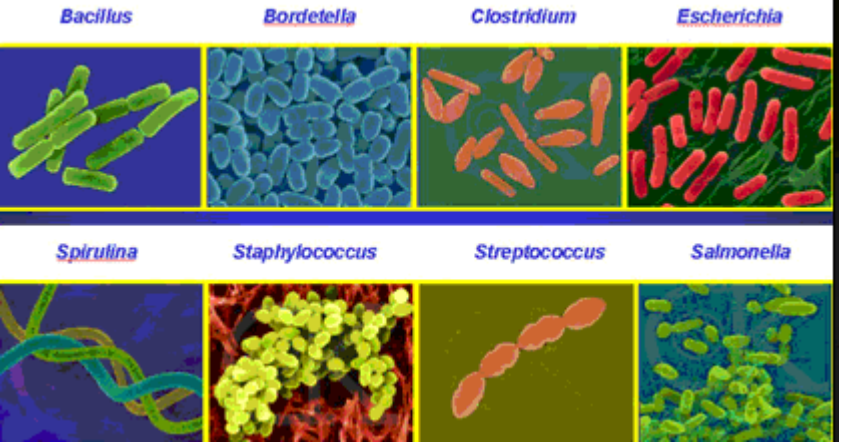
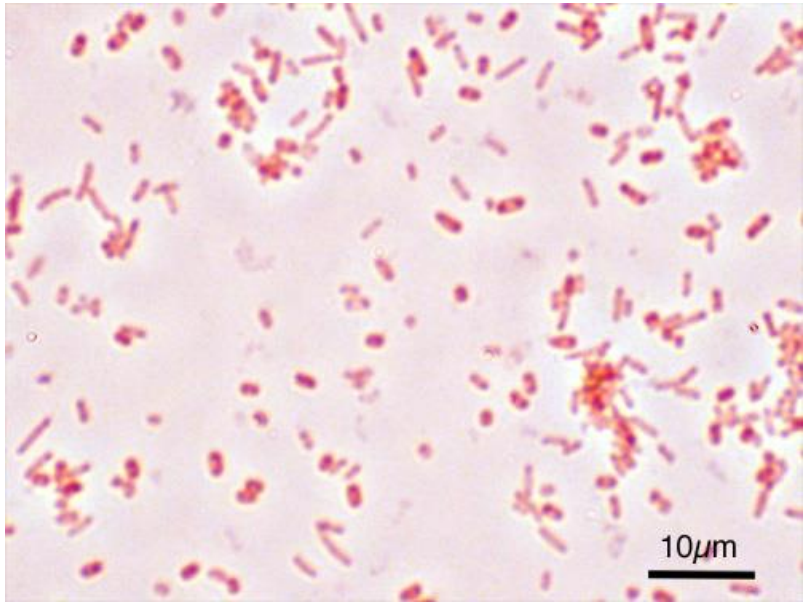
The Biology of water

- **The Biology of water** include the pathogens like bacteria, virus, protozoa and helminthes.
- Water is a carrier of thousands of biological species. Many of the species **spend either their full life or part of it in aquatic environment.**
- A healthy water system should be a host to large number of species of optimum numbers. **Certain organisms due to their adverse effect on humans and plant and animal life are considered to be pollutants**.

- **Pathogens** are those organisms capable of infecting and transmitting diseases to human beings. **Many pathogen species survive in water and maintain their ability to infect for considerable lengths of time**. The water borne pathogens include species like bacteria, viruses, protozoa and helminthes.



- **Bacteria** are single cell microorganisms and are the lowest form of cell life. **Gastrointestinal problems are mainly due to water borne pathogenic bacteria**. Cholera transmitted by *Vibrio cholera* causes vomiting and diarrhea, which can result in dehydration, and death if left untreated.



- *Salmonella typhi* transmits typhoid, which leads to **high fever and ulceration of intestines.**
- Disinfection of water are the only ways to eliminate cholera and typhoid. However in **over crowded and poor sanitary conditions, water pollution by these bacteria result in the outbreak of these diseases.**

- **Viruses** are small biological organisms, **which can be seen only with the aid of an electron microscope**. **Water borne viral pathogens causes poliomyelitis and infectious hepatitis**.
- **Disinfection** of water will **reduce the incidence of polio and hepatitis.**

