

CHAPTER TWO

2. BASIC CONCEPTS OF ATMOSPHERE

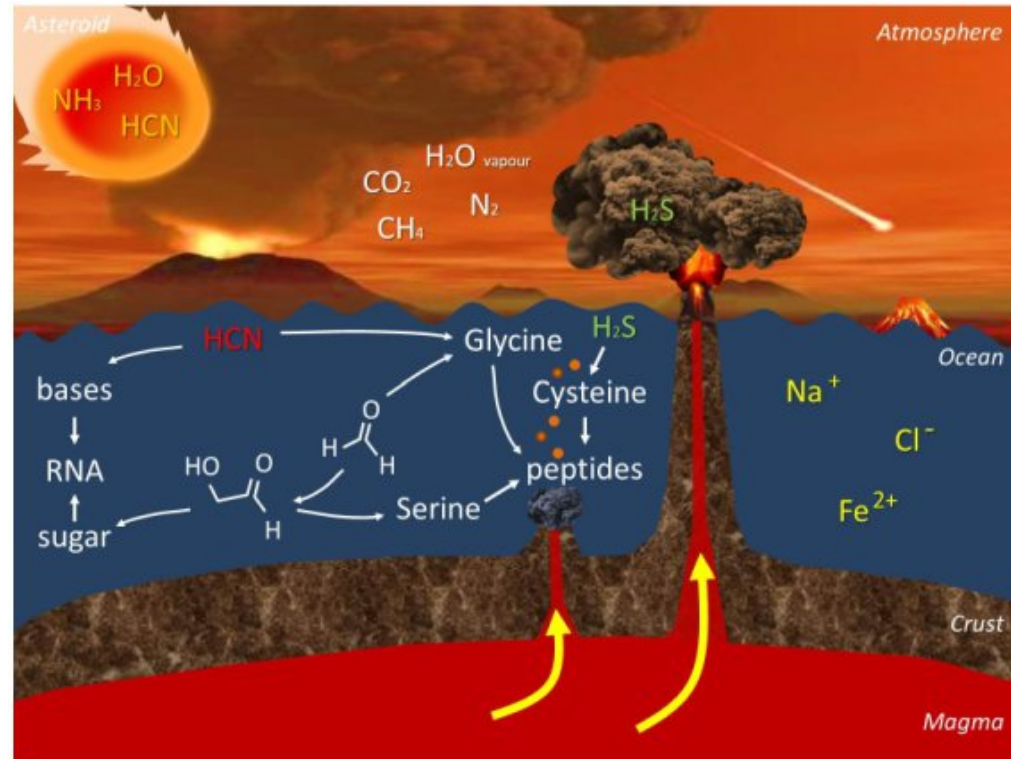
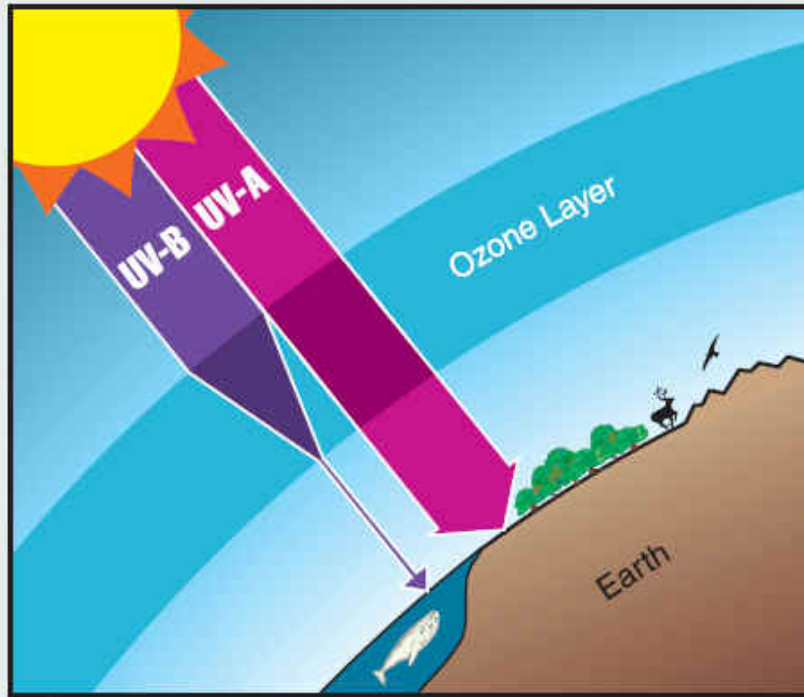


