

4 Occupational Hazards

- In a workplace, the worker may be exposed to: safety hazards and health hazards.

Safety hazards

- Material handling: these can lead to muscle strains due to lifting/carrying materials. Forklifts, cranes, etc. expose the worker to accidental contact with moving equipment
- Machine: Rotating shafts, moving belts, presses, etc. can cause very serious injuries
- Energy: all energy sources such as electricity, steam, hydraulic pressure, etc.
- Work practice: failure to follow safe operating procedures may lead to serious injuries
- Confined space: in such spaces (silos, storage tanks) hazards arise due to difficulty to enter or exit, build-up of hazardous materials and oxygen deficiency.

Health Hazards

- Physical: due to presence of physical agents such as pressure and temperature extremes, excessive noise and vibration, and exposure to radiation
- Chemical: due to presence of chemical agents like dust, fume, gas, mist, smoke, vapor.
- Biological: presence of biological agents like bacteria, molds, and viruses
- Ergonomic: due to ergonomic stresses such as fatigue and repetitious work.

Assessment of Occupational Hazards

- To assess potential impact of occupational hazards, walk-through surveys are performed. These surveys include the study of the followings impact with workers:
 - 1 Processes, operations, and related activities: various emissions are evaluated because the emission of any physical, chemical, or biological agents has potential to be a health hazard
 - 2 Equipment: assessed in terms of mechanical and electrical safety + wont explode
 - 3 Properties of substances used and produced: an evaluation of raw and finished products in terms of their physical, chemical, and toxic properties and effects.
 - 4 Control measures: all engineering controls in place for proper materials handling, storage, etc. are evaluated. Also considered: ventilation system.
- **Physical Agents**: even though we are constantly exposed to such agents, their intensity and duration of exposure may be more significant in the workplace. Commonly encountered physical conditions with potential for adverse health effects:
 - Pressure + temperature extremes, noise + vibration, poor illumination, radiation
- **Pressure Extremes**: our bodies are conditioned to work at normal atmospheric pressure. Any extreme can be detrimental to ones health:
 - Hyperbaric: a pressure **higher** than normal pressure (mining, underwater)
 - Hypobaric: pressure **lower** than normal pressure (high elevations)

- **Temperature Extremes:** effect working efficiency and health of worker, even fatal.
 - Hot environments: heat exhaustion, fainting, heat stroke (factory, outdoor)
 - Cold environments: frostbite, hypothermia (outdoor, meat packers)
- **Noise:** a form of irregular vibration. May ruin communication between workers (annoyance) = poor job performance, or lots of exposure may cause to loss of hearing
- **Vibration:** not only does it cause discomfort, intense vibration has been known to cause serious health problems (back pain, carpal tunnel syndrome, damage to bones)
 - Whole-body vibration: transmitted through supporting surface (mining)
 - Hand-arm vibration: transmitted through hands/arms (power tools)
- **Radiation:** energy that travels through space from diff. natural/manmade sources:
 - Visible light, ultraviolet rays, microwaves, x-rays, radio waves
 Depending on its energy, radiation is of two main kinds:
 - 1 **Ionizing Radiation:** STRONG. High enough energy to damage cells and DNA. (Ex: x-rays, alpha, beta, gamma rays, and ultraviolet rays)
 - 2 **Non-Ionizing Radiation:** not as strong as ionizing radiation, but prolonged exposure can still cause harm. (Ex: visible light, microwaves, infrared, radio waves)
- **Chemical Agents:** chemical agents are found in workplaces due to diversity of raw materials and processes used. You may find chemical materials in: compressed gases, flammable, oxidizing, poisonous, corrosive, and dangerously reactive materials.
- **Fine Particles:** the particles of size less than 5 microns ($5 \times 10^{-6}\text{m}$) are potentially the most hazardous because of their effective entry and retention in our **lungs**.
 - Spray painting (**mist**), welding (**fume**), ore-grinding (**dust**), and incomplete combustion of oil and grease (**smoke**).
- **Gases and Vapors:** may be generated as result of various operations and can mix rapidly in workplace. Since their small size, they can enter bloodstream through lungs
 - Solvent degreasing + spray painting (**vapors of solvents**) and welding
- **Biological Agents:** living organisms, or substances produced by them that can cause illness or disease in humans.
 - Bacteria, fungi, viruses. They reproduce rapidly and hard to kill
- **Ergonomic Stresses:** ergonomics is the science or study of work. Ergonomics, properly applied can help: reduce workplace injuries and illnesses, improve productivity and quality of work, increase job satisfaction, and satisfy gov't regs

Toxicology

- **Toxicology** is the science that involves the study of properties and interactions of physical, chemical, or biological agents.
- Most common natural routes of entry of chemical agents into the body are:
→ Respiratory tract (inhalation), digestive tract (ingestion), skin and eyes (absorption)
- In occupational settings, **inhalation** is the most important route, then it's absorption
- **Toxicity**: the degree of danger of a material to injure a living organism
 - Depends on: physical and chemical properties, intensity of exposure, etc.
- **Dose**: the amount of toxicants delivered to the target organ. The unit to express the dose is mg/kg (mass of toxicant/body mass).
- **Exposure**: the total amount of toxicants present in the workplace. Higher the exposure, greater probability of larger amounts being delivered to the target organ.
 - **Units**: mg/mg^3 (mass of toxicant/volume of air) for particles. **Ppm** (parts per million) for gases and vapors
- **Threshold Limit Values (TLVs)**: guidelines developed for various physical and chemical agents by ACGIH. To specify these values: Threshold Limit Value-Time-Weighted Average (TLV-TWA). This is the time weighted average concentration of a substance for a normal 8-hour workday that all workers may be exposed. The **lower** the number, the **more risk it poses** as a toxicant.