- **The 5 types of viral hepatitis**
- Viral infections of the liver that are classified as hepatitis include hepatitis A, B, C, D, and E. A different virus is responsible for each type of virally transmitted hepatitis.
- **Hepatitis A**
- Hepatitis A is caused by an infection with the hepatitis A virus (HAV). This type of hepatitis is most commonly transmitted by consuming food or water contaminated by feces from a person infected with hepatitis A.
- **Hepatitis B**
- Hepatitis B is transmitted through contact with infectious body fluids, such as blood, vaginal secretions, or semen, containing the hepatitis B virus (HBV). Injection drug use, having sex with an infected partner, or sharing razors with an infected person increase your risk of getting hepatitis B.
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- **Hepatitis C**
- Hepatitis C comes from the hepatitis C virus (HCV). Hepatitis C is transmitted through direct contact with infected body fluids, typically through injection drug use and sexual contact. HCV is among the most common bloodborne viral infections in the United States. Approximately 2.7 to 3.9 million Americans are currently living with a chronic form of this infection.
- **Hepatitis D**
- Also called delta hepatitis, hepatitis D is a serious liver disease caused by the hepatitis D virus (HDV). HDV is contracted through direct contact with infected blood. Hepatitis D is a rare form of hepatitis that only occurs in conjunction with hepatitis B infection. The hepatitis D virus can’t multiply without the presence of hepatitis B. It’s very uncommon in the United States.

- **Hepatitis E**
- Hepatitis E is a waterborne disease caused by the hepatitis E virus (HEV). Hepatitis E is mainly found in areas with poor sanitation and typically results from ingesting fecal matter that contaminates the water supply. This disease is uncommon in the United States. However, cases of hepatitis E have been reported in the Middle East, Asia, Central America, and Africa,

- **Protozoa** are **low form of animal life and are unicellular organisms**. They are highly complex and are adaptable to different environment. They are widely distributed in natural waters.
- **Protozoal infections** result in gastrointestinal disorders of milder nature. ***Entamoeba histolytica*** and ***Giardia lamblia*** are examples of water borne protozoa causing gastrointestinal disorders. **Disinfection and filtration are necessary for complete elimination of protozoa.**

