# UNIT 1
# SUSTAINING ECOSYSTEMS

Chapter 2
Change and Stability in Ecosystems

Science 1206 / 2200

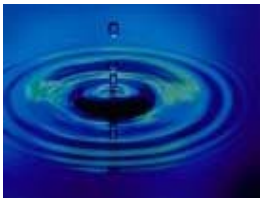
## Change & Recovery in Ecosystems

- What happens to the materials that make up a truck when it begins to rust?
- What happens to the tree after it dies?

# Cycling of Matter in Ecosystems

- Organic substances
  - Contain atoms of **Carbon and Hydrogen**
  - Are broken down into simpler forms in living things
  - **Ex.** Sugar, carbohydrates, proteins, amino acids

- Inorganic substances
  - Does **not** contain combination of carbon and hydrogen
  - **Ex.** Water ($H_2O$), ammonia ($NH_3$), Carbon dioxide ($CO_2$)



# Biological Processes Involved in Nutrient Cycling

1. Photosynthesis
   - Plants convert $CO_2$ and $H_2O$ into $O_2$ and sugar

$6CO_2 + 6H_2O + \text{energy} \rightarrow C_6H_{12}O_6 + 6O_2$

2. Respiration
   - Animals AND plants use $O_2$ and sugar, converting it to $CO_2$ and $H_2O$

$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + \text{energy}$

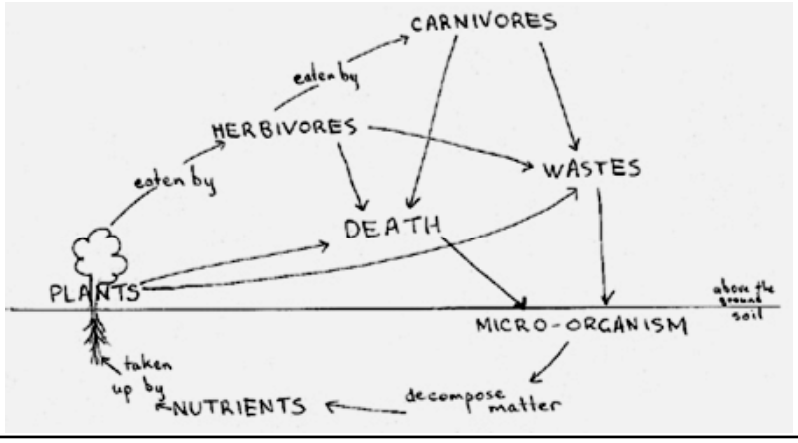
# More Processes

3. Decomposition
   - Remains of dead organisms are broken down by bacteria and fungi
   - All molecules are released into soil
4. Excretion
   - Waste material from animals is broken down and returned to the soil
5. Assimilation
   - Conversion of molecules into a useable form by bacteria
   - Nitrification, denitrification

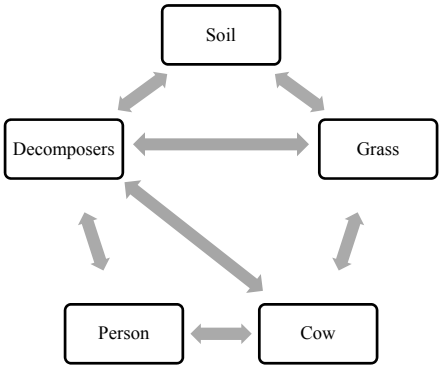
# Cycling of Organic Matter

- The atoms and molecules available to make up organisms on earth is limited
- All the atoms MUST be recycled in order for new organisms to form.
  - It is very likely that at least one of the carbon atoms in your body was also in a 70 million year old dinosaur