Effects of Toxicants

1. **Duration of the Effect**: can be classified as acute or chronic
 - Acute: the observed effect of a toxicant is **acute** if it appears **soon** after the exposure. The effect results from **brief exposure to a high concentration** of the contaminant. The effect is also easy to observe and relate.
 - Chronic: considered **chronic** if it is observed **much later** after exposure. Chronic effects result from **low and repeated exposure** over a long period.
2. **Organ Affected and Physiological Action**: the toxicant may change normal functioning of one organ or a set of organs that operate as a system.
 - Asphyxiants: asphyxia (suffocation due to lack of oxygen)
 - Irritants: eye, skin, mucous membrane irritation
 - Anesthetics: depressants
 - Systemics: organ (s) or system (s) damage
 - Narcotics: habit forming depressants
 - Mutagens: changes in DNA
3. **Physiological Action**:
Mutagenic effect: exposure to radioactivity → mutagenic effect → transmission of the effects to future children

5 Air&Water

- Air composes the atmosphere and is a complex mixture of **gases** surrounding Earth
- The atmosphere is a layered structure divided into layers of criteria such as:
 - Altitude
 - Pressure
 - Chemical composition and concentration
 - Temperature
 - Electric Nature
- **The Atmosphere** is divided into layers:
 - Troposphere (closed to earth 8-15km)
 - Stratosphere (50km)
 - Mesosphere (80km)
 - Ionosphere/Thermosphere (furthest to earth 500-600km)
- **Composition of Air:** the air we breathe is a mixture of gases, fine particles, and vapors. Dry air consist of 78% nitrogen + other natural and man-made substances
 - Major components of air:
 - Nitrogen (N₂)
 - Oxygen (O₂)
 - Water (H₂O)
 - Carbon Dioxide (CO₂)
 - Minor components of air:
 - Carbon Monoxide (CO)
 - Ozone (O₃)
 - Oxides of Sulfur (SO_x)
 - Oxides of Nitrogen (NO_x)
 - The major components are essential for life; minor are pollutants, which can have negative environmental and health effects.
 - The **burning of fossil fuels** (petroleum, gas) can be used:
 - To generate energy (electricity, gas, and steam)
 - In transportation (combustion gases)
 - In industrial processes that use a lot of energy resources (pulp and paper mills, ore smelters, petroleum refineries)
- **Carbon Monoxide (CO):** when there is an adequate supply of oxygen, there is complete combustion of fossil fuels thereby forming major by-products: carbon monoxide and water. Most carbon monoxide produced in this process is immediately oxidized to carbon dioxide. However, when insufficient oxygen = carbon monoxide released. Can also be produced: combustion of organic matter, forest fires and volcanoes. When a person inhales it, it binds to the oxygen-carrying site on the

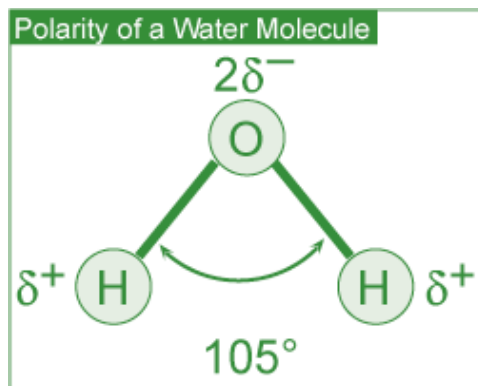
hemoglobin of red blood cells, causing a reduction of oxygen transport in the body = cell and tissue death. This causes: impaired ability to use oxygen + cardiac problems.

- **Ground-level Ozone (O₃):** natural gas that forms protective layer in the atmosphere. It protects the Earth by absorbing harmful ultraviolet radiation from the Sun. It is produced during photochemical reactions between volatile organic compounds (VOCs) release by cars and oxides of nitrogen (NO_x) in presence of sunlight. Health Effects: reduced lung function, breathing problems, itchy eyes, damaged tissues/cells
- **Oxides of Sulfur (SO_x):** released during processing (smelting) of mineral ores and combustion of fossil fuels (burning coal/petroleum).
 - Industrial processes like pulp/paper production also generate oxides of sulfur.
 - Reactions in atmosphere can be: sulfuric acid and sulfate salts.
 - Most common natural source of sulfur dioxide is volcanoes
- **Oxides of Nitrogen (NO_x):** sources of emissions of nitrogen oxides: fuel combustion for transportation, home, and industrial use; manufacture of nitric acid; welding.
 - Forms in the air because fuel is burnt at high temperatures.
 - Main oxides of nitrogen present in atmosphere: nitric oxide (NO), nitrogen dioxide (NO₂), and nitrous oxide (N₂O).
 - Also emitted from natural sources like: lightning and microbial activity in soil.
 - Health effects: serious lung damage and shortness of breath and chest pains
- **Entry into the Body:** the air we breathe (inhalation) is handle by the **lungs**, which makes us get oxygen IN and carbon dioxide OUT our body.
 - Lungs also effect by pollutants that diffuse into blood stream in the alveoli.
- **Risk Assessment:** integrates exposure and effects components to estimate the **risk**
 - **Exposure:** estimates concentrations using chemical measurements. Can find this by: air sampling in laboratory or real time monitoring using direct reading monitors.
 - Units: *gases/vapors*: ppm, ppb and % (parts per million/billion).
Particles: mg/m³ and ug/m³ (milligrams/micrograms per cubic meter)
 - **Threshold Limit Values** developed by ACGIH to assist health hazards. CO = 25 ppm, NO₂ = 3 ppm, O₃ = 0.1 ppm, SO₂ = 2ppm
 - **Effects:** relies on toxicity testing and computer models to extrapolate data from human population, animal, and bacterial toxicity studies.
- **Air Quality:** other parts in the world are worse than Canada. We are also exposed to a large variety of environmental contaminants: combustion products, fibers, particulates, radon, formaldehyde, pesticides, microorganisms, and VOCs
- **Control Strategies:** over past two decades, stricter environmental emission control

