | Horse 5,500 Central Asia | Camel (two-humped) 4,500 Central Asia | Camel (one-humped) 3,000 Middle East | Duck 1,000 East Asia/ Middle East |

15,000 years ago — 10,000 years ago — 5,000 years ago — Present day

| Sheep 11,000 Middle East | Pig 10,300 Middle East | Humped cow 8,000 South Asia | Llama 6,000 South America | Alpaca 5,000 South America | Chicken 4,000 East Asia/ Middle East | Turkey 2,000 North America |

**Plant Breeding**

☐ Almost all of the plant foods that we grow are also _____ organisms resulting from long periods of _____

☐ _____ were probably the first plants to be domesticated by humans, around 12,000 years ago from Middle Eastern grasses

☐ Since then we have domesticated plants for their _____ (grains, rice, peas, beans), _____ (apples, oranges, berries), _____ (lettuce, spinach, kale), _____ (onions, celery), and _____ (carrots, beets)

wheat was domesticated about 12,000 years ago
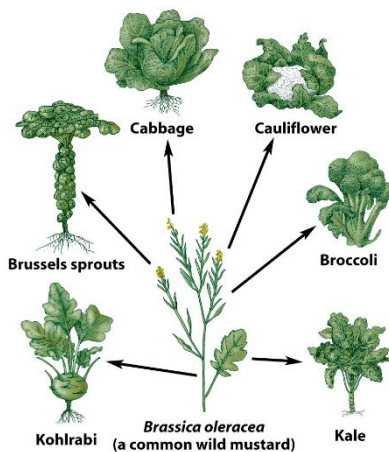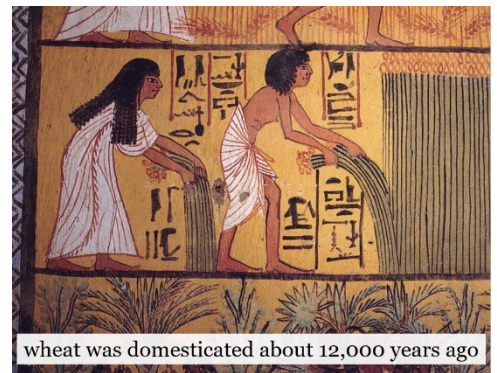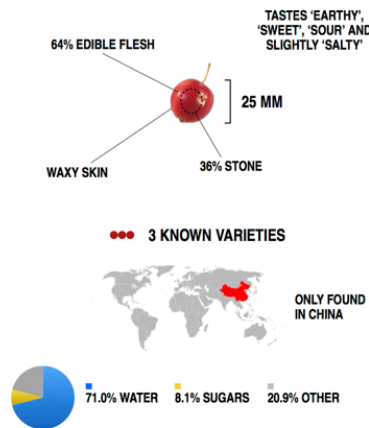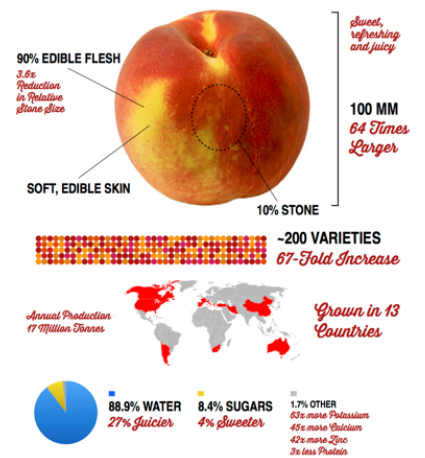
comparison of wild and domesticated peaches

Modern Agriculture

☐ Modern agriculture grows _____ of plants or animals of the _____ kind (called a _____) in as _____ as possible, using _____ do as much of the physical labour as possible

modern industrial agriculture

monoculture agriculture: a field of soybeans

WORLD AGRICULTURAL PRODUCTION

☐ This system is _____ and produces _____ food globally than is required (sadly distribution of the food is not equal), but has several disadvantages:
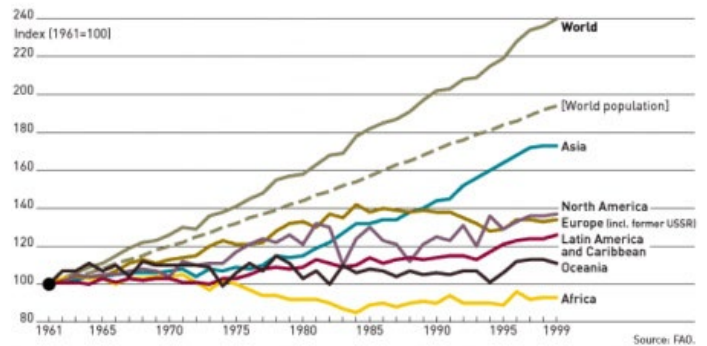
○ _____ in our crops and animal breeds means that they are vulnerable to the same _____

bananas infected with Panama disease

○ Crops and animals are selected for their _____, not necessarily for their _____ or _____

○ Welfare of crops and animals is _____ to how efficiently they can be grown

industrial farming of animals

OVERVIEW   <u>1.7 Worksheet: Artificially Selecting Dogs</u>

1. You will learn how artificial selection can be used to develop new dog breeds with characteristics that make the dog capable of performing a desirable task.
2. You will begin by examining canine features and their functions.
3. Then, you will be given a scenario that describes the type of task you need a new breed of dog to perform.
4. Next, you will select two existing breeds you feel will most likely produce a successful new breed and determine the resulting offspring's characteristics.

