



## Unit 1 - Biological Diversity

### 1.0 Biological diversity is reflected in the variety of life on the Earth.

#### 1.1 Ecosystems, Species and Genetic Diversity

A **species** is a particular group of organisms that have the same structure and can reproduce with each other. Of the 30 – 100 million possible different species of living things, there are over 1.5 million species of animals and 350,000 species of plants that have been identified by biologists. The most successful life form seems to be the insect.

*(Grade 7 Review) All living things are made up of cells, need energy, grow and develop, reproduce and have adaptations, which suit them to the specific habitat in which they live.*

The entire collection of living organisms, each with their own unique characteristics, makes up the Earth's **biodiversity**. “*Biological diversity refers to the variety of species and ecosystems on the Earth and the ecological processes of they are a part of.*” The **main components of biodiversity** are:

- **Ecosystem diversity** – the different types of living communities and the environments, such as marshes, lakes, streams and forests, in which they are found
- **Community (populations of different species living in the same area) diversity** – occurs within **populations (members of a species that live in a specific area and share the same resources)** of organisms living within a particular ecosystem
- **Species diversity** – occurs within individual organisms of the same species
- **Genetic diversity** – occurs within organisms at a cellular level, as it describes the variety of genetic material in all living things.
- **Species Distribution** – Plant and animal species are not distributed evenly throughout the various eco-regions of the world. Most of the different species of plants and animals can be found in tropical regions and, more specifically, in the rainforests. As you move closer to the poles of the Earth, there is less biological diversity.

#### Biological Diversity Classification

The two-name Latin naming system for all living things was developed by Carolus Linnaeus in the 18<sup>th</sup> century, enabling scientists, around the world, to refer to the same species, by the same name. This classification system was much more reliable than previous systems, because he used structure, rather than habitat. Two words identify each organism. The 1<sup>st</sup> represents the organisms **genus** and the 2<sup>nd</sup> represents the organisms particular **species**.

Scientists earlier had developed a system, which classifies all organisms, based on their structural differences, into [5 kingdoms](#).

- **Animalia** (animals)
- **Plantae** (plants)
- **Fungi** (yeasts, moulds and mushrooms)
- **Protista** (mostly single-celled organisms)
- **Monera** (*bacteria*)

The 5 kingdom classification system can be further subdivided, with each sub-division having its own name.

- ◆ **Kingdom**
  - **phylum**
  - **class**
  - **order**
  - **family**
  - **genus**
  - **species**

*Specialists refer to other sub-divisions as well, such as; subfamilies, super-orders, and sub-species or varieties.*

### **Biodiversity under the Sea**

Coral reefs reflect a great diversity of species. Like tropical forests, coral reefs support many different communities of organisms surviving on a small amount of nutrients, which are very efficiently recycled.

## **1.2 Interdependence**

Each and every species depends on many other species within an environment in order to survive and prosper. Food chains and Food webs represent different types of ongoing relationships between and among all the organisms, within a particular environment.

### **Symbiosis**

A different type of interdependence is an association, within a certain population, between members of different species.

There are different types of symbiotic relationships:

- **Commensalism** – in which one of the participating members benefits, but the other does not, and there is no harm done to that organism.  
(a bird using a tree to build its nest in) (barnacles on a whale)
- **Mutualism** – both organisms benefit from the relationship.  
(lichen (algae and fungi) growing in the Arctic Tundra benefit each other)  
(flower *Clusia* provides medicine to bees)
- **Parasitism** – one organism benefits while the other organism (the victim) is harmed. (the parasite usually doesn't kill the host, because the host represents the parasite's food supply).  
(tapeworm in a human host) (Mexican bean beetle is a plant parasite)
- **Interspecies competition** happens when two or more species need the same resource. This type of relationship helps to limit the size of populations, of the competing species.

There are many examples of these types of symbiotic relationships, which show the importance of adaptations, helping particular species survive.

## Niches

A **niche** is the role of an organism within a particular ecosystem. An organism's niche includes:

- What it eats
- What eats it
- Its habitat
- Nesting site, range and habits
- What effect it has on the other populations
- What effect it has on the environment

A niche, for a particular organism, can change, depending on the environment in which it is located and the organisms with which it inter-relates.

**Resource partitioning** is the action, which enables competing species to share the resources by accessing these resources in different ways, involving less direct competition.