2.1. Origin and Nature of the Atmosphere

- Our atmosphere is a delicate *life-giving blanket of air* that *surrounds the fragile Earth*
- In one way or another, it *influences everything* we *see* and *hear* it is *intimately connected to our lives*.
- Air is with us from birth, and *we cannot detach ourselves from its presence*.
- In the open air, we can travel for *many thousands of kilometers in any horizontal direction*, but *we move a mere 8 kilometers* above *the surface*, thereafter we would **suffocate**.

- We may be able to survive *without food for a few weeks*, or *without water for a few days*, but, *without our atmosphere*, we would *not survive more than a few minutes*.
- Just as fish are confined to an *environment of water*, so we are confined to an *ocean of air*.
- Anywhere we go, air must go with us.
- *Earth without an atmosphere* would have *no lakes* or *oceans*.
- There would be *no sounds*, *no clouds*, *no red sunsets*.
- The *beautiful pageantry* of the *sky* would be *absent*.
- It would be *unimaginably cold at night* and *unbearably hot during the day*.

UV Protection by the Ozone Layer



- Even though air is *tasteless, odorless*, and (most of the time) *invisible*, it *protects us* from the *scorching rays of the sun* and provides us with a *mixture of gases* that *allows life to flourish*.

- There are *trillions of air molecules* above the earth's surface. Some of these may have been in a cloud only yesterday, or over another continent last week, or perhaps part of the life-giving breath of a person who lived hundreds of years ago.
- The earth atmosphere is a *deep blanket of gases* and *suspended liquids* and *solids* that entirely envelops the earth.
- *Compared to the radius of the earth* however, the atmosphere is a *very thin layer of air* and *cover 2%* of the earth radius.
- The radius of the earth is **6371** km while the height of the atmosphere above the surface of the earth is *very small*.
- *Half the atmosphere* lies below a height of **6 km** while **99%** of the atmosphere lies below a height of **30 km** above the surface of the earth.

- The Earth's atmosphere is a complex *dynamical*, *physical*, and *chemical* system.
- *Dynamic processes* cover a large range of scales *from the microscopic scale dynamics* of evaporation, condensation, cloud formation and precipitation, to small-scale, localized vertical and horizontal wind motions, to medium-scale cyclones, anticyclones, hurricanes, typhoons, tornadoes, thunderstorms, fronts, etc., *to the large scale general circulation of the atmosphere.*

➤ **Physical processes in the atmosphere** include:

- The transfer of *incoming solar radiation* [*InSolAtion*] through the atmosphere *to the surface*,
- The *heating of the surface*,
- The *emission of outgoing infrared radiation*,
- The *absorption of infrared radiation by atmospheric gases*,
- The *evaporation of water*, the *condensation of atmospheric water vapor* into *clouds*, and *precipitation*.

