Syllabus – Physical Science and the Environment (Sci -5100)

I. Foundations of Environmental Science

➢ **The Biosphere**.

James Lovelock, a British scientist, postulated in the 1970's the Gaia Hypothesis which states that Earth can be considered as a self-sustaining entity, the so-called **Biosphere** or *Living Earth*.

- **Biomes**

  The biosphere in turn is made up of geographical regions called **biomes** ,each biome containing a dominant vegetation dictated by climate differences. The biomes are organized by latitude, as well as altitude. The biomes of latitude from the Polar Regions to the equator are, namely the tundra, coniferous forest (taiga), deciduous(broadleaf) forest and prairie, desert and rainforest. Biomes are also organized by altitude along the slope of tall mountains like the Rocky Mountains. On the windward side of the mountain one can pass through a succession of biomes from sea level to the summit , which includes , grasslands, deciduous(broadleaf) forest, coniferous forest(taiga) and alpine tundra. The biomes of altitude resemble the biomes of latitude since there are similar weather and climate conditions in both regions.

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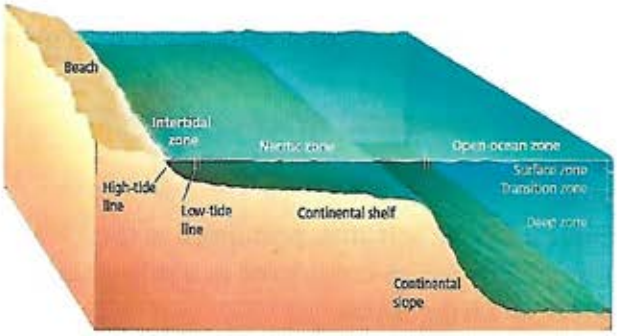
- **Productivity**

  The number of organisms in a measured site within the biome is referred to as its **productivity** .Productivity can be determined by measuring the biomass or biodiversity. **Biomass** is the total weight of all animals and plants in a measured location. **Biodiversity** is the number of different species of animals and plants in a given region. With its limited rainfall, a desert biome would be low in biomass and biodiversity. On the other hand, the tropical rain forest would be high in biomass and biodiversity because of plentiful rain and sunlight.

➢ **Ocean Profile**

The ocean which occupies approximately 70% of Earth's surface is the biggest biome. A side view or profile of the ocean reveals **life zones** which are regions that vary greatly in animal and plant life..



The beach or **supratidal** zone is the beach area above high tide mark. The intertidal zone is the area between high and low tide. The strandline is a long line of seaweed and debris deposited at the high tide mark. The **neritic zone** is the area above the continental shelf where most of the world's fishing takes place because of its high productivity. From the ocean surface down to about 200 meters on the average is the **photic zone,** the area of light penetration. Below the photic zone is the **aphotic zone** with little or no light. Productivity is much lower in the aphotic than in the photic zone because of the absence of light. Light is necessary for photosynthesis, the process of making food and oxygen for all creatures.

➢ **Energy Relationships**

Energy in its different forms is transformed and transferred between living things and the physical environment as demonstrated in photosynthesis, chemosynthesis and cellular respiration.

- **Photosynthesis**

  In photosynthesis light energy (photon) is changed into chemical energy found in the simple sugar, glucose, as shown in the following chemical reaction.

$$6\,CO_2 + 12\,H_2O \xrightarrow[chlorophyll]{sunlight} C_6H_{12}O_6 + 6\,H_2O + 6\,O_2$$

  Photosynthesis takes place in all green plants, both aquatic and terrestrial. During this reaction, oxygen gas is produced as a by-product. After the oxygen is released by the plant, some of it will dissolve in the water. The rest enters the atmosphere. The oxygen you take in with every breath comes from some green plant in the water or on land.

- **Chemosynthesis**

  The energy in glucose, called **chemical energy**, is found in the bonds that hold the atoms together in the glucose molecule. It was once thought that glucose could only be synthesized during photosynthesis until it was discovered that glucose can be produced in the absence of light at **hydrothermal vents** in the aphotic zone thousands of meters below the ocean surface. A species of bacteria found near the vent provide the enzymes that oxidize a compound, hydrogen sulfide (H_2S), in the presence of CO_2 to produce glucose. The chemical reaction that produces sugar from these inorganic materials is called **chemosynthesis**. Chemosynthesis is shown in the following chemical reaction.

The part of the scientific method where data is analyzed and interpreted is called the **conclusion.** The student should conclude whether the hypothesis is supported or should be rejected by the data. A hypothesis that is supported by the data is called a **valid hypothesis.** The rejection of a hypothesis doesn't mean that the experiment is a failure. Data, whether it confirms or rejects a hypothesis is important information . Offering new ideas for further research is an important part of the conclusion section in a research paper.

➢ Ecological Relationships

The study of the interrelationships between living things and their environment is called **ecology**. Important substances necessary for living things are recycled**.** Water is an important nature resource that is recycled in the form of a water cycle

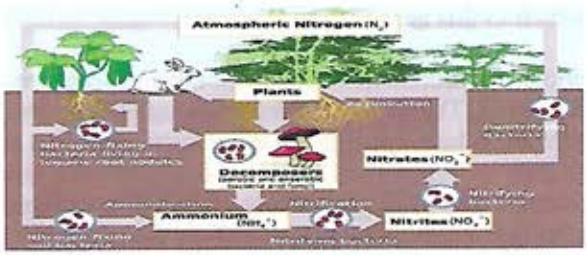
- **The Water Cycle**

  The water cycle occurs through the processes of **evaporation, condensation** and **precipitation**.

  Evaporation occurs when liquid water changes to a water vapor, a gas that rises into the atmosphere. Condensation occurs when the gas comes close enough together to for a cloud. Clouds contain tiny droplets of water. If the droplets are heavy enough they fall to the earth as rain, snow, sleet or hail which are all forms of **precipitation**

- **The Nitrogen Cycle**

  Nitrogen (N) is an essential element found in all proteins. Protein is a nutrient compound found in food and required for the growth and repair of body cells. The element nitrogen is made available to living things in an ecosystem by a process called the **nitrogen cycle**.