regulations and technologies led to reduction of many pollutants. The NAFTA (**north American free trade agreement**) obliges all three signatories to enforce laws. Also IRPTC (**international register of potentially toxic chemicals**).

Water

- Water (H₂O) consists of two nonmetals: **hydrogen** and **oxygen**.
- The covalent bonding of two hydrogen atoms to one oxygen atom forms the water molecule.
- Water is everywhere. We use it in everyday life: cooking/drinking, hygiene, recreation, transportation, energy generation, agriculture
- Unique properties of water: the polar nature and capability to form **hydrogen bonds**
- **Polarity of Water:** water is highly polar. The polar nature of water molecule is bc of: Polar Covalent Bonds: the electron pair forming the covalent bond (between oxygen atom and hydrogen atoms), is more strongly attracted to oxygen due to its higher **electronegativity**.
 - This leads to a partial positive charge on each of the two hydrogen atoms and a partial negative charge on the central oxygen atom, making the water molecule behave like a dipole.
 - Molecular Shape: a water molecule has a bent (V-shape) (H-O-H). This leads to a resultant dipole and therefore the polarity of the water molecule.



- **Hydrogen Bonding with Water:** the partial charges lead to intermolecular attraction between water molecules. A single water molecule can thus attract four other water molecules. These intermolecular attractive forces are called **hydrogen bonds**.
- **Solvent Properties of Water:** water is a powerful **solvent** due to its high polarity and hydrogen bonding ability. It is an excellent solvent for ionic (table salt), polar covalent (sugar), and non-polar (oxygen) **compounds**. In the cases of these ionic compounds, these ions are separated from the solid and caged (solvated) by polar water molecules, thus keeping them in solution.

- Polar covalent compounds (i.e., ethanol and glucose) dissolve in water by the formation of hydrogen bonds. Water thus plays an important role in the transportation of nutrients and waste products in biological processes. Aquatic life and plants survive due to dissolved oxygen and carbon dioxide.

- **Thermal Properties of Water:** the presence of hydrogen bonds in water explains its exceptionally high boiling point, specific heat and heat of vaporization. A portion of the heat supplied is used up in breaking the hydrogen bonds.
 - **Specific Heat:** is defined as the amount of heat energy required to increase the temperature of 1 g of a substance by 1 degree C.

 - High specific heat of water regulates and stabilizes the temperatures of geographical regions and organisms within a narrow range.

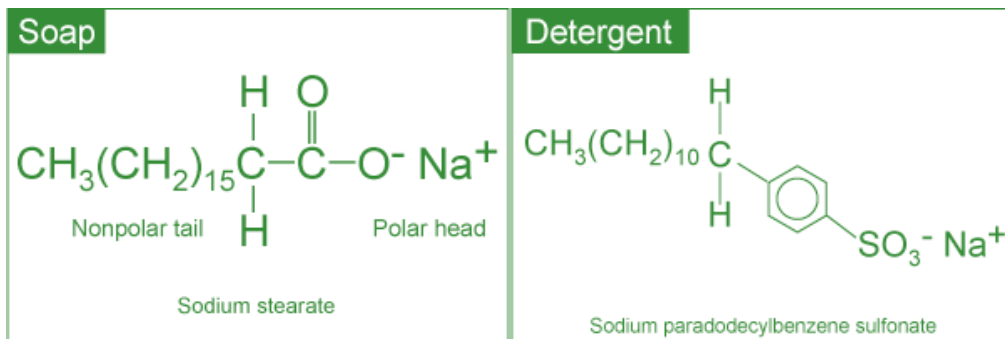
 - **Heat of Vaporization:** the quantity of heat required for the conversion of 1 g of a liquid entirely into its vapor at a constant temperature. High heat vaporization of water helps in regulating the temperature of our body. Also powering winds and storms in our planet.