## 1.3 Variation within Species

**Variation** within a population, of a single species, is called **variability**.

Variability is important if the environment, in which the species lives, changes (suddenly or drastically). When a species has a great deal of variation, then, some of the individuals within that species will likely survive when there is change.

Examples of variability include:

- Red fox (color of coat)
- Antibiotic resistance (bacteria)
- Banded snail (color of shell)

**Natural selection** happens when factors in the environment determines, or 'selects' which individuals, within a species, will be able to survive. If they are able to live long enough to reproduce, then those individuals with their 'survival adaptations (characteristics) will have offspring with similar survival characteristics.

## 2.0 As species reproduce, characteristics are passed on from parents to offspring.

### 2.1 A Closer Look at Variation

Variation is one of the most critical aspects of species survival. This variation may not always be as easy to find as color usually is, because it may be a behavioral tendency or a genetic (cellular code) modification that enables some individuals within a species to survive, while others, of the same species, will perish.

#### Genetic Trait Variations

(Observing Variation in Human Characteristics p. 27)

<http://edquest.ca/Projects/GHTS/ghts.html>

#### Inherited and Non-inherited Characteristics

**Inherited** (heritable) characteristics are those traits which are passed on to offspring directly from their parents. These traits are passed on by way of the genetic material that is combined from the parents during the process of sexual reproduction. Heritable traits include, structural and distinguishing characteristics, such as eye color, hair type, skin color and earlobes.

**Non-inherited** characteristics are acquired and not necessarily passed on from generation to generation. Athleticism, artistic ability, leadership qualities are all learned during the early years of life.

#### Discrete and Continuous Variations

**Discrete** variations are differences in characteristics that have a definite form. This includes those individuals, within a species, that have either one characteristic, or the single, other variation, of the characteristic.

**Continuous** variations are differences in characteristics that have a multitude of variations, such as height, shoe size, etc.

#### Variation and the Environment

Some variations may be influenced by interactions with the environment. These variations are not inherited. Examples include:

- Change in the pigmentation of skin color throughout the seasons due to the sun.
- Height and weight can be influenced by diet.

## 2.2 Asexual and Sexual Reproduction

### Asexual Reproduction

Asexual reproduction involves only one parent. All of the offspring are identical to the parent. There are different types of asexual reproduction:

- **Binary Fission** - only single-celled organisms reproduce in this way. The cell splits into two cells and each one is identical. (**bacteria, amoeba, algae**)
- **Budding** - the parent organism produces a bud (a smaller version of itself), which eventually detaches itself from the parent and becomes a self-sufficient individual - identical to the parent. Coral also reproduces in this way, but do not detach themselves (**hydra, yeast, coral**)
- **Spore Production** - spores are similar to seeds, but are produced by the division of cells on the parent, not by the union of two cells. One parent may produce many spores, each of which will grow into a new individual, identical to its parent. (**fungi, green algae, moulds, ferns**)
- **Vegetative Reproduction** - is the reproduction of a plant not involving a seed, including; cuttings, runners, suckers, tubers. (**coleus plant, spider plants, strawberries, aspen, potatoes**)

### Sexual Reproduction

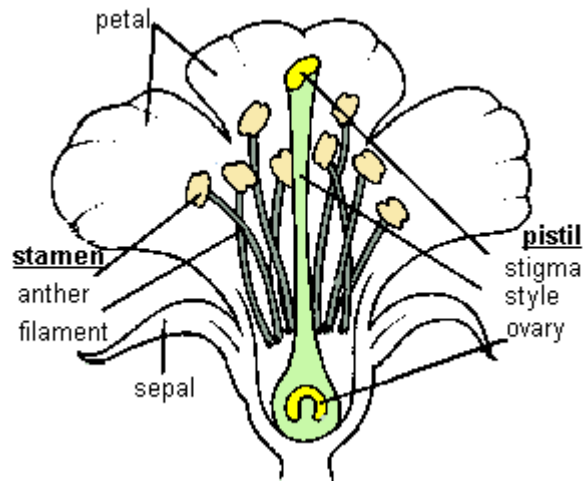
Sexual reproduction usually involves two individual organisms. The offspring that are produced from this union have a mix of characteristics, half from one parent and the other half from the other parent. Sexual reproduction does not always involve male and female parents, but can have specialized **gametes** (reproductive cells that have only one role - to join with another gamete during reproduction).