# Recycling of Matter by Micro-organisms



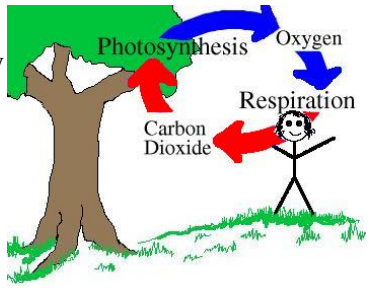

# The Matter Cycle



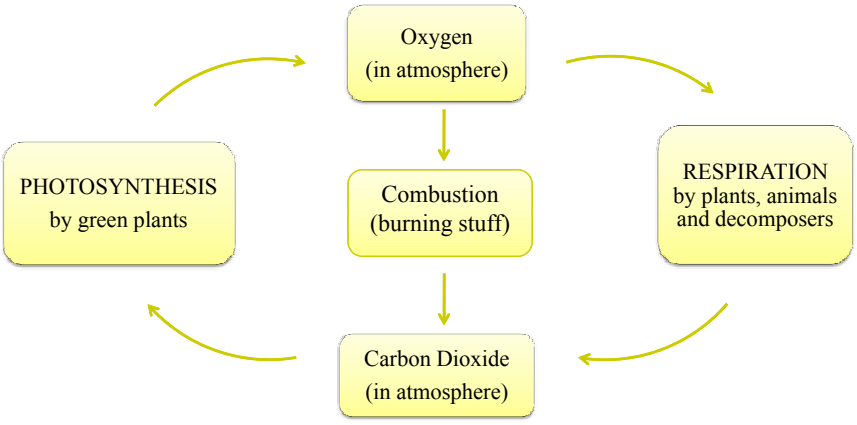

1. Dead plants and animals are broken down by decomposers – their atoms / molecules are released into the system to be re-used
2. Atoms, molecules accumulate in the soil
3. Nutrients are taken up by grasses
4. Cows eat the grass – nutrients and atoms are passed on to the cow
5. Person eats cow – nutrients and atoms are passed on to person
6. Each of these things can die, the atoms are broken down by decomposers and recycled for the next living things

# The Oxygen Cycle

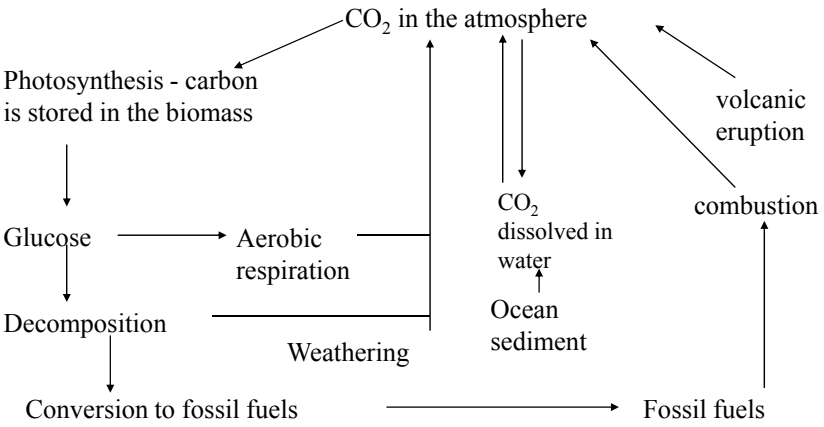
- **Respiration:**
  - $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + \text{energy}$
- **Photosynthesis:**
  - $6\ CO_2 + 6\ H_2O + \text{light} \rightarrow C_6H_{12}O_6 + 6O_2$
- What do you notice about these two chemical reactions?