- **Density of Solid and Liquid Water:** Ice has a hexagonal open structure due to the presence of hydrogen bonds. When ice melts, the open spaces are filled with liquid water, causing the crystal structure to break down.
 - This leads to a reduction of volume for the same mass and hence an increase in density (density = mass/volume). The higher density of liquid water than that of ice accounts for phenomena such as:
 - Floating of ice on water, survival of aquatic life during winter, formation of pebbles, soil and sand, bursting of frozen water pipes

- **Surface Properties of Water:** high surface tension and high capillarity of water is also due to the presence of hydrogen bonds. Water is the liquid with the highest surface tension. Plant debris rests (rather than sinks) on the surface of water bodies due to its high surface tension. This gives aquatic life needed shelter and nutrients
 - **Capillary action:** makes water in soil available to plants

6. Soaps and Detergents

- Soaps and detergents are chemicals that make our surroundings cleaner and healthier.
- For more effective cleaning, the water must be made to spread and wet surfaces; this is achieved by using compounds called **surfactants**.
- **Surfactants:** soaps and detergents are made of this. They are water-soluble and surface-active agents. Composed of a hydrophilic (water-soluble) head and a hydrophobic (fat-soluble, water-hating) tail. The hydrophilic end is stable when solubilized in water and the hydrophobic end is made of a long chain of hydrocarbon that is more stable when surrounded by other organic groups.
 - Anionic: these surfactants have a **negative** charge
 - Cationic: these have a **positive** charge
 - Non-ionic: these have **no** charge
 - Amphoteric: have both **positive** and **negative** charges
- **Soaps** (anionic surfactants) consist of the long hydrocarbon tails of fatty acids and the polar heads of sodium or potassium salts of fatty acids (found in fats/oils of animals and plants).
 - Traditionally soap was made from animal fat and wood ash



- Certain **disadvantages** of soap as a cleaning agent are:
 - Formation of soap film (scum) in water containing Ca^{2+} and Mg^{2+} ions (hard water). The calcium and magnesium ions react with soap molecules to produce calcium/magnesium salts of fatty acids. These salts are insoluble in water and soap scum is difficult to rinse away and can be visible on fabrics etc
 - Poor adaptability to diversity of fibers, washing temperatures and conditions
- **Detergents** (variety of anionic or nonionic surfactants) were developed to perform well under diverse conditions and eliminate film formation. It is synthetic surfactants
 - Made from petrochemicals. The main advantage to using detergents is that they are less affected by Ca and Mg ions in water, thus better cleaning agents

The Cleaning Process

- In the cleaning process, the polar end of the surfactant molecule interacts with water (polar molecule), and the non-polar end is attracted to oil/grease (non-polar molecule)
- **Chemical Interaction** (with soap or detergent) traps the oily and greasy soil molecules. In aqueous solution, surfactants cluster near the surface.
- The hydrophobic tails are attracted to grease and the hydrophilic heads to the water, therefore forcing the grease away from the soiled surface. The grease is then surrounded by the individual surfactant molecules and removed from soiled surface.
- **Thermal Interaction** (with hot water) helps dissolve oil and grease molecules
- **Mechanical Interaction** (machine/rubbing) releases oily and grease soils from fabric

- Depending upon the function, household soaps/detergents can be classified for use:
 - Personal hygiene
 - Laundry
 - Dishwashing
 - Household cleaning

- Health risks are real, mostly in case of some specialty household cleaners. Drain openers, oven cleaners, and others may contain reactive and/or corrosive chemicals. The manufacturers are obliged by law to evaluate the environmental safety of the ingredients. Most of these are formulated to work with water and end up in wastewater treatment plants, so impact on nature is minimized.

- **Recent Trends:** The recent trend is to develop home/fabric care products that: contain surface protectors or modifiers that repel soil/stains, deliver active ingredients in a controlled way, effective in cold water, contain natural ingredients, do not contain chemicals of concern with toxicity, and generate less CO₂ during production

Personal Care Products

- Some influencing factors that make most of us use personal care products are: aging population, changing attitudes in men, more women in the workplace, and concerns about exposure to ultraviolet radiation
- The chemical ingredients in these products are changing at a very fast pace. Also more efficient delivery systems are being introduced. These include a variety of encapsulation systems to deliver the active ingredients in cosmetics.

- **Hair Care Products:** these products are used for a variety of purposes such as wash, condition, and color hair. These products include: shampoos, conditioners, styling agents, and colorants.
 - Shampoo: are cleansing agents containing anionic surfactants to remove oil

and dirt from the hair and scalp. Surfactants produce foam, lifting the oil and dirt from the hair. Fragrances, thickeners, foam boosters can be added.

- Conditioner: usually contain cationic surfactants. These help in rinsing out any residual shampoo and at the same time provide softer hair.
- Curling of Hair: carried out in three steps
 - i. Treatment of the hair with a reducing agent (electron donor) that breaks certain covalent bonds
 - ii. Setting hair in the desired shape
 - iii. Treating hair with an oxidizing agent (an electron acceptor) such as dilute solution of hydrogen peroxide to reform previously broken covalent bonds in the new shape
- Hair Coloring: two steps
 - a. Oxidation of natural hair pigments to colorless products using bleaching agent
 - b. Application of an organic/synthetic dye to obtain desired color

- The dye or hair curling products, the formulations contain ammonia, hydrogen peroxide and a surfactant. In order to reduce damage during coloring process and smell, ammonia is replaced with ammonium carbonate.
- Major developments in the field of hair coloring: a large variety of colors, improved delivery systems to enhance adhesion of colors to the hair, and more effective conditioners to neutralize the harsh effects of dye chemicals.
- **Skin Care Products**: can be classified as: 1) Moisturizers 2) Sunscreens
- Various creams and lotions are used to maintain the moisture of skin. Some chemical ingredients present: oils/waxes, emulsifiers, surfactants, perfumes
- **Sunscreen** products are used to protect the skin against harmful effects of UV radiation. It is believed that exposure to UV radiation can cause sunburn, damage to skin, and lead to cancer.
- The two types of active ingredients that absorb UV radiation in sunscreen is:
 - **Inorganic**: titanium dioxide and zinc oxide (scatters/reflects UV light)
 - **Organic**: many are organic, absorb UV light and dissipating it as heat
- The effectiveness of a sunscreen in a formulation is rated by its ability to block the UV-B rays that cause skin burns. It is called **Sun Protection Factor (SPF)**. The higher the SPF, the better it protects against UV-rays.