#### Sexual Reproduction in Animals

Sexual reproduction in animals involves gametes. The male gametes are called **sperm cells**, and the female gametes are called **egg cells** (ova). During mating, the sperm cell and the egg cell unite to form a fertilized combination of cells called a **zygote**. This zygote is the first of many cells of a new individual. This zygote will begin to divide into two cells and this continues to be repeated over and over resulting in the development of an **embryo**. This embryo develops into a multi-cellular organism inside the female (in most mammals) or, outside (in an egg shell) in other animals.

#### Sexual Reproduction in Plants

Sexual reproduction in plants involves gametes as well, male gametes and female gametes joining, during **fertilization**, to produce a zygote and then an embryo. Most plants produce both male and female gametes, while some produce one or the other only.



**Pollen** contains the male gametes and is found on the **stamen**. **Ovules** contain the female gametes and are found in the **pistil**. **Pollination** occurs when pollen is transferred from the **anther** of the **stamen** to the **stigma** of the **pistil**. **Cross-pollination** occurs when **pollen** from one plant is carried to the **stigma** of another plant by wind, water or animals (bees or butterflies). **Cross-fertilization** occurs when a grain of the pollen forms a long tube, which grows down the **style** into the **ovary**. The gametes unite to produce a **zygote**, which then develops into an **embryo**. This usually happens inside a **seed**, which protects the embryo and provides food (**cotyledon**) for the embryo when growing conditions are right.

Plants which are produced, as a result of **cross-fertilization**, are not identical to either plant.

### Advantages and disadvantages of Asexual and Sexual Reproduction

Variation usually helps a species survive when the environment changes.

**Asexual reproduction** does not require any specialized cells to produce a new plant. It can therefore produce many plants very quickly. This is an advantage in places where the environment doesn't change very much (**bacteria**). By building a large population of organisms very quickly the species is able to thrive. The great disadvantage is that when the environment changes, all of the organisms will die, if they do not have the ability to adapt to the change.

**Sexual reproduction** has the advantage of providing lots of variation within a species, helping it to survive when the environment changes. The main disadvantage is that this process takes a lot of energy. This means that they can only produce small populations.

### Organisms that Reproduce both Sexually and Asexually

**Sponges** are organisms that can produce both sexually and asexually. Most plants that produce seeds can also reproduce asexually (cuttings, runners). Depending on the environmental conditions the amount of energy varies, enabling the plant organism to control its population.

### 3.0 DNA is the inherited material responsible for variation.

Captive breeding programs enable scientists to control populations of species at risk of extinction. Using modern technology, geneticists and staff from zoos around the world can analyze the genetic code of the species they are trying to save and use it to introduce variation that will help the species survive when the environment changes.

#### 3.1 DNA - Transmitter of Genetic Code

Characteristics are passed on from one generation to another within a species through the genetic code of the parents. This genetic code is called DNA.



#### DNA

The blueprint that is passed on from the parents to the offspring is found in a molecule of the cell nuclei. This molecule, **desoxyribonucleic acid**, (**DNA**) is the inherited material responsible for variation. All living organisms contain DNA in their cells.

#### DNA and the Genetic Code

DNA was discovered prior to 1944. All DNA molecules contain exactly the same chemicals, but the way the chemicals combine determines the characteristics of the organism. **James Watson and Francis Crick** unraveled the structure of DNA, revealing the key to the multitude combinations of variation that are possible. The DNA molecule is like a ladder twisted into a spiral (see image). The sides of the ladder are the same in all DNA molecules, but the rungs are what make the variations. Each rung pairs up two of the following chemicals: guanine (G), cytosine (C), adenine (A) and thiamine (T). The arrangement of these four chemicals creates the code that the cells are able to interpret. This is the **genetic code** of the organism.

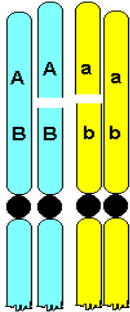
#### Chromosomes

**DNA** contains all the instructions, which create the organism's characteristics. The multitude of characteristics for each organism means that there is a lot of DNA in any one cell. This DNA is arranged in the cell in compact packages, called **chromosomes**. Every human cell contains **46 chromosomes**. In order to have a complete human organism, all 46 of the chromosomes must be present. Not all organisms have the same number of chromosomes (Dogs have 78, cats have 38). Every cell of a human contains **23 pairs** of chromosomes (dogs 39, cats 19). Not all of the chromosomes from species to species are the same, which accounts for the different characteristics between the species.