- **Helminthes** are parasitic worms, which thrive on human or animal hosts. **Consumption of water contaminated with human or animal waste containing helminthes propagates them**. **Helminthes are effectively destroyed by modern water treatment processes**.
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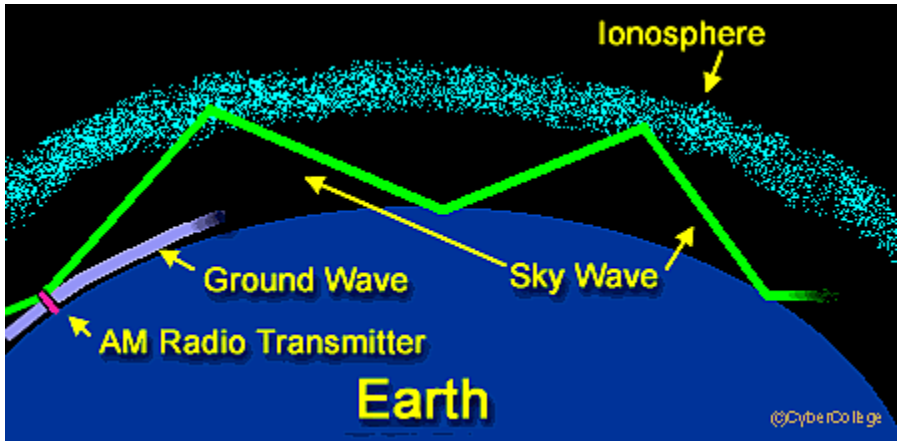
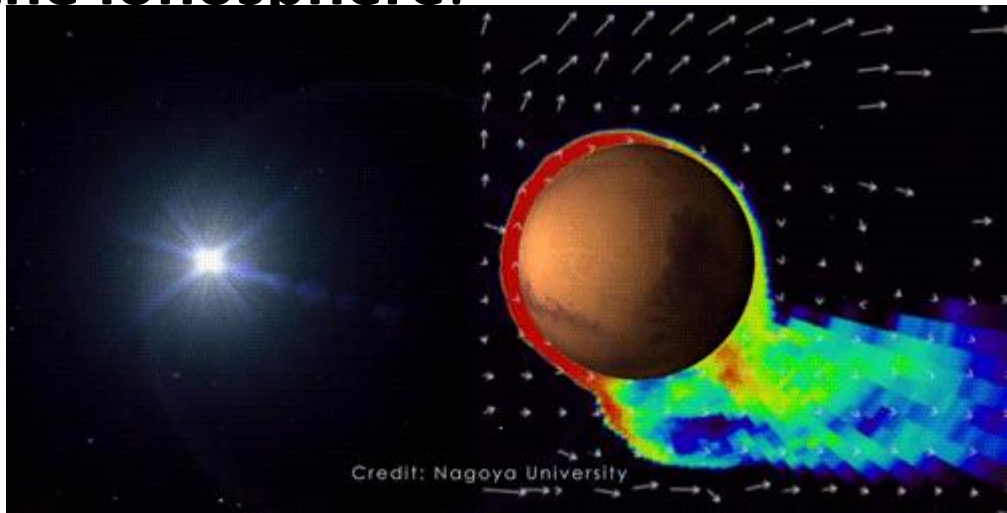
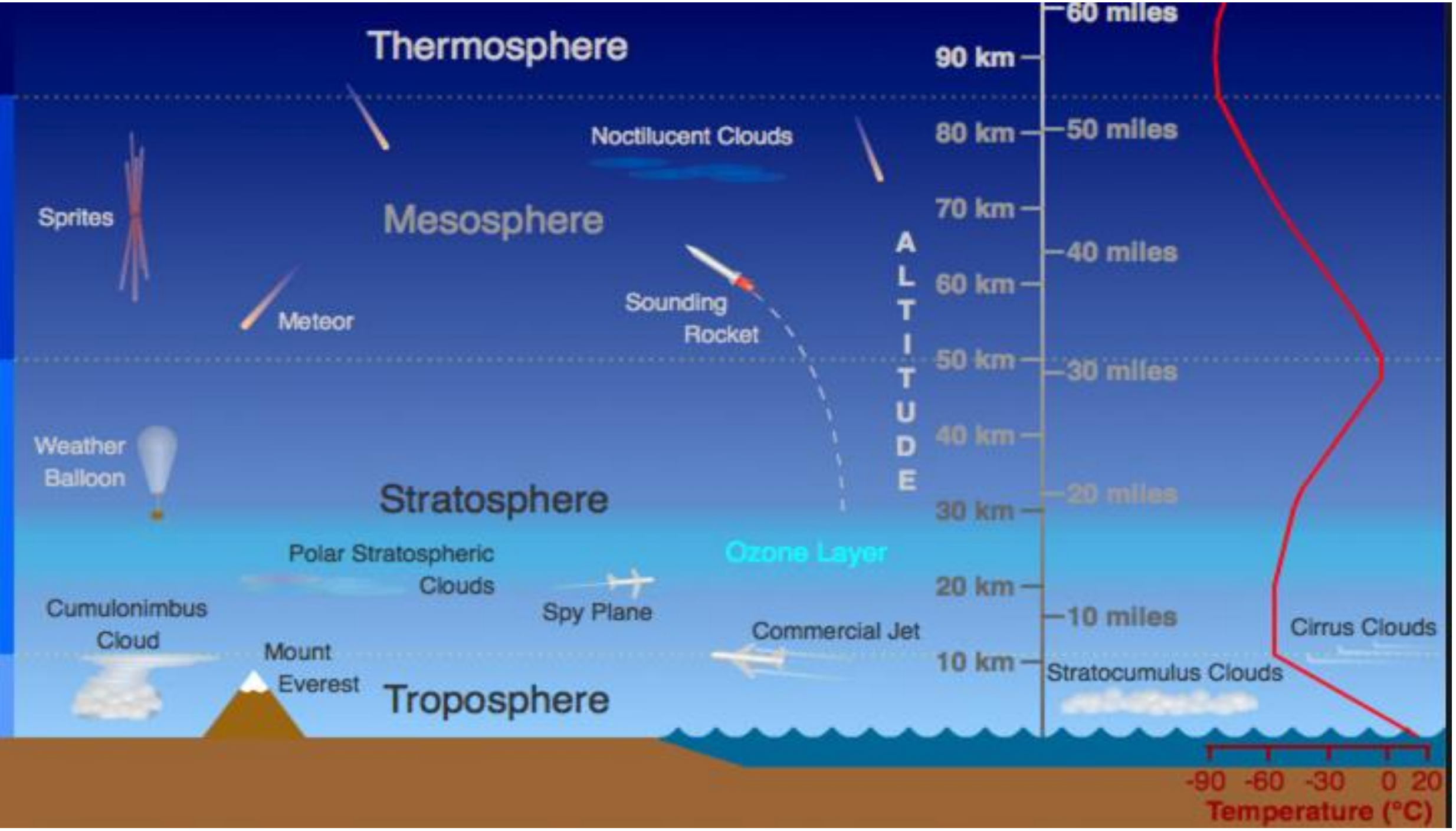
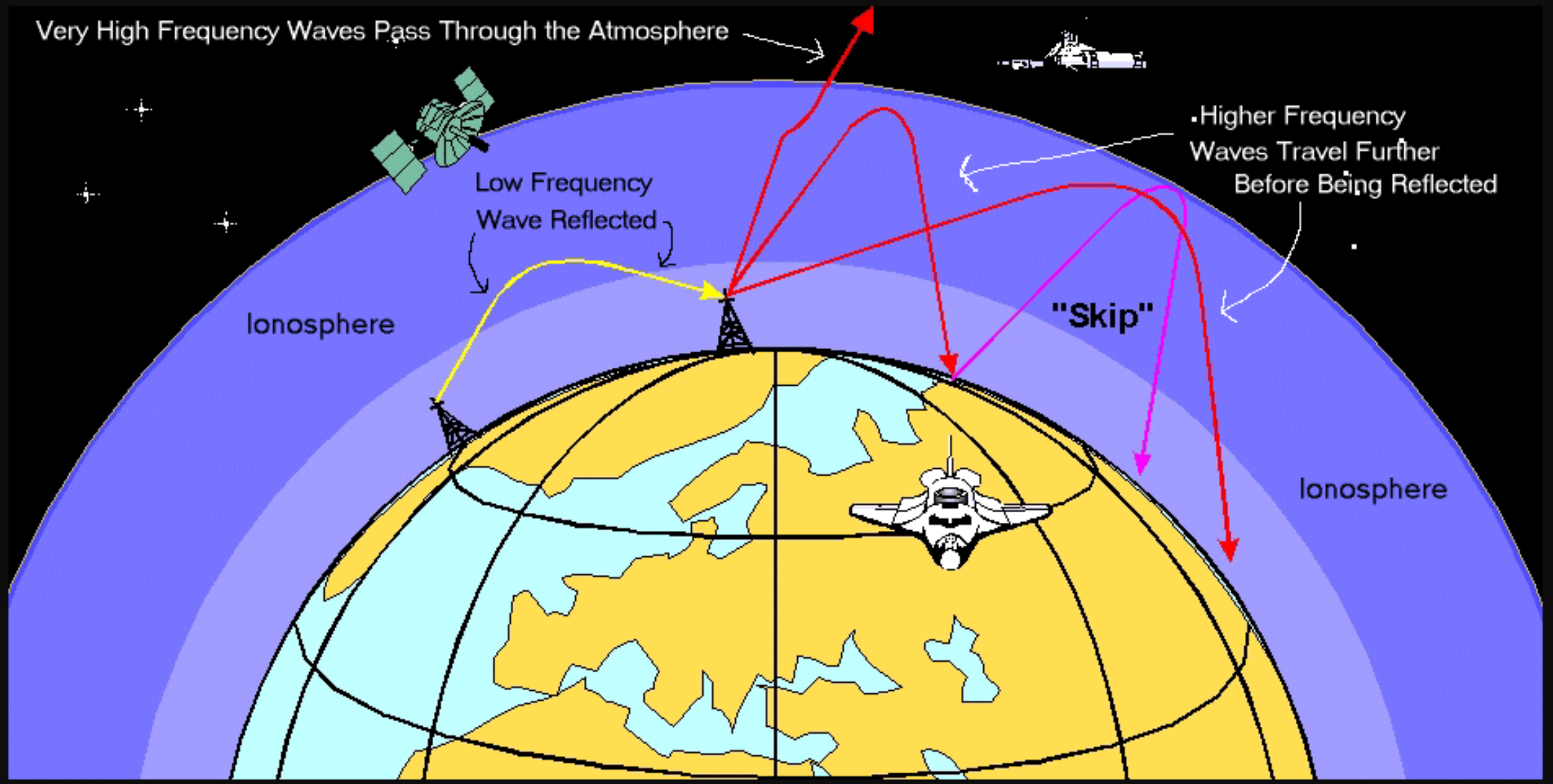
Physics, Chemistry and Biology of Air