  Dead matter is broken down on land and sea in a series of steps by decay bacteria. The chemical products produced include **ammonia (NH_3),** **nitrite (NO_2^-)**,and **nitrate (NO_3^-).** Ammonia and nitrites are toxic but nitrates are

Bacteria

$$6CO_2 + 6H_20 + 3H_2S \longrightarrow C_6H_{12}O_6 + 3H_2SO_4$$

carbon dioxide + water+ hydrogen sulfide glucose + sulfuric acid

- **Cellular Respiration**
  The energy in glucose that cannot be directly used by a cell is transformed, in a series of enzyme controlled reactions, to the usable form of chemical energy called **adenosine triphosphate**, or **ATP**. This process, which occurs inside the cell is called **cellular respiration** or aerobic respiration and can be summarized in the following chemical reaction:

$$C_6H_{12}O_6 + 6O_2 \xrightarrow{\textit{enzymes}} 6CO_2 + 6H_20 + 38ATP$$

For every molecule of glucose that is burned, or oxidixed, in the cell, 36 molecules of ATP are produced. The ATP releases the energy that is used by the cell to do work. For example, the contraction of muscle fibers to produce movement in living animals uses the chemical energy in ATP molecule, the

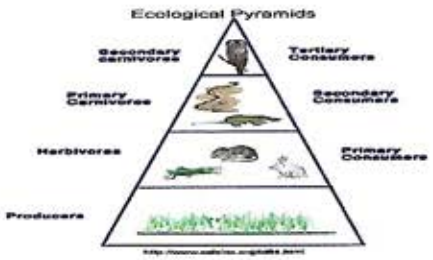
➢ **Scientific Method** -(Add Experiment on oxygen generation in photosynthesis)

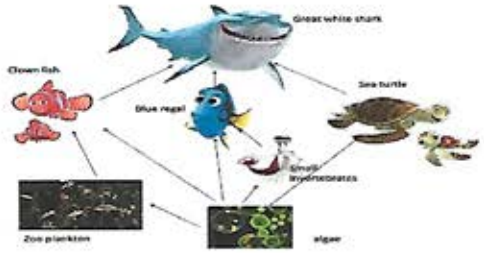
Scientists learn about the environment by performing experiments. An experiment is an investigation using an organized step-by step problem solving approach called the **scientific method.** The steps in scientific method are : statement of problem, hypothesis, materials and methods, results and conclusion. The first step in the use of the scientific method is to make observations. Observations are descriptions of your environment that require the use of your senses. Observations are recorded in a **log book**. The next step in the scientific method is a **statement of the problem.** After a problem is selected the next step is the formation and the testing of the **hypothesis**. The hypothesis is called an educated guess. To test the hypothesis an experiment must be designed and carried out. Before one can do the experiment, the appropriate **materials** must be selected. The materials are assembled according to a **method** or **procedure** . The procedure or **experiment** contains **variables**. A variable is any factor that could affect the outcome in an experiment.

The part of the experiment containing the variable being tested is called the **experimental group.** The **control group** contains the same conditions as the experimental group, except the one being tested, which in this case is food.

In making observations measurements need to be taken. Measurements recorded in an experiment are called **data**. The data collected make up the **results** of the experiment. Numerical data from an experiment is best recorded in table form. Data in a table is better organized and easier to read. Each time an experiment is carried out is called a **trial**. More than one trial should be used in an experiment. The average of many trials will give more accurate results. The results of an experiment also include calculations. Scientists use mathematics in solving problems. The data from an experiment should also be displayed in the form of a **graph**. A **bar graph** or line graph can be constructed using 2 lines or axes, the x axis and the y axis.

animal. The prey is the victim. The number of organisms in food chains and food webs can





Food Pyramid **Food Web**

be arranged in the geometrical shape of a triangle or **food pyramid**. In a pyramid producers outnumber consumers and prey outnumber predators.

- **Symbiosis**

Organisms interacting with one another and their environment is known as **interdependence.** The place where organisms interact is called a **habitat**. A **community** contains groups of animals and plants interacting with one another and their environment. In their struggle for existence, marine organisms have evolved a variety of relationships that give them survival value. In one type of relationship, known as **symbiosis**, organisms of different species live in close association. A clown fish living among the stinging tentacles of a sea anemone is a special kind of symbiosis called **mutualism.** In this relationship both species benefit. In another symbiotic relationship, called **commensalism** , one species benefits while the other species is not affected by the association. Barnacles growing on the back of a whale is an example of commensalism. A third type of symbiosis, called **parasitism**, involves a relationship Any condition of the environment that can result in harmful effects on living things, including humans is called **pollution** where one species benefits while the other species is harmed. A tick carrying the bacterium that causes Lyme Disease biting a human host is an example of parasitism. The tick is the **vector** or carrier, the bacterium is the parasite, and the victim is the host.

- **Ecological Succession**

The process by which one community of organisms gradually replaces another community over a period of time is called **succession**. The first organisms to appear in marine succession are part of the **pioneer** community. The last stable community to appear in marine succession is called the **climax community.** Succession can occur in a forest destroyed by a forest fire, on the hull of a trip at sea, or on a newly emerged volcanic island that gradually becomes colonized by plants.

useful because they can be absorbd by green plants to make proteins.

- **Food Cycle**

  Another natural resource that needs to be recycled and used again is food itself which contains the seven basic nutrients required for life.

In a **food cycle** the green plants, called **producers,** make food. Animals that feed on producers are called **consumers** . Dead producers and consumers, in turn, are broken down in the water and the soil by **decomposers** which are mainly decay bacteria. The products of decay include nitrates (NO_3^-)phosphates (PO_4^{3-}), both of which are absorbed by green plants for growth. In fact, nitrates and phosphates are found in all fertilizers.

- **Carbon Cycle**

  By definition, organic compounds contain the element **carbon** (C). Photsynthesizing plants and algae take in carbon, in the form of carbon dioxide and produce carbohydrates, namely glucose or sugar. Animals take in carbon compounds when they eat plants. Animals give off this carbon, again in thee form of carbon dioxide as a waste product of cellular respiration. This carbon then becomes available to plants for photosynthesis. The movement of carbon through living things in an ecosystem is called the **carbon cycle**.

- **Food Chains**

  A relationship in which one living organism serves as food for another organism is called a **food chain**. All food chains begin with a producer. The first animal in the food chain is called a **primary consumer**. The animal that feeds on the primary consumer is called a **secondary consumer**. Food chains may have other consumers including **third level** and beyond. Consumers that only feed on plants are called **herbivores.** All the other animals in the food chain are **carnivores ,** animals that eat other animals. The meat eating shark is an example of a carnivore. An animal, like the baleen whale, that consumes both animals and plants is called an **omnivore.** There is an energy transfer in all food relationships as radiant energy from the sun is transformed into the chemical energy

- **Food Webs and Food Pyramids**

  Food chains are interconnected with one another forming a giant **food web.**The food web shows **predator - prey relationships.**. A predator is an animal that eats another living

Sci 5100 Physical Science and the Environment
Syllabus
Unit II Environmental Problems

II. Environmental Pollution

Any environmenal condition that results in harmful effects on living things is called **pollution**. The substances that cause pollution are called **pollutants.** Pollution on planet Earth can result from natural causes or from activities caused by humans, referred to an **anthropogenic** causes.
The human or anthropogenic causes can be conveniently divided into three main categories: water pollution, air pollution and land pollution.