- **Cosmeceuticals**: cosmetics are something superficial to cover a deficiency or defect
- The term *cosmeceuticals* is used to describe cosmetics containing ingredients that may affect the structure or function of the body like pharmaceutical ingredients.
- During late 1980s, *alpha hydroxyl acids* (AHAs) became important ingredients in many cosmetic formulations claiming to reduce signs of aging, sun-damaged skin, and wrinkles. These work by breaking down and lifting

off part of the top layer of dead skin cells in order to get rid of some surface damage and accelerate growth of living cells. Some of these products are only available with a doctor's prescription and supervision. They include, Botox, Vaniqa (unwanted facial hair) and Propecia (bald men).

- **Perfumes:** alcoholic solutions of organic compounds with pleasant odors (fragrant compounds). Today a large variety of natural and synthetic compounds are available that create perfumes. In creating perfumes, the ingredients are blended based on their molecular size and volatility.
- **Miscellaneous Products:** Body odors are reduced or masked by the use of deodorants. Such odors may originate from conversion of certain compounds (sweat) to unpleasant odors. Facial cosmetics such as lipstick and mascara generally contain oils, waxes, pigments, and perfumes.

7 Into To Organic Chemistry

- From Sumerians (2200 BC) to the present, the discovery and usage of drugs went through a number of phases such as:
 - Medicinal preparations and concoctions from plants, minerals, and animals
 - Isolation and the use of plant ingredients as medication
 - Synthesis and testing of variety of chemicals as potential cures for ailments
 - New areas of research into marine plants and organisms as potential drugs
 - Molecular modeling in designing drugs
- **The Element Carbon:** element carbon is present in the majority of drugs today
 - Main characteristics of carbon that lead to the formation of large organic compounds with dramatically different physical and chemical properties include the ability to form:
 - Covalent single, double and triple bonds with some other elements
 - Covalent bonds with other carbon atoms to build chains and cyclic structures
 - Covalent bonds with hydrogen, nitrogen, oxygen + halogens
- In the structures shown below, each line (bond) represents a pair of electrons:
 - Single Bond: formed by the sharing of one pair of atoms
 - Double Bond: formed by the sharing of two pairs of electrons
 - Triple Bond: formed by the sharing of three pairs of electrons
- Among the cyclic structures, the arrangement of carbon atoms in 5- or 6-membered rings is quite common. The hexagonal (6-membered) ring with three single and three double bonds is called a **benzene** ring.
- Organic compounds are divided into some important families based on their characteristic functional group. A **functional group** can be visualized as a small structural unit or arrangement of atoms in a molecule that is the chemically functioning part of the molecule. In the case of drugs, the functional group(s) are responsible for their action. In addition, the functional group(s) may also determine important parameters such as the rate of uptake and reaction as well as the time of residence of the drug in the body.

Treatment of Infections and Diseases

- **Antibiotics:** antibiotic drugs are used to fight (prevent or treat) bacteria that cause infectious diseases such as meningitis, pneumonia, tuberculosis, etc.
- Different categories of antibiotics: Penicillin, Cephalosporin, and Tetracycline

- Antibiotics are isolated from bacterial sources, but can also be human-made. Antibiotics act directly on bacteria and destroy them or inhibit their growth. Antibiotics will not kill viruses.

The mechanism of antibacterial drugs is to alter/inhibit one of the following processes:

- **Cell wall synthesis:** prevents new bacterial cells from forming by preventing formation of the cell wall
- **Cell membrane permeability:** kills bacteria cells by causing breakdown of the outer cell membrane
- **Protein synthesis:** prevents bacteria from converting proteins to energy, causing starvation and ultimate cell death
- **Nucleic acid synthesis:** keeps bacteria cells from growing by interrupting DNA synthesis
- **Competitive inhibitor:** mimics bacteria's growth factors, preventing spreading

Penicillins:

- Treat infections caused by bacteria
- Do not fight infections caused by viruses
- Mode of action: affect the development (damaging) of bacterial cell walls

Cephalosporins:

- Have the same structure similar to that of penicillins
- Treat a much broader range of infections compared to penicillins
- Mode of action: affect the development of bacterial cell walls

Tetracyclines:

- Chemical structure consisting of four rings
- Used to treat penicillin-resistant infections
- Mode of action: inhibit the synthesis of required bacterial proteins
- The emerging concern in the use of antibiotics is the resistance many of the **superbugs** have shown towards the known antibiotics. The suggested ways to decrease antibiotic resistance: 1) more cautious use of antibiotics 2) monitoring outbreaks of antibiotic resistances 3) developing new antibiotics

Antiviral Drugs: are used to treat (cure/control) viral infections such as flu, polio, herpes and AIDS. A different strategy has been used to combat viruses, as these do not respond to antibiotics. Two commonly used strategies: 1) prevention through vaccination 2) use of antiviral drugs

- When a **vaccine** (consisting of inactivated virus) is injected, antibodies to fight off a virus are developed and stored in the body. The stored antibodies become available to fight future infection. Commonly used **antiviral drugs** fall into three classes
 - Nucleoside derivatives: inhibit the synthesis of DNA, stops virus spreading
 - Protease inhibitors: mess with the viral protein formation, stop reproduction
 - Combination cocktails: a **three-drug cocktail** consisting of different nucleoside derivatives and protease inhibitors has shown considerable promise in the treatment of AIDS. The triple cocktail treatment is also known as highly active antiretroviral therapy (HAART). The success of the therapy is probably due to the cocktail's ability to disrupt the viral replication at different stages.