# The Oxygen Cycle



# The Carbon Cycle




# The Carbon Cycle

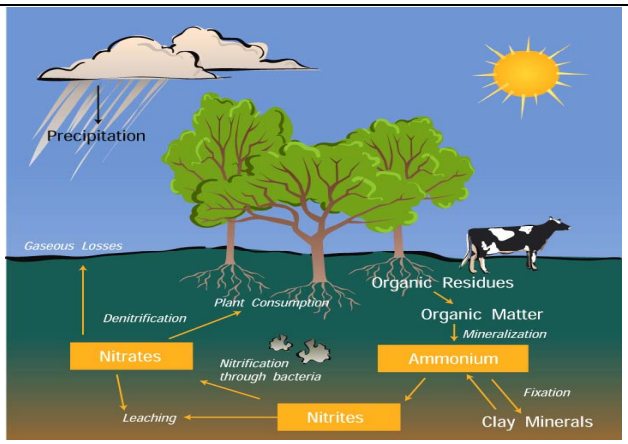
- Two groups of carbon sources in the carbon cycle
  1. Biotic - Aerobic respiration (in the presence of $O_2$), and decomposition
     - The organic reservoirs (storage areas) for carbon are the bodies of living things
  2. Abiotic - Combustion and geological activity
     - The inorganic reservoirs for carbon are the atmosphere, the oceans, and the Earth's crust

# The Nitrogen Cycle

- The movement of nitrogen through the ecosystems, the soil, and the atmosphere is called the **nitrogen cycle**. Nitrogen gas composes 79% of the Earth's atmosphere. In order for nitrogen to be useful to organisms, it must be available as a **nitrate ion ($NO_3^-$)**. Atmospheric nitrogen is converted into nitrates by the process of **nitrogen fixation**, or **nitrification**, either by lightning or by bacteria in the soil

- Nitrogen is required to make proteins and DNA which is the genetic material found in every cell.

# The Nitrogen Cycle



## The Nitrogen Cycle

- Essential to living things for the production of amino acids used to synthesize proteins, and nucleic acids which are used to carry the hereditary or genetic code
- Plants and animals are unable to use any of the $N_2$ that is in the atmosphere
- The nitrogen cycle can occur in both terrestrial and aquatic ecosystems

## Nitrogen Cycle

- Complex cycle can be simplified as follows
  - plants to make use of nitrogen it must first be converted into ammonia or nitrates ($NO_3^-$)
  - two pathways that produce nitrate ions:
    - fixation by lightning (produces nitrates directly)
    - fixation by bacteria (producing ammonia) followed by nitrification by bacteria (converting the ammonia to nitrates)

(ANIMATION)

## Question

IN YOUR NOTEBOOK, ANSWER THE FOLLOWING QUESTION

1. What are some ways that the balance of the carbon cycle is affected by human activity?

## The Greenhouse Effect

- The cause of **global warming**
  - Excess $CO_2$ in the atmosphere acts like a blanket
- Where does the $CO_2$ come from?
  - Burning of fossil fuels in factories and cars
  - Mining → removing more carbon from the earth
  - Burning of rainforests → clearing farmland
  - Destruction of rainforests reduces the number of trees to remove the $CO_2$

# Global Warming

- Describes the increase in the earth's atmospheric and ocean temperatures
- Caused by the Greenhouse effect
  - Radiation reaches earth from the sun
  - Some is blocked by the ozone layer, some not
  - Heat radiation reflects from the earth back into space
  - $CO_2$ and Methane ($CH_4$) in the atmosphere absorbs some of this heat, reflecting it back to earth
  - **The Result** → The earth then gets warmer

# Effects of Global Warming

**General Effects**

- Increase in global temperature
- Changes in climate
- Increasing ocean levels
- Decreased Ozone layer

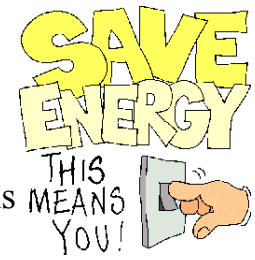
**Effects on Ecosystems**

- Species forced out of habitats (possibly to extinction)
- Other species may flourish
- Less snow cover = less protection for some species

(ANIMATION)

## What Are We Doing About It?

1. Reducing $CO_2$ output
   - 1-tonne challenge, electric/ hybrid cars
   - Cutting back on energy consumption
2. Kyoto Accord
   - Global agreement to reduce emissions
3. Reducing deforestation




## Nutrient Cycling, Interrupted

IN YOUR NOTEBOOK

How do you suppose human activities affect the other chemical cycles?