➢ **Water Pollution**

Planet Earth is often referred to as the Water Planet since more than 70% is covered by a layer of water called the **hydrosphere** or ocean. The remaining 30% is land of which 3% is composed of fresh water. The following are examples of water pollution:

- **Acid Rain**

  The burning of fossil fuels produces sulfur dioxide (SO_2) and nitrogen oxide compounds (NO and NO_2) that react with moisture in the atmosphere to produce weak acids such as sulfuric acid (H_2SO_4)and nitric acid (HNO_3). The presence of these acids in rain water is called **acid rain** or **acid precipitation**. The chemical equations are as follows:

  $$\underset{\textit{Sulfur dioxide}}{2SO_2} + \underset{\textit{Water}}{2H_2O} + O_2 \Longrightarrow \underset{\textit{sulfuric acid}}{2H_2SO_4}$$

  $$\underset{\textit{Nitrogen dioxide}}{3NO_2} + \underset{\textit{water}}{H_2O} \Longrightarrow \underset{\textit{nitric acid}}{2HNO_3} + \underset{\textit{nitrogen oxide}}{NO}$$

  Acid rain lowers the pH of fresh water as a result of the addition of hydrogen ions (H^+). If rain water lowers the pH in a fresh water lake or pond below 5 on the pH scale, it constitutes acid rain according to the EPA.

- **Ocean Acidification**

  Ocean water has a more stable pH and is less affected by acid rain than is a smaller body of water such as a lake or pond. When it rains into the ocean, the large volume of ocean water dilutes the acid rain. Also, chemicals in ocean water, called **buffers**, help maintain a stable pH. A buffer is a substance that lessens the tendency of a solution to become too acidic or too basic. One of the buffers present in ocean water is the carbonate buffer (CO_3^{2-}). The carbonate buffer can accept hydrogen ions, causing the water to become less acidic or more basic. The carbonate buffer can also release hydrogen ions, making the water more acidic and less basic. The actions of this buffer can be seen in the following reaction:

  acidity increases→

  $$CO_2 + H_2O \rightarrow H_2CO_3 \rightarrow HCO_3^- + H^+ \rightarrow CO_3^{2-} + 2H^+$$

  Carbon dioxide + Water → Carbonic acid → Bicarbonate ion + Hydrogen → Carbonate ion + Hydrogen ions

  ← **Acidity decreases**

Ocean acidification occurs when excessive CO_2 from the atmosphere enters the ocean and reacts with water producing carbonic acid(H_2CO_3), which is responsible for the **bleaching** and the eventual death of corals. (**Figure 1**) and a variety of animal embryos **Figure 2** During recent decades the pH of ocean water has declined from approximately 8.1 to 8.0. This may not appear to be a significant decline but a 0.1 unit fall in pH is a 30% increase in acidity.

Figure 1 Coral Bleaching

Figure 2 Embryonic Death

When excess carbon dioxide from the atmosphere is absorbed by ocean water, it forms carbonic acid which increases the hydrogen ion concentration and thus lowers the ocean pH.

$$CO_2\ (aq) + H_2O \leftrightarrow H_2CO_3\ (aq)$$

Carbon dioxide *carbonic acid*

Since the beginning of the industrial revolution in the early 1800's scientists estimate that ocean pH has dropped by approximately 0.1 units from 8.25 to 8.14.By 2100 it is estimated that the pH will drop by a further 0.3 - 0.4 units making ocean water less alkaline and therefore more acidic. As the acidity of ocean water increases the breakdown of the compound calcium carbonate (**$CaCO_3$**) also increases. Calcium carbonate, of which chalk is composed, serves as the structural framework of all shellfish, corals and phytoplankton. The chemical reaction is as follows:

$$\mathbf{CaCO_3} + \mathbf{H_2CO_3} \Longrightarrow \mathbf{Ca^{+2} + 2HCO_3^-}$$

Calcium carbonate + carbonic acid → calcium + bicarbonate

The marine animal's calcium carbonate skeleton gradually begins to dissolve into calcium and bicarbonate ions as ocean water acidity increases resulting in a decline in growth and vitality.

- **Sewage Pollution**

Sewage consists of human intestinal or **fecal wastes** that are flushed down toilets and transported to Waste Water Treatment Plants that treat the sewage, which contains harmful **pathogenic** bacteria that can cause life threatening diseases such as typhoid fever, dysentery and cholera.The treated liquid effluent which is much lower in pathogens is discharged into bodies of water. Unfortunately, during heavy rains, the treatment plants, unable to handle the excess water, discharges raw or partially treated sewage directly into the bay at various locations. In addition, dog and cat feces left on paved surfaces are carried by rain water runoff into local waters The possible discharge of toilet wastes from the many boats that anchor and navigate in

local waters and bird droppings from swans, gulls ,geese and ducks are other possible sources.

S

SSince bacteria are microscopic in size, it is necessary to grow or **culture** them in the laboratory in order to see and count them more easily. When grown under suitable conditions of warmth, food, darkness and moisture they produce enough cells to form masses called **colonies (Fig. 2)** Water that is contaminated with lots of sewage will have a high coliform colony count. Cleaner water will have fewer or no coliform colonies.

Fig 2 Fecal Coliform Colonies in Petri dish

The Environmental Protection Agency(EPA) sets standards for water quality. The standards for permissible levels of fecal coliform bacteria are as follows

Type of Water	**Fecal Coliform Colonies in100mL Water Sample**
Drinking	Zero colonies
Shellfishing	< 14 colonies
Swimming	< 200 colonies
Boating	<2000 colonies

- **Oil Pollution**

Oil spills from tankers and off-shore oil rigs that destroy marine life are examples of **oil pollution.** The crude oil sinks to the bottom burying the shellfish beds, suffocating fish and coating marine birds with oil. Oil spills account for only 20 % of all oil pollution. Most oil pollution originates from the discharge of consumer products containing oil into local waterways from many locations along the shore, a condition called **non-point source pollution.**

- **Radioactive Wastes**

Another pollutant from the industrialized world that has accumulated in parts of the marine environment are **radioactive wastes** that originate from power plants and from medical and industrial sources. Radioactive wastes consist of radio-active **isotopes,** which are atoms that are unstable, i.e. they break down or **decay** into smaller atoms and emit high energy rays and particles that can pass through living things causing damage to cells. In the past, low level radioactive wastes have been placed in metal drums and dumped hundredths of kilometers off the Atlantic and Pacific coasts. Some of these drums have washed ashore while others have been pulled up in trawl nets. Other drums have rusted causing the release of radioactive elements into the water. Ocean dumping of radio-active wastes has now ceased. The wastes are now placed in secure containers and buried deep in the Earths crust far from underground aquifers.