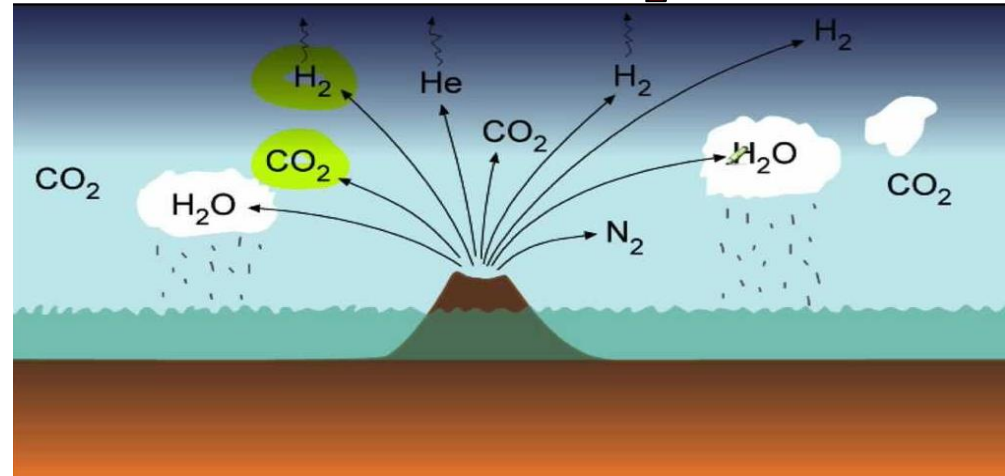
ayelebehailu@dbu.edu.et

➤ **Chemical processes** include:

- The *transformation* and *production* of *atmospheric gases*, such as *atmospheric ozone*, via *chemical reactions* involving *many dozens of gases* in the atmosphere.

Origin of the Atmosphere

- Evolution and development of Earth's *atmosphere* was across the geologic time.
- The process by which the *current atmosphere* arose from *earlier conditions* is *complex*;
 - however, evidence related to the evolution of Earth's atmosphere, though *indirect*, is abundant.
- *Ancient sediments* and *rocks record of the past* changes in atmospheric composition due to *chemical reactions* with *Earth's crust* and, in particular, to *biochemical processes* associated with life are the most important evidences for the *evolution* and *development* of *earth's atmosphere*.



The Early Atmosphere

- The atmosphere that *originally surrounded Earth* was probably much *different from the air we breathe today*.
- Earth's *first atmosphere* (some 4.6 billion years ago) was most likely hydrogen and helium — the two most abundant gases found in the universe—as well as *hydrogen compounds*, such as *methane* (CH₄) and *ammonia* (NH₃).
- Most scientists believe that this early atmosphere escaped into *space* from *Earth's hot surface*.

- A *second*, more *dense atmosphere*, however, *gradually enveloped Earth* as gases from *molten rock* within its *hot interior* escaped through *volcanoes* and *steam vents*.
- We assume that *volcanoes spewed out* the same gases then as they do today: mostly *water vapor* (about 80%), *carbon dioxide* (about 10%), and up to a few percent *nitrogen*.
- These gases (*mostly water vapor and carbon dioxide*) probably created Earth's *second atmosphere*.

➤ As millions of years passed, the constant ***outpouring*** of gases from the hot interior known as ***outgassing*** provided a rich supply of ***water vapor***, which formed into ***clouds***.