Think about the effects of agriculture and industry

## Affects on Carbon & Oxygen Cycles

- Eutrophication
  - Fertilizer runoff increases growth in water
  - Increased nutrient levels released into the environment
  - In aquatic ecosystems – Number of organisms increases, $O_2$ levels decrease as consumption increases
  - The water becomes anaerobic (no oxygen), organisms die off
- Habitat destruction & exotic species introduction

## 4 types of Pesticides

- **Herbicides → kills plants**
- **Insecticides→ kills insects**
- **Fungicides → kills fungi**
- **Bactericides → kills bacteria**
  - **Antibiotics**

# Pesticides

**First Generation**

- **Substances such as sulfur, arsenic, lead and mercury.**
  - **Banned usage around the world**
  - **These are toxic to humans so people began to use plant extracts**
  - **Still can be found in fish populations around the world**

**Second Generation**

- **Chemicals made in a lab**
  - **Synthetic pesticides**
  - **Not necessarily better than the first generation chemicals**
  - **Chemicals like DDT or Round-Up**

# Bioaccumulation & Bioamplification

**Bioaccumulation**

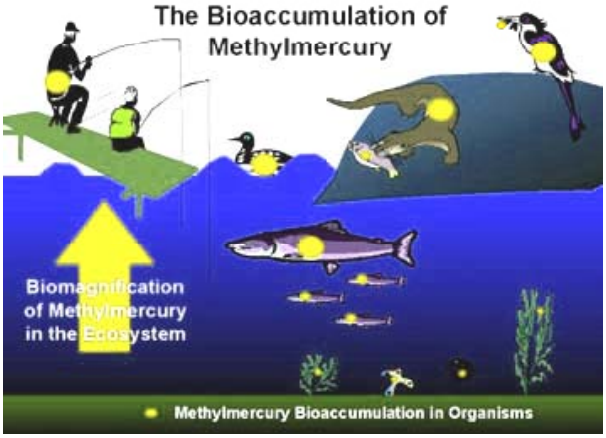
- Increase in concentration of a pesticide from the environment in all organisms in a food chain
- Often insects consuming herbicides

**Bioamplification**

- The higher up the food chain, and thus the higher the trophic level, the higher the concentration of toxins
- Top carnivores end up with the greatest concentrations of toxins

**Figure 4 on page 54 in your book**

# Bioaccumulation




# Bioamplification

- Long-lived -
  Present for a long time in the system
- Mobile -
  Easily passed up the food chain
- Soluble in fats -
  Dissolves in, and is stored in fatty tissue
- Biologically active –
  Affects biological body tissue