Some major problems associated with multiple drug therapy are:

- Moderate effectiveness
- Lack of response in some cases
- Serious to severe side effects
- Drug resistance by the virus

Recent efforts in the fight against AIDS has been directed toward the development of:

- Viral entry inhibitors
- Vaccines

Anticancer Drugs: Cancer involves an uncontrolled division of some cells of the body due to mutation of DNA within the healthy cells. These cells invade nearby tissue and spread throughout the body via the bloodstream or lymphatic system. Thus the chemical treatment of cancer (chemotherapy) involves drugs targeting rapidly dividing cells to kill the cancerous cells. Some chemotherapeutic agents include:

- **Alkylating agents:** Mode of action: due to their high reactivity, agents introduce defects in the DNA, killing the rapidly growing cells by preventing cell growth and multiplication. Also affect the growth of normal cells and cause mutations
- **Antimetabolites:** Metabolite is a general term for the organic compounds that are synthesized, recycled, or broken down in cells. Antimetabolites inhibit DNA synthesis, thus stopping cell replication. MOA: compete for binding sites on enzymes and are incorporated into nucleic acids
- **Topoisomerase inhibitors:** damage DNA that causes cell death. MOA: act against the topoisomerase enzymes to prevent cancer cell growth
- **Hormones:** Hormone therapy is used against certain cancers that depend on hormones for their growth. Hormone treatment is used primarily for the treatment of breast cancer and that of the sexual organs. As these tissues require hormones for their growth, the chemotherapeutic agent acts by inhibiting the hormone supply thus stopping the tissue growth. MOA: stop production of some hormones

Antidepressants: a deficiency of certain neurotransmitters particularly serotonin in the

brain, seems to be partly responsible for causing clinical depression. Neurotransmitters are needed for normal brain function and mood control, in addition to other functions.

- Although the effects of antidepressants are not fully understood, there is substantial evidence to show that antidepressants help restore the brain's chemical balance. Commonly used antidepressants include:
 - **Selective Serotonin Reuptake Inhibitors (SSRIs)** (e.g. Prozac, Paxil and Zoloft)
 - **Monoamine Oxidase Inhibitors (MAOIs)** (e.g. Nardil, Marplan and Parnate)
 - **Serotonin and Norepinephrine Reuptake Inhibitors** (e.g. Effexor)
 - **Norepinephrine and Dopamine Reuptake Inhibitors** (e.g. Welbutrin)
 - **Tricyclics** (e.g. Norpramine, Pamelor and Tofranil)

Whereas SSRIs target the serotonin levels only, tricyclics affect the brain levels of other neurotransmitters (including serotonin) as well.

Anti-Inflammatory Drugs: Inflammation is the first response of the immune system to infection or irritation characterized by pain, swelling, redness and heat. An inflammation results from the rapid transport of blood proteins and other substances to a damaged tissue site or an area under attack by a foreign organism. Certain steroids are used as potent anti-inflammatory drugs because they suppress and reduce inflammation.

Over The Counter Drugs: a considerable number of drugs are sold over the counter (OTC) without a prescription. According to the Non Prescription Drug Manufacturers Association, in the US alone there are **more than six hundred OTC drugs**. The criteria generally used by the regulatory agencies to designate a drug with OTC status or switch its status from Rx-to-OTC (i.e., from a prescription drug to one sold without a prescription) involves a benefit-risk comparison and making sure that patients alone can achieve the desired medical result without endangering their safety. Although OTC drugs allow patients to participate in their own health care, experts emphasize that the labels must be followed closely because OTC drugs are not without risk.

Aspirin: the best-known OTC drug, Aspirin was introduced more than a century ago. It is used as: Analgesic (relieving minor pain), Antipyretic (lowering fever) and Anti-Inflammatory (reducing swelling). It is believed that Aspirin's effectiveness as an analgesic, anti-inflammatory agent and its protective effects against heart attacks and strokes are due to its ability to reduce the production of prostaglandins (a hormone-like substance that promotes inflammation, fever and pain) and thromboxanes (responsible for platelet aggregation in the formation of blood clots) in the body.

Some possible side effects of Aspirin: stomach irritation, ringing in the ears, allergy and Reye syndrome (brain disorder) in children.

Drug Delivery Systems: Active pharmaceutical ingredient (API) in a medicine is delivered to the body in many forms, such as tablets, gel caps, liquids, etc. Some newer alternate methods for drug delivery have been developed with three major advantages: 1) user convenience 2) improved drug performance 3) better patient compliance

Some of these methods include:

- **Pulmonary delivery:** the system is noninvasive and facilitates the rapid absorption of the drug on the large surface area of the lungs followed by rapid absorption in the blood stream.
- **Skin absorption:** skin patches are being used to deliver medication via skin
- **Nanocrystals:** this method reduces the drug particle size to Nano scale making it more soluble in body fluids.