- **Turbidity**
  When water is not clear or transparent it is considered as **turbid** water. Water turbidity is caused by suspended substances that cloud the waters making it difficult for marine plants to carry on photosynthesis. A simple device called a **Secchi disk** is used to measure water turbidity. Natural, as well as unnatural conditions, can cloud the waters. On occasion coastal waters may turn cloudy, caused by an overpopulation of algae, called an **algae bloom.** The algae bloom are often caused by water run-off from the land that contains fertilizers that stimulate plant growth. Many of the algae die and the dead matter uses up oxygen in the process of decay. The low levels of DO(<2mg/l) cause fish to suffocate, a condition called **hypoxia.** Hypoxia may result in **fish kill** the sudden death of large numbers of fish.

- **Toxic Chemical Wastes**
  Rachel Carson(1907-1964), an American biologist, wrote the Silent Spring, in which she warned about the increasing dangers of chemical pollutants, or **toxic** substances, in our environment that are harmful to living things One toxic chemical, the insecticide **DDT** passes through the food chains from mosquito larvae to marine birds causing thin shelled eggs to be produced, resulting in a decline of marine birds including the California brown pelican, *Pelecanus.* Another toxic chemical, PCB has been discharged into waterways from industrial plants and passed into marine food chains . PCB's have increased in concentration at each trophic level in the food chain, a process called **bio-accumulation.** Toxic levels have been found in the striped bass, *Moron* and in the Canadian beluga whales, *Delphinapterus.*The toxic element, **mercury (Hg)** was first discovered as a pollutant in Minamata Bay, Japan, in the 1950's and early 1960'. Hundreds of people developed tremors, fell into comas and died after eating fish contaminated with mercury discharged from industrial plants.

➢ **Air Pollution**
Unwanted chemical or particulate matter in the atmosphere that can cause harmful effects on living things constitutes air pollution. The following are examples of air pollution:

- **Natural Causes**
  Dust storms, volcanic eruptions and forest fires contribute harmful substances to the atmosphere. Dust storms carry bacteria and fungal spores which have been linked to die-offs in Caribbean reef ecosystems and respiratory ailments among air breathing animals, including humans. Volcanic eruptions release large quantities of particulate matter. Forest fires releases tons of carbon monoxide and sulfur dioxide into the atmosphere
- **Anthropogenic (Human) Causes**
  The burning of fossil fuels is the greatest source of air pollution The combustion of oil, gas and coal discharges into the atmosphere emissions that contain a number of pollutants, including excess carbon dioxide(**CO_2**), carbon monoxide (**CO**) sulfur dioxide (**SO_2**), nitrogen dioxide (**NO_2**) lead (**Pb**), mercury(**Hg**) and particulates including dust, soot and tars. In addition, toxic chemicals reacting with UV light during hot summer days can produce 0zone(O_3), a gas that when inhaled can cause respiratory distress.
- **Ozone Depletion**
  Ozone at sea level is harmful to our health but in the upper atmosphere it acts as a shield that absorbs excess ultraviolet(UV) light. While moderate exposure to UV light produces Vit D, the so called sunshine vitamin, too much UV light can cause skin cancer. Recently holes in the protective ozone shield were created by

chlorofluorocarbons(CFC) a chemical propellant used in spray cans that drifted up to the ozone layer. CFC broke down the ozone molecule, the protective shield, causing excess UV light to penetrate the atmosphere.

➢ **Land Pollution_**

The United States throws away more trash or **litter** than does any nation in the world. More than 150 million tons of solid wastes, or **debris,** are thrown out each year – nearly 10 million tons are dumped into offshore waters. No spot is too remote for seagoing trash. Scientists discovered litter on tiny Ducie Island , an uninhabited atoll 2.5 km long, in the middle of the South Pacific nearly 500 kilometers from the nearest inhabited island,. On one occasion, 953 pieces of trash, most of it plastic, was counted along a 2.5-kilometer stretch of beach. Much of the garbage came from ships, such as cruise ships that had routinely dumped their trash overboard. There are two types of litter **biodegradeable** and **non-biodegradeable**

- **Biodegradeable**

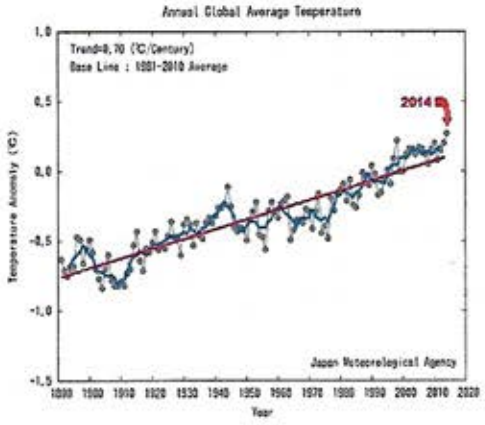
  Litter that comes from dead plant and animal material and can be broken down into products of decay by bacteria is called biodegradeable. Paper and wood products are common kinds of biodegradeable materials. All food wastes are also biodegradeable.

- **Nonbiodegradeable**

  Litter that does not undergo natural bacterial decay is nonbiodegradeable. Plastic, glass, and metal are the most common kinds of nonbiodegradeable litter. They cannot be broken down biologically since they don't come from living things. A nonbiodegradable waste such as plastic may remain in the environment for hundreds of years. Plastic wastes are not only unsightly but often pose a threat to marine life. Some animals, particularly sea turtles that eat jellyfish, mistake plastic bags for food. The turtles then die, either of starvation, with plastic filling their stomachs, or of suffocation after choking on the plastic bags. Carelessly discarded plastic rings from beverage six-packs trap and choke fish, birds, and other marine life when the animals swim, or put their heads in, through the rings and are unable to get them off their bodies. And each year, thousands of fish, seabirds, turtles, and marine mammals die when they become entangled in plastic gill nets and huge drift nets that are discarded or lost at sea by fishing vessels. **Microplastics** are also a very serious problem. They come from the mechanical breakdown of larger plastic debris into tiny particles that can be absorbed into the tissues of many aquatic animals.