# Bioamplification

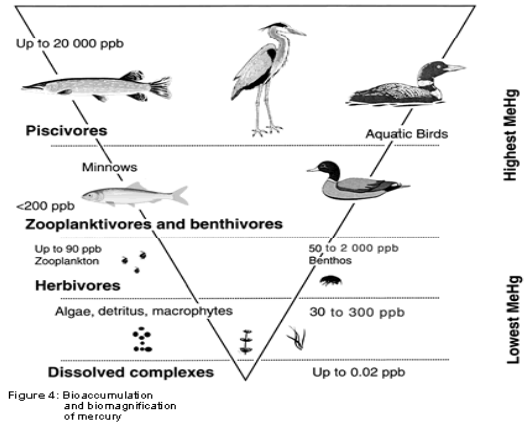



Figure 4: Bioaccumulation and biomagnification of mercury

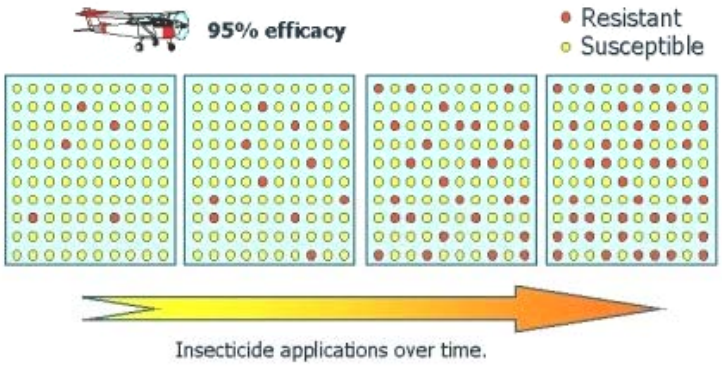
# Pesticides: Past and Present

- **Past Chemical Pesticides**
  - Stored in fat tissue
  - Not soluble in water
- **Modern Chemical Pesticides**
  - Not stored in fat tissue
  - Soluble in water

## Pesticide Resistance

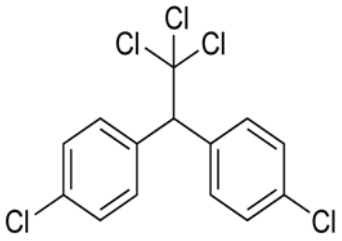
- **When pests become resistant to pesticides pesticide no longer effects them**
- **Sometimes individuals have the genetic ability to resist a chemical. If all others die when they are sprayed, then the survivors are about to reproduce**
- **A resistant population of pests is created**

## Resistance is Futile… Or Not

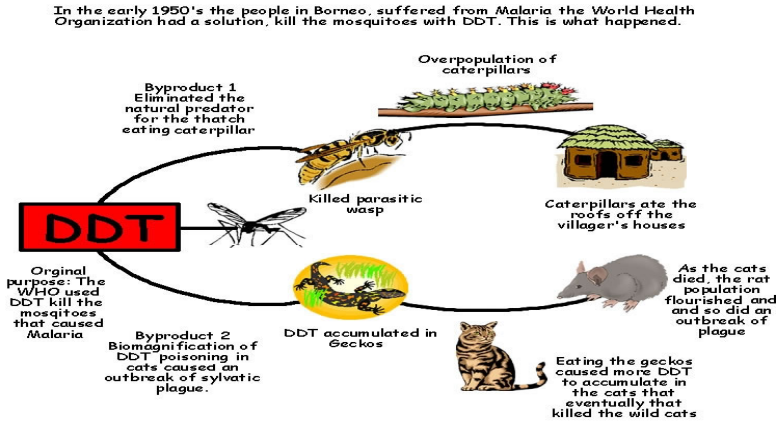


# Dichloro-diphenyl-trichloroethane (DDT)

- Pesticide that is suitable for bioamplification
  - Meets the 4 requirements
- Has a half-life of 15 years
  - That is, every 15 years the amount left in the system will be reduced by one half.
  - If you use 100 kg of DDT, after 15 years it will be reduced to 50 kg, and after another 15 years it will be 25 kg, and so on.




# Effects of DDT Usage in Borneo



# Effects of DDT on Top Predators

- Shell thinning
  1. Carnivorous birds such as ospreys and bald eagles eat other birds, dead animals and fish which contain a build-up of DDT
  2. DDT causes the shells to become too thin to allow the large females to sit on the eggs without them breaking
  3. Since eggs are being broken, the over-all population of these birds is declining
- After DDT was banned in the US and Canada in the early 1970's the bird populations of recovered.
- DDT bioaccumulates in humans the same as it would other animals
- Male birds have also become more feminine as the DDT mimics female sex hormones

# A Couple Final Questions

- Not all countries, like Mexico for example, have banned the use of DDT

1. Since birds migrate from winter to summer from one country another, do you think the birds are 100% safe from the presence and the effects of DDT? Why?
2. How do you think a pesticide like DDT would affect the over all biodiversity in an ecosystem?

# Chapter Two Review & Test

- Chapter Review questions:
  Handout due: _____
- Chapter 2 Test date: _____