- **Air**
- The mixture of invisible odorless tasteless gases (such as nitrogen and oxygen) that surrounds the earth; *also* : the equivalent mix of gases on another planet
- **Ions**
- At an altitude of **50 km to 100 kms** considerable **concentrations of electrons and positive ions such as O+, NO+** etc. **exist for reasonably longer residence times**. This zone of the atmosphere is called ionosphere. **The UV radiations from the sun lead to the formation of ions in the ionosphere**.






Thermosphere
Noctilucent Clouds
Sprites
Mesosphere
Meteor
Sounding Rocket
Weather Balloon
Stratosphere
Polar Stratospheric Clouds
Ozone Layer
Spy Plane
Cumulonimbus Cloud
Commercial Jet
Cirrus Clouds
Mount Everest
Stratocumulus Clouds
Troposphere
ALTITUDE
90 km
80 km
70 km
60 km
50 km
40 km
30 km
20 km
10 km
60 miles
50 miles
40 miles
30 miles
20 miles
10 miles
-90 -60 -30 0 20
Temperature (°C)


Very High Frequency Waves Pass Through the Atmosphere
Higher Frequency
Waves Travel Further
Before Being Reflected
Low Frequency
Wave Reflected
Ionosphere
"Skip"
Ionosphere

- **Particulate matter**
- Particles of wide range of sizes ranging from 0.1 µ to 10µ exist in the atmosphere. Highly polluted air may contain up to **105 particles per cc.**
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- **Dust, fog, ash, mist, smoke, pollen, fumes and bacteria contribute to the presence of particulate matter**. **Particulate matter may be either organic or inorganic in nature**. **Inorganic particulates are volcanic ash, fine silica dust, iron oxide, and calcium oxide, Lead etc**. **Organic particulates are generated from automobile exhaust, fuel combustion, and solid organic matter.**
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- Particular matter may be **generated either by natural means** (Volcanic eruption, wild fires, dust storms etc.) or by **anthropogenic** means (Automobile exhaust, fossil fuel burning, mining and quarrying and various other industrial activities).
- **Particulate matter is a health hazard since they enter the human beings and animals through the respiratory tract and are absorbed by them**. Removal of particulate matter from the atmosphere is a very important function in air pollution control. **However the particulate matter also leads to certain beneficial effects. They provide the nuclei for condensation of water vapor and cloud formation. They also contribute to maintaining a radiation and heat balance on earth.**

- Aerosol: Suspension of solid or liquid particles in gas stream
- (0.001 µm to 100 µm)

Forms of aerosol:

Dust - ฝุ่น - mechanical disintegration

Fume - ละออง - condensation of vapor or gases

Smoke - เขม่า - incomplete combustion

} solid

Mist, fog or haze - หมอก - condensation or atomization → liquid

- An **aerosol** is a colloid of fine solid particles or liquid droplets, in air or another gas. Aerosols can be natural or anthropogenic. Examples of natural aerosols are fog, dust, forest exudates and geyser steam. Examples of anthropogenic aerosols are haze, particulate air pollutants and smoke. The liquid or solid particles have diameter mostly smaller than 1 μm or so; larger particles with a significant settling speed make the mixture a suspension, but the distinction is not clear-cut.

- **What are aerosols??**
- Combustion - smoke, soot, fly ash
- Natural - volcanic ash, dust, mist, fog, clouds
- Biological - pollen, spores, viruses, bacteria
- Manufactured powders - silicon nitrite, carbon black, titanium dioxide, catalytic metals, etc.

Aerosol can be bad as well as good

- **Clouds**: visible aerosol with boundaries
- **Dust**: solid-particle aerosol formed by mechanical disintegration (crushing, grinding), submicron to 100 micron, irregular shapes
- **Fume**: solid-particle aerosol formed by condensation of vapors or gaseous combustion products, submicron
- **Haze**: atmospheric aerosol that reduces visibility
- **Mist/Fog**: liquid-particle aerosols formed by condensation or atomization, submicron to 200 micron
- **Smoke**: aerosol resulting from incomplete combustion, submicron, can aglomerate to become fume
- **Smog**: smoke+fog, visible atmospheric pollution, formed in the atmosphere by the action of sunlight on hydrocarbons and Nox, less than 2 micron

Cloud

Dust

Fume

Haz

Fog/Mist

Smoke

Smog

- **Droplet**: liquid-aerosol particle
- **Particulate Matter**: solid- or liquid-aerosol particle
- **Monodisperse**: aerosol particles that are all the same size
- **Polydisperse**: aerosol particles with wide range of size
- **Homogeneous aerosol**: aerosol that all particles are chemically identical