➢ Global Warming

- **Global warming** is the gradual increase in Earth's temperature over time **(Figure 1).** Global atmospheric temperatures are measured using satellite technology and from worldwide weather stations. One of the hottest years on record was 2014 with an atmospheric temperature of 13.9 ^{o} C (57.0^{o} F). The global oceans also showed a slight rise in temperature since it is in contact with the atmosphere.(**Figure 2**)



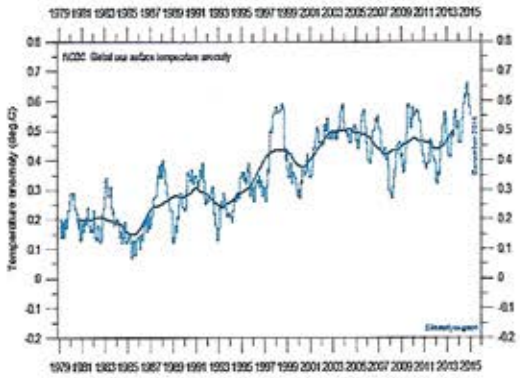


Figure 1 Global Atmospheric Temperature Change **Figure 2 Sea Surface Temperatures**

One cause for the increase in the temperature of the atmosphere (air) and the hydrosphere (oceans) is the increase in the amount of carbon dioxide (CO_2) discovered in the atmosphere**(Figure 3).** Carbon dioxide is normally found in small concentrations, about 0.04% when compared with other gases like oxygen(21%) and nitrogen(78%). Scientists like to use the unit "parts per million" or ppm to represent concentrations of gases in the atmosphere. Current CO_2 levels are around 399 ppm. This means that for every million molecules in the atmosphere, 399 of them are CO_2.

According to **Figure 3** CO_2 has increased dramatically since 1960. Scientists are worried because CO_2 normally is heat trapping **greenhouse gas** because, like a warm greenhouse, it helps to keep Earth warm. But if CO_2 increases in the atmosphere global warming will result.

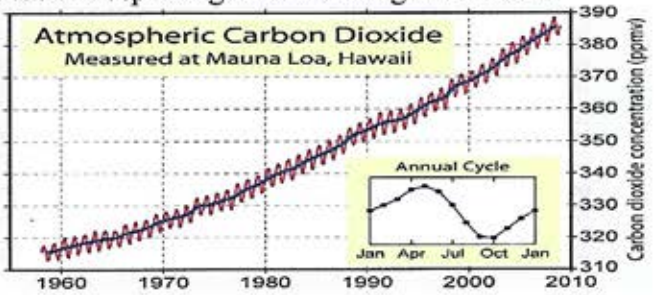


Figure 3 CO2 in the atmosphere

Global warming has resulted in the gradual melting of the polar ice caps (**Figure 1**). Satellite images show a dramatic change in ice cover between 1980 and 2012.The shrinkage and thinning of the ice caps has affected the polar bear population (**Figure 2**). Since polar bears feed almost exclusively on seals which they can only capture on ice, habitat loss has caused a dramatic decline in the number of polar bears in the Arctic.

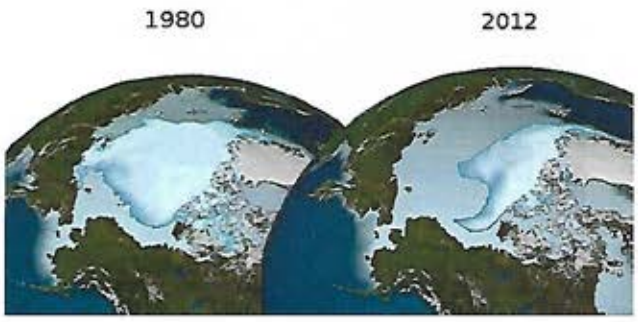


Figure 1 Melting of Polar Ice Caps

Figure2 Habitat Loss for the Polar Bear

It only takes a one degree change in temperature for ice to melt into water When the polar ice melts over the continents in the Arctic and Antarctic the melt water flows into the ocean causing it to rise. A rising sea level is also caused by **thermal expansion**, an increase in the volume of water due to an increase in its temperature. An increase in the volume of ocean water causes an elevation in sea level. When **glaciers,** which are rivers of moving ice melt, the water runs off into the ocean. Melting icebergs also contribute to a rising sea level.

How do scientists measure the change in sea level caused by the addition of water from melting ice? The sea level has been measured very accurately by orbiting satellites using an instrument called a **radar altimeter. (Figure 3).** The radar altimeter inside the orbiting satellite emits very short radar pulses which are beamed down and bounce off the sea surface back to the satellite. By timing the interval between the transmission and reception of the signals the precise height above the water and the topography (surface features) can be determined.

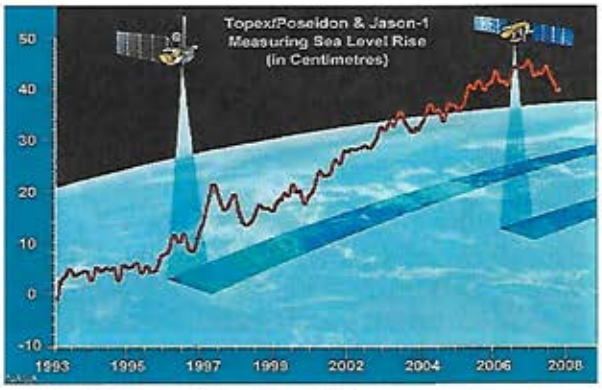


Figure 3 Radar Altimetry

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Physical Science and the Environment(Sci5100) Syllabus
Unit III Natural Resources

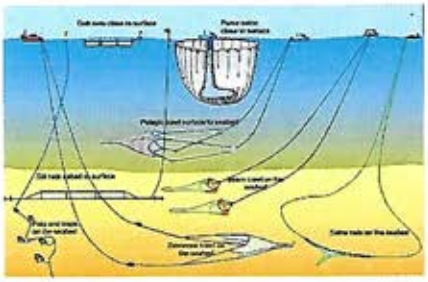
III. Natural Resource Management and Conservation

One of the solutions to pollution and environmental degradation is **conservation,** the care, protection and wise management of our natural resources. Substances like plants, animals, oil, gas, minerals and other materials that are native to Earth and are part of nature are called **natural resources**.