## Genes

A single **gene** is an uninterrupted segment of DNA, which contains the coded instructions for the organism. Researchers found out that (by working on the fruit fly):



- Genes are located in the chromosomes
- Each chromosome has numerous gene locations
- Genes come in pairs
- Both genes in a pair carry DNA instructions for the same thing
- Specific characteristic genes occupy matching locations on the two chromosomes
- DNA code may not be exactly the same in both locations

Offspring inherit genes from both parents. The genes exist in an array of possible forms that differ as to their exact DNA sequence. These variations in forms are called **alleles**. The ultimate combination of the chromosome pair is what makes the variation possible - combining the different variations of different characteristics to create a unique variation.

### 3.2 Cell Division

#### Cell Division and Asexual Reproduction

Mitosis



Asexual reproduction involves only one parent. All of the offspring are genetically identical to the parent. In single celled organisms, **binary fission** enables the parent cell to split its contents equally between the two new cells. Prior to this division, the parent cell duplicates its DNA and when the split takes place each new cell receives a complete exact copy of the DNA, of the parent. In multi-cellular organisms the process that produces two new cells with the same number of chromosomes is called **Mitosis**.

#### Cell Division and Sexual Reproduction in Plants and Animals

Sexual reproduction usually involves two individual organisms. The offspring that are produced from this union have genetically different characteristics, half from one parent and the other half from the other parent - making a unique offspring.

During sexual reproduction, the specialized sex cells (gametes) unite to form a zygote, which develops into the new organism. When a male gamete and a female gamete unite, meiosis takes place. **Meiosis** is a type of cell division that produces cells with only half the DNA of a normal cell. This process involves two cell divisions, not one.

Meiosis





### 3.3 Patterns of Inheritance (Gregor Mendel)

Long before the science of genetics started, people tried to reproduce organisms with only the most preferred traits, by allowing only those organisms with the desirable traits to reproduce. This method was not always successful, but through time (trial and error), this practice of controlled breeding provided scientists with the information to determine which alleles were responsible for specific traits.

#### Purebred VS Hybrid

To produce purebred organisms, a breeder would choose pure bred parents, those parents whose ancestors have produced only the desired characteristic they want (**true-breeding**). If a breeder chooses two different 'true-breeds' then a **hybrid** would be produced.

#### Dominant Traits

Crossbreeding two different true-breeds will result in all of the offspring having the same characteristic, that is, the **dominant trait**. Only the DNA instructions for the dominant trait will be carried out.

#### Recessive Traits



When crossbreeding hybrids, the average results will produce 75% of the offspring with the dominant trait and 25% of the offspring with the recessive trait, because there are only 4 possible combinations. One trait is recessive and therefore the allele is recessive. A recessive trait only appears in the offspring if two recessive alleles are inherited. [[Punnett Squares](#)]

#### Other Patterns of Inheritance

**Incomplete dominance** occurs because the dominant-recessive pattern does not always prevail. When the alleles are neither dominant, nor recessive, an intermediate trait will occur (combining the two traits).

**Offspring Unlike Either Parent. More than one gene location and more than one allele** may be responsible for specific traits. As a result, the complex mixing of the possible combinations for that particular trait may account for the variation of traits an offspring has.

**Environmental Factors** can also have a bearing on how DNA is interpreted and developed. Fetal alcohol syndrome can be a direct result of alcohol consumption during the developing stages of the offspring. The 'normal' DNA is affected by the alcohol and will not develop normally. Taking drugs can also affect the DNA during normal development and defects in the organism can occur. (Thalidomide)

### 4.0 Human Activity affects Biological Diversity.

## 4.1 A Closer Look at Variation

### Reduction of Biological Diversity

The stresses of urbanization and habitat intrusion by farming and industry have resulted in a decline in genetic, species and ecosystem diversity. Extinction, population decreases and degradation of ecosystems reduces biological diversity on the Earth.

### Extinction and Extirpation

**Extinction** is the disappearance of every individual of a species from the entire planet. It is a natural part of the Earth's history. Scientists estimate that 99% of species that have ever existed on the Earth are now extinct (many by mass extinction - sudden environmental change, like the Ice Age). Most extinction take place over long periods of time, but the rate of extinctions is rising, and this is reducing the biological diversity of our planet.

**Extirpation** is a local extinction, or the disappearance of a species from a particular area.

[The General Status of Alberta Wild Species 2000](#) (pdf format)

### **Natural Causes of Extinction and Extirpation**

**Natural selection** is a slow process. Even if there is a lot of variation within a species, sometimes the changes in the environment are so drastic that and so quick, that none of the individuals within a species can survive. Most extinctions, in the past, were due to:

- catastrophic events (volcanic eruptions, earthquakes, floods, fire)
- lack of food (due to overpopulation)
- disease

Not all extinctions happened millions of years ago. Diseases and natural events occur all the time and when they do, a species, within a particular area, can be extirpated very quickly.