- **Chemical reaction in Atmosphere**
- Different chemical species available in the environment undergo chemical changes by reaction with other molecules. The **chemical reactions** are also **assisted by the solar radiation**. **The chemical and photochemical reactions taking place in the atmosphere depend up on the temperature, nature and concentration of the chemical species available, humidity, and intensity of sun's radiation.**
- The **oxides of nitrogen** (Referred to as NO*x*) viz. N2O, NO and NO2 originate from burning of fossil fuels and other anthropogenic activities. In the stratosphere, **N2O decomposes photo chemically to NO which intern depletes ozone layer.**
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- **Photochemical smog** can also be initiated by the **dissociation of NO2 and subsequent secondary reactions with hydrocarbons** and other **organic compounds**. The stepwise chemistry of the formation of photochemical smog is illustrated below:
- **Photochemical smog results in very poor visibility** leading to disruption/accidents in air and road traffic. It also causes irritation to the eyes and lungs and chronic respiratory problems. **Damage to plants and rubber, polymer goods** are also the adverse impacts of photochemical smog.

(1) Nitrogen oxides generate oxygen atoms by photochemical reaction.

$$NO_2 + h \longrightarrow NO + O^*$$

(2) Oxygen atoms form hydroxyl (HO*) radicals catalyzed by particulate matter (PM)

$$O^* + O_2 + PM \longrightarrow O_3 + PM$$

$$NO + O_3 \longrightarrow NO_2 + O_2$$

$$O^* + H_2O \longrightarrow 2HO^*$$

(3) Hydroxyl radicals generate hydrocarbon radicals (R*) from hydrocarbons (RH)

$$RH + HO^* \longrightarrow H_2O + R^*$$

(4) Hydrocarbon radicals form hydrocarbon peroxides (RO)

$$R^* + O_2 \longrightarrow RO_2$$

(5) Hydrocarbon peroxides form aldehydes

$$RO_2{}^* + NO \longrightarrow NO_2 + RO^*$$

$$RO^* + O_2 \longrightarrow RCHO + HO_2{}^*$$

(6) Aldehydes form aldehyde peroxides

$$RCHO + HO^* \longrightarrow RCO^* + H_2O$$

$$RCO^* + O_2 \longrightarrow RC(O)O_2{}^*$$

(7) Aldehyde peroxides form peroxyacylnitrates (PAN)

Ozone is an important constituent in the atmosphere. At an altitude of 30 kms. This stratospheric ozone layer absorbs UV radiation from the sun and hence protects the life on earth against radiation damages like **skin cancer, mutation of DNA etc.**

The chemistry of ozone formation and depletion is as under:

$$O_2 + h \longrightarrow O + O$$

$$O + O_2 \longrightarrow O_3$$

This reaction is catalyzed by a third body viz. N_2 or O_2. Thus ozone is continuously formed in the stratosphere by photochemical reaction. Ozone is also destroyed by chlorine released in

- To the atmosphere by natural (volcanic activity) or anthropogenic (Refrigerants containing Chloro Flouro Carbons) causes. Nitric Oxide and reactive hydroxyl radicals also contribute to ozone depletion.

$$Cl + O_3 \longrightarrow ClO + O_2$$
$$ClO + O \longrightarrow Cl + O_2$$
$$O_3 + NO \longrightarrow NO_2 + O_2$$
$$O_3 + O \longrightarrow 2O_2$$

The overall ozone depletion reaction is $2O_3 \longrightarrow 3O_2$

- **Biological Air Quality**
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- In addition to the chemical constituents, biological microorganisms are also present in the atmosphere. These microorganisms are dispersed in air as **bioaerosols**, which are extremely small living organisms or fragments of living things suspended in the air. **Dust mites, molds, fungi, spores, pollen, bacteria, viruses, amoebas, fragments of plant materials, and human and pet dander** (skin which has been shed) are some examples. **They cannot be seen without a magnifying glass or microscope. Some of the adverse impacts caused by these bioaerosols are listed below:**

- **Viruses and bacteria**, cause infections (like a cold or pneumonia). Others cause allergies. Both allergic responses and infections may be serious or even fatal. An allergic reaction occurs when a substance provokes formation of antibodies in a susceptible person. We call substances, which will cause an allergic reaction in some people ***antigens* or *allergens***.
- Bioaerosols may cause allergic reactions on the skin or in the respiratory tract. Rashes, hay fever, asthma (tightness in the chest, difficulty in breathing), and runny noses are common allergic reactions.
- A few people develop a severe allergic reaction in the lung, which can destroy lung tissue.

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