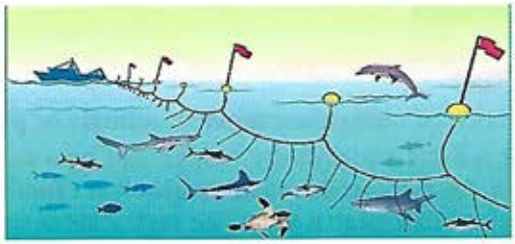
➢ **Fisheries**

One of the most important resources in the ocean are the fish because they provide food for the human population. Catching fish commercially is part of the **fisheries** industry. Since the 1950's fishing fleets have harvested increasingly larger amounts of fish. Japan and Russia are the leading fishing nations, with the United States ranking third. Large numbers of fish are caught commercially by using fishing lines and nets including the trawling seine, purse and gill nets . The bottom trawls result in habitat loss to bottom fish due to damage done to the bottom sediments. The intensive and widespread use of fishing nets by commercial fishing fleets has contributed to a decline in the world catch of some of the more important species of food fish. Many of these nets also contribute to catching unwanted marine species or **by-catch**.

To reverse this decline the United States Congress in 1976 passed the **Magnuson Act** which forbids foreign fishing fleets from fishing within 133 kilometers of our coast. Fish need time to recover before they can increase their population or **stock.** Limiting the size of the salmon catch on the West Coast and closing the fishing grounds temporarily off Cape Cod to cod, haddock and flounder are two important conservation measures that the Federal Government has taken in recent years to increase the stock. When a fish species increases in number to the point where it can be fished commercially without threatening its population **size it has reached its maximum sustainable yield**



Fishing Nets



By-Catch

➢ **Fossil Fuels**

One of the natural resources that the human civilization has come to depend upon are the **fossil fuels** , which include oil, gas and coa.l **Fossil fuels** originally come from the remains of dead animals and plants, mostly plankton. Oil, gas and coal which are classified as **hydrocarbons** are formed in Earth's crust, on land as well as in the ocean floor. Dead plankton containing hydrocarbons accumulate in layers on the sea floor and over time form thick deposits in the sedimentary rock. High temperatures and pressures from Earth's interior change the hydrocarbons into **petroleum**, either gas or oil. The oil and gas under pressure seeps through porous layers in the sedimentary rock until it encounters a non-porous layer called a **dome** where it accumulates. Presently , 75% of petroleum comes from land drilling and about 25% from the sea floor. Sometimes the oil and gas accumulates in the rock layers under such great pressure that when a drill breaks through, the whole pipe assembly is forcefully ejected in what is called a **blowout**

➢ **Agriculture**

The practice of cultivating soil, producing crops, and raising livestock for human use and consumption is called agriculture. **Soil**, which provides a foundation for feeding a growing human population, is formed slowly from biological and chemical weathering of rocks and minerals. Regional differences in soil chemistry and climate dictate the kind of crops produced. **Erosion** is movement of soil from place to place. **Good agricultural practices** include crop rotation, contour farming and terracing which reduces soil erosion and degradation. **Poor agricultural practices** include overgrazing and clear cutting(deforestation) which contributes to soil degradation. Measures that can be undertaken to improve agricultural practices include grazing livestock in open fields or **open range**. Limiting the use of chemical fertilizers, pesticides and herbicides on land and the use of hormones in livestock will reduce toxic chemicals getting into our food chains. Creating buffer zones of land along the coast and adjacent to rivers and streams that will act as a barrier by filtering out harmful substances. All these practices constitute **organic farming**

Open Range

Clear Cutting

Reforestation

Many citizens in local communities have banded together to form a non-profit organization called a **Conservancy** to help protect and conserve natural resources like parks, beaches, wetlands and prime agricultural lands

➢ **Aquaculture**

The practice of cultivating aquatic animals or plants for food is called **aquaculture. Fish farming,** a form aquaculture, started in China more than 3000 years ago with the rearing of a large meaty fish, the carp, a relative of the goldfish. Today a one acre pond containing carp can produce 12,700 kg's of fish meat a year. This high yield is a result of using a method called **polyculture**, where different species of carp consume different kinds of food in the pond. The most widely cultured salt water fish is the milk fish *Chano,* an important food item South East Asia. After the milk fish spawns in coastal waters and hatches into small fish called **fry,** they are caught in nets and transferred to larger salt ponds for fattening. The Japanese have also been able to culture a popular salt water fish, the red sea breen, *Chysophrys,* from fertilization to maturity in closed salt water ponds. Farming the sea is called **mariculture**. Mariculture started in Japan with the raising of oysters along the shore. An oyster produces more than 100 million eggs at a single spawning. The swimming embryos called **veligers** attach to hard surfaces and develop into baby oysters called **spat** which are placed like seeds on different substrates to grow into adults. Oysters are cultivated in vast numbers, approximately 21,000 kg's of oysters per acre per year. The techniques of oyster mariculture have been adapted to raising mussels. However, the crustacea, including shrimp, lobster and crab ,are more difficult to farm because these arthropods are cannibalistic. The farming of seaweed's or plant mariculture, is big business. Many popular consumer goods are made from seaweeds. A chemical substance , **carrageenan** that is extracted from the seaweed, Irish moss *Chondrus* is used to manufacture toothpaste and ice cream. **Algin,** a chemical extract from kelp, is used as a thickener and stabilizer in many processed foods. Two of the most popular edible

Off Shore Salmon Aquaculture

Alga(seaweed) Aquaculture

seaweed's the green alga, *Ulva,* is used by Hawaiians in salads and the red alga ,*Porphyra,* which also comes in thin sheets is used to wrap boiled rice in the Japanese dish, sushi.

➢ **Stewardship**

Environmental degradation is most likely to occur in fragile environments including tropical rain forests and coral reefs . Coral Reefs are referred to as the "rainforests of the sea." because like the rain forest, the coral reef ecosystem has a spectacular and thriving biodiversity. Many scientists today, however, are concerned about the future health of coral reefs given the stressful conditions under which they presently exist. The stress is due largely to human or **anthropogenic** causes. What can we do as citizens to reverse this trend? Become involved in improving the quality of your environment.. Taking personal responsibility in caring for the environment is called **stewardship**..