### **Overspecialization**

Sometimes organisms have adaptations that suit them only to a very narrow set of environmental conditions. This usually occurs in a relatively stable area, where the environment does not change for a very long period of time. This is called **overspecialization** and it is another cause of extinction. The giant panda is a species that is overspecialized, because it relies on bamboo, making it vulnerable to extinction, when the bamboo is scarce.

## **Human Causes of Extinctions and Extirpations**

Most extinctions and extirpations today are caused by human activity.

**Habitat destruction** - as a result of -

- Urbanization
- Construction
- agricultural development
- Logging
- Damming of rivers
- Pollution
- Pesticides, Herbicides and Fertilizers

## **Introduction of Non-Native Species**

When introduced species use the same resources, as the native species, the competition will cause a decline in the numbers of native species, simply because there is less to go around. The introduced species will have no natural predators to limit its population and will, in time, take over from the native species.

## **Over-Hunting**

This was the major cause of the decline and eventual extirpation of the plains **Bison**, as well as the extinction of the **passenger pigeon**. Sometimes species are hunted to deliberately extirpate them. The **black-tailed prairie dogs** were considered a pest in the 1930's and were hunted to reduce their numbers.

## **Effects of Extinctions and Extirpations**

Extinctions and extirpations reduce biological diversity. When an organism disappears locally or globally, many other species are affected. The cycle of life is adversely affected.

## 4.2 Selecting Desirable Traits

**Artificial Selection** is the process of selecting and breeding individuals with desirable traits to produce offspring with the desired traits. The selection process is simple. Only those individuals, with the desired trait, will be allowed to reproduce. This selection process also applies to plants, which can be bred to possess desirable traits. The main difference between '**natural**' selection and '**artificial**' selection is that, humans control the artificial selection process.

### Biotechnology

The process of intervention to produce more desirable organisms has been going on for some time. This process takes a long time to see results - usually many generations. Farmers, dog and horse breeders, along with scientists can now speed up the artificial selection process by using 'low-tech' or 'high-tech' technologies, such as;

- **cloning** (made from cells)
- **artificial insemination** (artificially joining the male and female gametes)
- **in vitro fertilization** (male and female gametes are selected and then allowed to fertilize in a controlled setting)
- **genetic engineering** (directly altering the DNA of an organism)

### Biotechnology and Society

**Beneficial** or **detrimental** to society? That is one of the pressing questions that many humans are struggling with, when it comes to biotechnology. There are many good things that can be produced, but what about the problems, including,

- **risks in animals** (reducing genetic variation within a specific population, less resistance to disease, birth defects and other abnormalities)
- **risks in plants** (resistance to herbicides)

### 4.3 Reducing Our Impact on Biological Diversity

Preserving global biological diversity is a challenge that is receiving much attention. The 1995 **Canadian Biodiversity Strategy** was created to preserve biodiversity in Canada. It will be done through the cooperation of many levels of government, along with many groups, agencies and individuals, who are dedicated to preserving our bio-diverse future.

- **Protected Areas** (National Parks, Provincial Parks, game preserves, natural areas)
- **Restoration Programs for Ecosystems and Species** (Governments and *Nature Conservancy of Canada* programs to purchase land for species habitat renewal, individual landowners giving habitat back - in the form of a naturally protected area, Ducks Unlimited *CARE* program, **Swift Fox** - restoration of a species - extirpated from Canada and now recovering)
- **Resource Use Policies** (Laws - *National Accord for the Protection of Species at Risk - Species at Risk Act - Wildlife Act, 1998*)
- **Controlling the Introduction and Spread of Exotic Species** (Information and teaching about the invasiveness of an exotic species is communicated to the public on a regular basis. Penalties and fines, as well as loss of desirable areas for recreational purposes, has improved the perception of the negative effect an exotic species can have on a local ecosystem.)
- **Conservation of Genetic Resources** (*Ex-situ* conservation refers to conservation of components of biodiversity outside of a natural habitat.
  - The collection and storage of genetic resources, such as seeds (**IPGRI**)
  - Zoos (captive breeding programs)
  - Sperm and Egg Banks
  - Human Genome Project