Environmental Effects of Pharmaceuticals: Recent research has led scientists to be concerned about the environmental impact of old and/or expired medications that are discarded. The pharmaceuticals enter the environment mostly through raw or treated sewage. Some of the effects observed include: 1) feminization of male fish due to estrogenic compounds 2) slow development of fish and frogs due to antidepressants

Recent Trends:

- A shift from blockbuster drugs (drugs that work for a large number of patients) to personalized medicine. In personalized medicine, therapies are catered towards genetic profiles of patients and their diseased cells.
- Exploring marine organisms in an attempt to obtain new compounds with therapeutic potential.

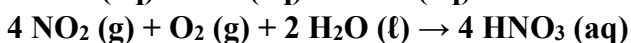
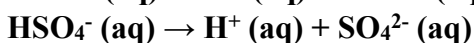
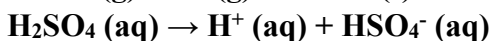
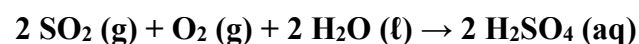
Conclusion: Drugs should not be considered risk-free chemical substances. It is strongly recommended by health professionals that patients should always bear in mind the fact that medications have side effects and may have serious interactions with other medications, dietary supplements, food and beverages consumed.

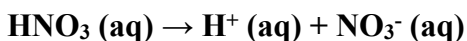
In order to reduce risks, it is strongly recommended that all individuals:

- Read drug labels carefully;
- Learn about the warnings of all drugs taken;
- Inform health care providers of all prescription and OTC drugs & supplements taken;
- Keep a record of all medications taken.

8. Acid Rain

- Human activities producing particulate (soot/fly ash) and gaseous pollutants (CO, CO₂, SO_x, NO_x, Hydrocarbons, etc.) alter the atmosphere
- Some of these activities include:
 - Generation of industrial emissions
 - Burning of fossil fuels (power generation/transportation) and vegetation
 - Agricultural practices
- The end result of these activities has been a deterioration of the environment, leading to several environmental concerns: acid rain, global warming, ozone depletion
- The weakly acidic nature of rain can be explained by its formation of carbonic acid:
 - CO₂ (g) + H₂O (l) → H₂CO₃ (aq)
 - Which dissociates partially, generating only small amounts of hydrogen ions:
 - H₂CO₃ (aq) → H⁺ (aq) + HCO₃⁻ (aq)
- **PH Scale:** the acidity (a measure of hydrogen ion concentration) of a solution is conveniently described in terms of pH scale. According to the scale, if:
 - P H < 7: solution is acidic
 - P H > 7: solution is basic
 - P H = 7: solution is neutral
- **Origin:** based on the concentration of carbonic acid and small amounts of other natural acids, the estimated PH of rain (as well as fog, dew, and snow) under normal conditions should be **around 5.3**. Higher acidity (lower PH) is due to reactions of NO_x AND SO_x present in the atmosphere.
- Various reactions of these oxides lead to the formation of acids. The dissociation of formed acids generates hydrogen ions and hence higher acidity (or lower PH).





Effects

1. Material Damage: Marble and Limestone (CaCO_3) used in many historic or irreplaceable statues and buildings react with acid in the rain: $\text{CaCO}_3 (\text{s}) + 2 \text{H}^+ (\text{aq}) \rightarrow \text{Ca}^{2+} (\text{aq}) + \text{CO}_2 (\text{g}) + \text{H}_2\text{O} (\text{l})$
 2. Corrosion of Metals: The corrosion process is accelerated in the presence of acid. Thus, iron structures, bridges, railroads, etc. show a faster rate of corrosion (rusting) in the acid rain predominant areas: $4 \text{Fe} (\text{s}) + 3 \text{O}_2 (\text{g}) \rightarrow 2 \text{Fe}_2\text{O}_3 (\text{s})$
 3. Forest Damage: considerable damage to trees has been reported in various parts of NA and Europe. Acid rain is implicated in depleting the nutrient supply to the trees by: 1) attacking the leaves whose protective coating has already been destroyed due to attack by other pollutants such as O_3 and NO_x 2) mobilizing various metals (Al, Pb, etc.) in the soil that attack the roots.
 4. Aquatic Life: aquatic life is quite susceptible to changes in PH. Reduced PH has led to lakes with no fish or other living beings. Adverse effects of acid rain on aquatic life are due to: 1) lowering of PH well below the required value of about 6.5 for healthy aquatic life 2) increasing aqueous concentrations of metals due to their higher solubility at lowered PH.
- **Suggested Control Strategies:**
 - Reduction of SO_x and NO_x emissions by using emission control technologies
 - Using cleaner energy sources (alcohol/hydrogen) in transportation
 - Developing and/or using alternate energy (hydroelectric/wind) sources

Global Warming

Origin: global warming refers to an increase in the Earth's average temperature. Global warming is the result of increased absorption by the atmosphere of infrared (IR), a major source of heat, radiated back from Earth's surface. This is due to an increase in concentration of gases that trap heat in the atmosphere. These gases are often called greenhouse gases. Greenhouse gases enter the atmosphere due to human activities like:

- Carbon dioxide (CO_2): enters the atmosphere due to burning of fossil fuels (oil, natural gases, coal) waste materials, and other chemical reactions.
- Methane (CH_4): main sources of emission are the production and transport of fossil fuels, livestock, agricultural practices, and organic waste decay
- Nitrous oxide (N_2O): emitted during agricultural and industrial activities as well as during combustion of fossil fuels and waste materials
- Fluorinated gases: these fluorine containing compounds are emitted from a variety of industrial processes and are sometimes called High Global Warming Potential (GWP)

- It is estimated that the temperature of the atmosphere may increase anywhere from 1.5°C to 3.5°C during the next fifty years.
- **Effects:** possible effects include:
 - Climatic changes
 - Changes in sea level due to melting of polar ice caps
 - Possibility of droughts and increased heat waves due to warming
 - Unforeseen problems in relation to vegetation, pests, and other insects
 - Greater possibility of heat-related illnesses and deaths
- **Suggested Control Strategies:**
 - Reduction of CO₂ emissions
 - Development and use of alternate non-fossil energy sources (hydroelectric, solar, nuclear and wind)
 - Energy conservation
 - Replanting of forests, thereby creating a CO₂ sink
- **Present Situation:** in order to limit global warming, the Kyoto Protocol was signed in 1997. The document calls for industrialized nations to cut their emissions of GHG.
 - In 1998, United Nations Environment Program (UNEP) and World Meteorological Organization Intergovernmental Panel on Climate Change (IPCC) to focus on:
 - Assessment of scientific knowledge
 - Examination of the environmental, economic and social impacts
 - Formulation of response strategies
 - Final report in 2007 states global warming is clearly evident from diverse observations like: increases in average air/ocean temperatures, widespread melting of snow and ice, and rising global average sea level.
 - Stern report suggests that global warming can shrink global economy by 20%.

Lesson 6.3: Ozone Depletion

- Ozone plays a double role in our environment:
 - In our immediate atmosphere, it acts as an air pollutant contributing to photochemical smog
 - In the stratosphere, it filters the solar ultraviolet (UV) radiation, protecting us
- **Origin:** exposure to ozone may occur in operations involving:
 - High intensity UV lights such as mercury vapor lamps, plasma torches, etc.
 - High-voltage electrical equipment or welding
 - Interaction of high energy with oxygen in the surrounding atmosphere leads to formation of O₃: **3 O₂ (g) + Energy → 2 O₃ (g)**
 - In stratosphere, oxygen and ozone interact with energy from solar radiation to form a dynamic system. This constitutes the O₂/O₃ screen that filters out the

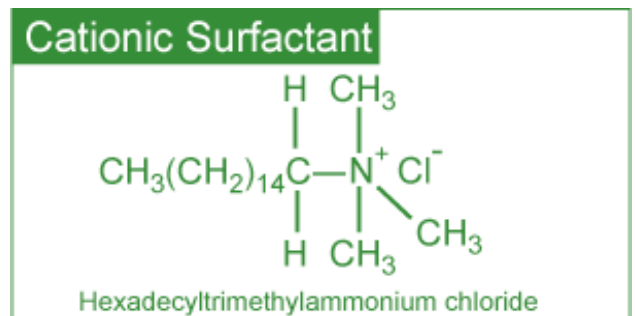
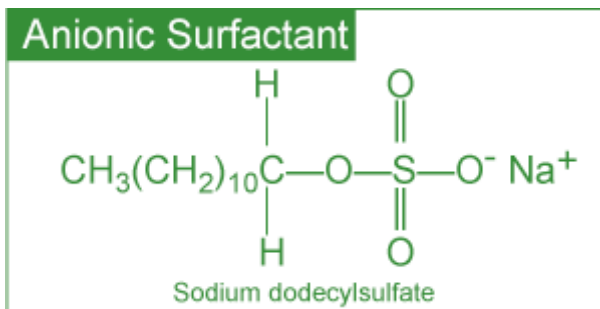
UV component of the solar radiation according to the following reactions:

- $\text{O}_2 + \text{Energy } (\lambda \leq 242 \text{ nm}) \rightarrow 2 \text{ O}$
- $\text{O}_3 + \text{Energy } (\lambda \leq 320 \text{ nm}) \rightarrow \text{O}_2 + \text{O}$
- The environmental concern in the case of ozone is its stratospheric depletion, which leads to less efficient filtration of **harmful solar UV rays**. The depletion is caused by both natural (water vapor, nitric acid) as well as human-made sources.
- These ozone depleting substances (ODSs) destroy the stratospheric ozone layer. Chlorofluorocarbons (CFCs) and halons have been used as:
 - Foam-blowing agents, solvents, fire-extinguishing agents, refrigerants

Effects

Stratospheric ozone depletion, leading to less efficient filtration of the ultraviolet radiation from the sun, will increase the intensity of ground-level UV radiation. This increased intensity may have adverse effects on:

- **Humans** (such as higher probability of skin cancer and cataracts)
- **Plants** (physiological and developmental processes of plants may be affected)
- **Marine ecosystems** (may lead to decreased reproductive capacity)



- **Materials** (may accelerate the breakdown of polymers and biopolymers)

Control Strategy: In North America, the use of chlorofluorocarbons (as propellants in spray cans) was banned in 1978 in response to the threat of ozone depletion.

The global response to the threat of ozone depletion came with the signing of the Montreal Protocol (in 1987). It set out to reduce and ultimately ban the manufacture and use of CFCs.