You may live far from a coral reef but rivers bring trash to the sea. Be pro-active - don't litter. Participate in beach clean-ups and you will improve ocean water quality. Take a lesson from nature by recycling. Participate in recycling efforts in your school and community. Do beach clean-ups. Think globally but act locally The economic benefits however, come at a price. High density tourism unfortunately has impacted coral reefs in a negative way, both directly and indirectly.. Snorkelers and scuba divers inadvertently trample on the tops of shallow reefs with their fins braking off pieces of branching corals. Training and briefing of divers and snorkelers will greatly reduce damage to the reefs. Anchor damage from boats fishing and diving near the reef is also a big problem. Anchor damage can be avoided to a large extent by designating anchorage sites at a safe distance from the reefs and installing permanent moorings at the anchorage sites. Research indicates that to maintain a healthy coral reef 5,000 to 6,000 dives per site per year should not be exceeded.
Indirect negative impact on coral reefs occur from the effects of resort development along the coast. The discharge of toxic substances into the ocean from commercial and residential properties will negatively impact the coral reef on and offshore. Laws limiting development in the coastal zone are needed to protect these fragile ecosystems.

➢ **Extinct and Endangered Species**When a species becomes extinct it is gone forever. Since the 1600's when settlers first came to America more than 500 animal species, several of which are marine species have become extinct. Organisms that are threatened with extinction are called **endangered species.** Less endangered species are classified into the lesser category of **threatened species.** The **Great Auk,** *Pinguinis* , part duck and part penguin and last seen alive in 1844, is now **extinct**. One species threatened with extinction is the Florida manatee, *Trichechus* , a large herbivore that inhabits the rivers and coastal waterways along Florida's Gulf and Atlantic coasts. Human intrusion and destruction of habitat have reduced the population of manatees to the point where its very existence is threatened. The Congress of the US passed the Wildlife Preservation Act in 1969 and the Endangered Species Act in 1973 which provides a list of species that are in danger of becoming extinct. The Endangered Species Act forbids the importation of any animal on the list or any product

made from these animals. It further prohibits the interstate trafficking of endangered species obtained illegally in their country of origin.

Manatee

Hawaiin Monk Seal

Great Auk

The Endangered Species Act together with the Marine Mammal Protection Act are responsible for saving a living relative of the extinct Caribbean Monk Seal, the Hawaiian Monk Seal (*Monachus schauinslandi)* from also becoming extinct . Listed as endangered the Hawaiian Monk Seal is now protected from being hunted or harassed. Another animal saved from extinction is the manatee or sea cow that inhabits the fresh and salt water habitats along the Florida coast.

Maintaining a normal population size not only requires that a species be free of human exploitation, but that it live in an ecologically healthy and sound habitat. Recently, the US Government created the largest coral reef reserve in the United States, the Northwestern Hawaiian Islands Coral Reef Ecosystem Reserve. This vast National Park which covers 84 million acres of remote islands, atolls and reefs is a critical habitat for the Hawaiian Monk Seal. There is now renewed hope that the Hawaiian Monk Seal will not met the same fate as the Caribbean Monk Seal. Scientists expect that the population of this endangered species will increase to the point in the foreseeable future where it will be taken off the Endangered Species List.

- **Ecoturism**

In recent years countries and communities with natural wildlife ecosystems like coral reefs and rain forests have realized that maintaining a healthy ecosystem attracts tourists which benefits the local economy. This nature-based tourism is called **ecotourism**. It is estimated that ecotourism associated with coral reefs, which occupy less than 1% of Earth's surface, generates as much as $375 billion each year in revenue. A coral reef. is one of the natural wonders of the world. Coral reefs attract huge numbers of tourists. Well over one million scuba divers, snorkelers, fisherman and boaters vacation in the Florida Keys each year. The reefs in the Caribbean, the Florida Keys, the Hawaiian Islands and the reefs of the South Pacific, including the Great Barrier Reef, are major destinations for people who want to see a living coral reef with its unique beauty and biodiversity. Reef watchers can observe colorful fish darting in and out of crevices on the top of a reef through a **glass bottom boat** , or go to greater depths to see moray eels, spiny lobsters, barracuda and maybe a few sharks closer to the bottom in a high tech tourist vehicle - the **passenger submersible**. More adventuresome souls can swim with the fishes by **snorkeling** or **scuba diving**.

- **Government Regulations**

Pollution affects everyone. It is harmful to the environment and costly to the economy. As a result many governments, organizations and individuals are working to develop solutions to the marine debris problem. In 1973 the International Maritime Organization, an agency of the United Nations, formed an agreement called **MARPOL**("Marine Pollution") that regulates the disposal of hazardous chemicals, sewage and trash from ships at sea. Private industry, non-profit research groups, environmental groups, and government organizations are also working to find ways to prevent and reduce marine debris. Plastic manufacturers have introduced photodegradable plastics. The US Environmental Protection Agency**(EPA)**, the National Oceanographic and Atmospheric Administration (**NOAA**), The United States Coast Guard(USCG), the Department of the Interior (DOI) and the Navy have undertaken a cooperative effort to deal with the marine debris problem. The EPA, along with

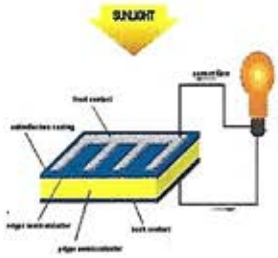
NOAA are co-sponsors of the Center for Marine Conservation(CMC). One of their initiatives is the national Beach Clean-up Campaign, during which volunteers record the types and quantities of marine debris they collect in the ocean.

To meet the challenge of cleaning up our oceans, NOAA instituted a Marine Debris Program(MDP) to "support a national effort focused on preventing, identifying, removing and educing the occurrence of marine debris, and to protect and conserve our nation's natural resources and coastal waterways from the impacts of marine debris." Also, through the Coral Reef Conservation Act of 2000, NOAA will "provide assistance to States in removing fishing gear, marine debris, and abandoned vessels from coral reefs to conserve living marine ecosystems." States Congress passed the Marine Mammal Protection Act which makes it illegal for any person to kill, hunt, injure or harass all species of marine mammals, regardless of their population status.

IV. Alternative Energy Sources

Today's energy needs are largely powered by fossil fuels, coal, gas and oil. The fossil fuels provide for about 80% of our energy needs. The energy that is produced from the burning of fossil fuels is mostly in the form of electricity. Electricity is necessary for both home and industry. However, the non-renewable fossil fuels will not last forever. They also pollute the environment with emissions of CO2 that increase global warming. **Alternative energy sources** that are renewable and do not pollute need to be developed to meet our technology needs while having a less negative impact on the environment. Alternative energy sources include solar power, hydropower, tidal power, wind energy, hydrogen fuel cells, geothermal energy and biomass conversion.