PROCEDURE

1. You will be trying to artificially select a new dog with certain traits by crossing two existing breeds. Look at your **Ownership Card**, and put you and your partner's name on the card. Follow the directions given in Part 1, and complete it.
2. Next, look at your **Dog Breeds Handout** and review the descriptions given for each breed. Discuss this information with your partner and select two dogs that have the features most likely to produce a breed with the features you need. In Part 2 of your **Ownership Card**, write in the breed names and reasons for your selections.
3. Now, choose which dog will be the mother and which will be the father. Circle the gender of each under the breed name in Part 2 of your **Ownership Card**. Your breeding pair will produce 3 puppies and each puppy will have a chance of inheriting traits from either the mother or father.
4. You will use a penny to determine which trait is inherited by your puppy. Keep track using the **Puppy Traits – Generation 1** table provided. You will fill in the Puppy #1 column. Flip the coin for each trait. Write in the trait that is inherited each time.
   - Heads = females (mother's) trait is inherited
   - Tails = males (father's) trait is inherited
5. Repeat step 4 again for Puppy #2 and again for the Puppy #3
6. Now, pick the puppy you feel would get you closest to your goal in another round of breeding. Record this puppy in Part 3 of your **Ownership Card**, and explain why you picked it.
7. After making your puppy selection, visit with a neighbouring group, and collect "trait" information for a puppy from that group's you feel would most likely get you closer to your goal. Record these on the "Puppy Traits – Generation 2" handout. Circle the gender of each dog under the breed name in Part 3 of your **Ownership Card**.
8. Next, repeat steps 3, 4, and 5, except now use **Puppy Traits – Generation 2** to record your data.
9. Pick the puppy from this second generation which you feel will provide a dog that can perform the assigned task, and **<u>draw</u>** this puppy on the **last page**, labelling the significant features of this animal.

Ownership Card

Breeders' Names: _____   Date: _____

Assignment: "You are a dog breeder. You have been contacted by a scientist who wants dogs that could be used to see and retrieve waterfowl (ducks and geese) from lakes in the area so the birds can be tagged and re---released. The birds are very skittish (scare easily) and must be retrieved unharmed and with a minimum amount of stress."

Part 1: Desired Features of the New Breed

For each feature below, circle the desired form you ideally want your dogs to have. For features that you do not think will affect your breed's ability to perform the given task, circle "any."

| Physical Features	Desired Form			
Smell	above average	average	below average	any
Sight	above average	average	below average	any
Hearing	above average	average	below average	any
Speed	above average	average	below average	any
Endurance	above average	average	below average	any
Strength	above average	average	below average	any
Coat color	very dark	average	very light	any
Hair length	long	average	short	any
Behavioral Features	**Desired Form**			
Trainability	high	average	low	any
Disposition	vicious	compatible	meek	any
Bark	very loud	average	very quiet	any

Part 2: Dog breeds chosen to mate:_____X_____(Generation 1)

                                                  male or female   *male or female*   *(circle)*

Reason:

Part 3: Dog breeds chosen to mate:_____X *Neighbor's Puppy* (Generation 2)

                                                  male or female   *male or female*   *(circle)*

Reason:

Dog Breeds
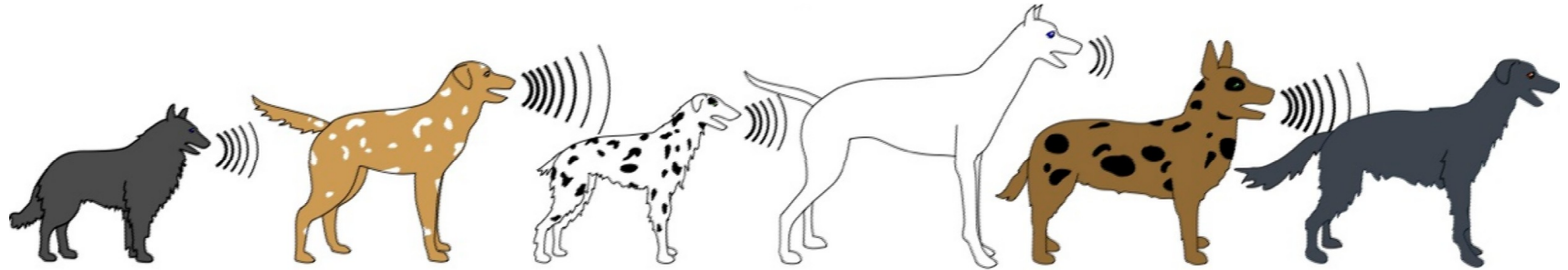
Physical Features	Breed A **Tally Collie**	Breed B **Floxich**	Breed C **Gootagan**	Breed D **Spalling**	Breed E **Cruxtic**	Breed F **Horvisianer**
Smell:	above average	average	above average	below average	average	above average
Sight:	average	average	average	above average	average	above average
Hearing:	above average	average	average	above average	above average	average
Speed:	average	above average	above average	above average	below average	average
Endurance:	below average	average	above average	average	above average	below average
Strength:	above average	above average	average	below average	average	below average
Coat color:	black	brown	white	white	brown	black
Hair length:	long	medium	long	short	medium	long
Behavioral Features						
Trainability:	average	average	high	high	low	high
Disposition:	meek	meek	vicious	meek	compatible	vicious
Bark:	average	very loud	average	very quiet	very loud	average

Puppy Traits - Generation #1

Physical Features	Puppy #1	Puppy #2	Puppy #3
Smell			
Sight			
Hearing			
Speed			
Endurance			
Strength			
Coat color			
Hair length			
Behavioral Features			
Trainability			
Disposition			
Bark			

Puppy Traits - Generation #2

Physical Features	Neighbouring Puppy Traits	Puppy #1	Puppy #2	Puppy #3
Smell				
Sight				
Hearing				
Speed				
Endurance				
Strength				
Coat color				
Hair length				
Behavioral Features				
Trainability				
Disposition				
Bark				

Drawing of your Best Artificially Selected Puppy