Alternative Energy



Solar Cell

Wind Turbine

➢ **Solar Energy**

Energy from the sun can be harnessed using passive methods or by active methods involving powered technology. Major solar technologies include solar panels, mirrors to concentrate solar rays and photovoltaic cells. Solar energy is perpetually renewable, and solar technology creates no emissions and allows for decentralized power. Solar radiation varies in intensity from place to place and time to time. Harnessing solar energy remains expensive.

➢ **Wind Power**

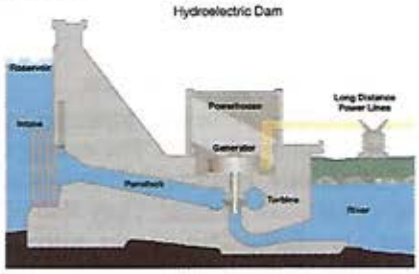
Energy from the wind is harnessed using wind **turbines** mounted on towers. A turbine is a device that converts mechanical energy into electrical energy. When the wind blows the blades on the turbine will rotate. The blades are attached to a drive shaft which is connected to magnets. A rotating drive shaft causes the magnets to spin which creates a magnetic field. The magnetic field induces electrons to flow through coils of copper wires adjacent to the magnets thereby creating an electric current which flows through transmission lines to the customer. Turbines are often erected in arrays at wind farms located on land or offshore. Wind farms are developed in locations with optimal wind conditions Wind power is renewable. Turbine operations creates no emissions. Wind farms can generate economic benefits. The cost of

wind power is nearly competitive with that of electricity generated from fossil fuels. It is an intermittent resource and occurs at adequate strengths only in some locations. Turbines kill some birds and bats, and wind farms can face opposition from local residents.

➢ **Hydroelectric Power**

Hydroelectric power or **hydropower** is generated when the force of water behind a dam runs through a powerhouse at the base of the dam to turn turbines inside a generator. Spinning turbines generates electricity. Hydropower produces no air pollution damage, but dams and reservoirs have a negative effect on river ecology.

Hydroelectric Dam

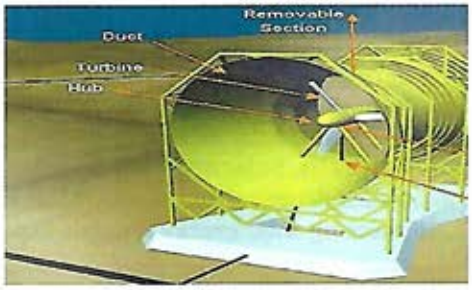


Water Pressure at Dam Base Spins Turbine Producing Electricity

➢ **Tidal Power**

The rising and falling tide along the coast generates tidal currents that flow into and out of narrow inlets. If the inlet is dammed up and turbines are built into the dam a tidal power plant can be created. When the incoming and outgoing tide passes through the turbines located in the dam electricity is generated. Tidal power plants are located along coasts that have a high intertidal range such as in the Bay of Fundy in Canada and the Rance River along the Atlantic coast in France. Tidal power is clean with no emissions but erecting power plants along the coasts impacts negatively on coastal ecology.

Tidal Power Plant



Turbine in Tidal Current

➢ **Biomass Conversion**

Biomass consists of organic material that makes up living things, including wood, charcoal, animal wastes and crops. These materials have traditionally been used as a source of fuel for heating and cooking. Recently one kind of biomass, corn, converted into **ethanol**. through the process of **fermentation** has been used as a **biofuel.** Ethanol is an alcohol that is added to gasoline because it burns more cleanly than gasoline.

$C_6H_{12}O_6 \rightarrow 2\ C_2H_5OH + 2\ CO_2$

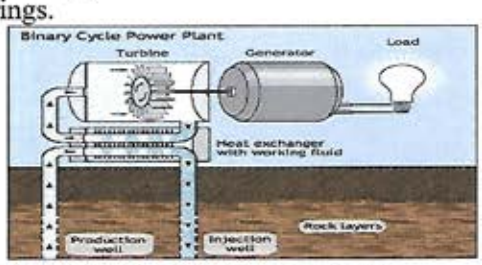
Glucose $\rightarrow$ alcohol(ethanol) + carbon dioxide

Another biomass called **biodiesel** comes from vegetable oil, cooking grease and animal fat. Vehicles with diesel engines can run on biodiesel. Biodiesel cuts down on emissions as compared with petrodiesel. Kingsborough Community College's Maritime Tech program uses discarded cooking oil from the cafeteria as a diesel fuel in the operation of its Green Boat.

➢ **Geothermal Energy**

Heat energy from hot molten magna in the mantle rises up through Earth's outer layer the crust at different locations on Earth's surface. This heat from the Earth's interior is called **geothermal energy**. The heat is hot enough to boil water into steam. The steam spurts up in tall columns called **geysers**. The steam can be harnessed to spin turbines and produce electricity. Geothermal power plants are most highly developed in Iceland. Geothermal energy is clean and renewable. Steam can be condensed into water and recycled back into the hot springs.

Geyser



Electricity from Geothermal Energy

➢ **Hydrogen Fuel Cells**

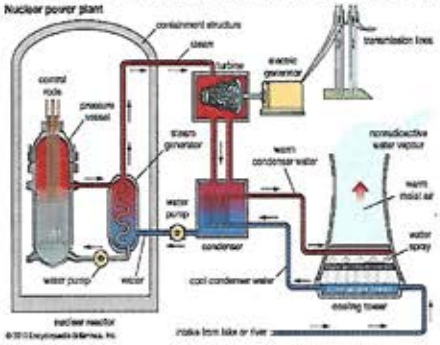
Hydrogen gas (H_2) can be used as a fuel to produce electricity. When hydrogen is reacted with oxygen in a fuel cell water is produced as a by product while electrons from the hydrogen atoms become the source of the electric current.

$$2H_2 + O_2 \rightarrow 2H_2O$$

Hydrogen can be clean, safe and efficient. Fuel cells are silent, nonpolluting and do not need recharging.

➢ **Nuclear Energy**

Many advocates of "clean" energy support nuclear power because it lacks the pollutant emissions of fossil fuels. For others, the risk of a major power plant accident, such as the one at Chernobyl outweighs the benefits of clean energy. The disposal of radioactive wastes poses a dilemma. Economic factors and cost overruns have slowed the nuclear industry's growth.



Nuclear Power Plant

Excess Steam from Cooling Towers

Revised 8/20/2020, TFG