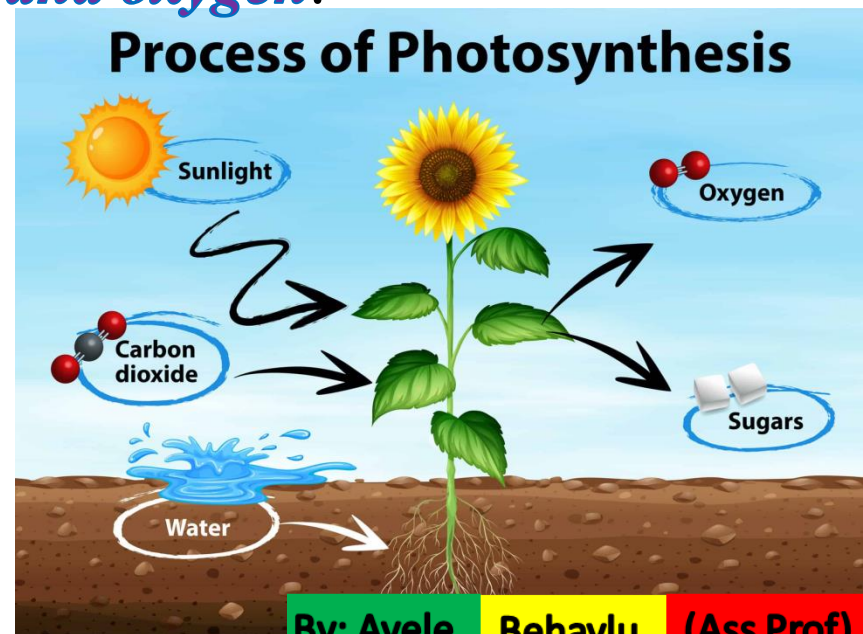


https://youtu.be/8qHJO_4mXfQ

- It is also believed that when Earth was very young, some of its ***water*** may have originated from numerous collisions with small ***meteors*** that pounded Earth, as well as from ***disintegrating comets***.
- Rain fell upon Earth for many thousands of years, forming the ***rivers, lakes, and oceans*** of the world.
- During this time, large amounts of ***carbon dioxide*** (CO₂) were ***dissolved*** in the ***oceans***.

- Through ***chemical*** and ***biological*** processes, much of the CO₂ became locked up in ***carbonate sedimentary rocks***, such as ***limestone***.
- With much of the ***water vapor*** already ***condensed*** and the concentration of ***CO₂*** ***dwindling***, the atmosphere gradually became dominated by ***molecular nitrogen (N₂)***, which is usually ***not chemically active***.
- It appears that ***molecular oxygen (O₂)***, the second most abundant gas in today's atmosphere, probably began an extremely slow increase in concentration as ***energetic rays from the sun split water vapor (H₂O)*** into ***hydrogen*** and ***oxygen*** during a process called ***photodissociation***.
- The ***hydrogen***, being ***lighter***, probably ***rose*** and ***escaped*** into ***space***, while the ***oxygen remained*** in the ***atmosphere***.

- It is uncertain whether this slow increase in oxygen supported the evolution of **primitive plants**, perhaps two to **three billion years ago**, or whether plants evolved in an almost **oxygen free (anaerobic)** environment.
- At any rate, **plant growth** greatly **enriched our atmosphere with oxygen**.
- The reason for this enrichment is that, during the process of **photosynthesis**, plants, in the presence of **sunlight**, combine **carbon dioxide** and **water** to produce **sugar and oxygen**.
- Hence, after plants evolved, the **atmospheric oxygen** content **increased** more rapidly, probably reaching its present composition about **several hundred million years ago**.



COMPOSITION [NATURE] OF TODAY'S ATMOSPHERE

- Notice that **molecular nitrogen** (N_2) occupies about 78 percent and **molecular oxygen** (O_2) about 21 percent of the total volume of dry air.
- If all the other gases are removed, these percentages for nitrogen and oxygen hold **fairly constant** up to an elevation of about 80 km.

ayelebehailu@dbu.edu.et

Composition of Atmosphere near the Earth's Surface

PERMANENT GASES			VARIABLE GASES			
Gas	Symbol	Percent (by Volume) Dry Air	Gas (and Particles)	Symbol	Percent (by Volume)	Parts per Million (ppm)*
Nitrogen	N_2	78.08	Water vapor	H_2O	0 to 4	
Oxygen	O_2	20.95	Carbon dioxide	CO_2	0.041	410*
Argon	Ar	0.93	Methane	CH_4	0.00018	1.8
Neon	Ne	0.0018	Nitrous oxide	N_2O	0.00003	0.3
Helium	He	0.0005	Ozone	O_3	0.000004	0.04**
Hydrogen	H_2	0.00006	Particles (dust, soot, etc.)		0.000001	0.01–0.15
Xenon	Xe	0.000009	Chlorofluorocarbons (CFCs) and hydrofluorocarbons (HFCs)		0.00000001	0.0001

*For CO_2 , 410 parts per million means that out of every million air molecules, 410 are CO_2 molecules.

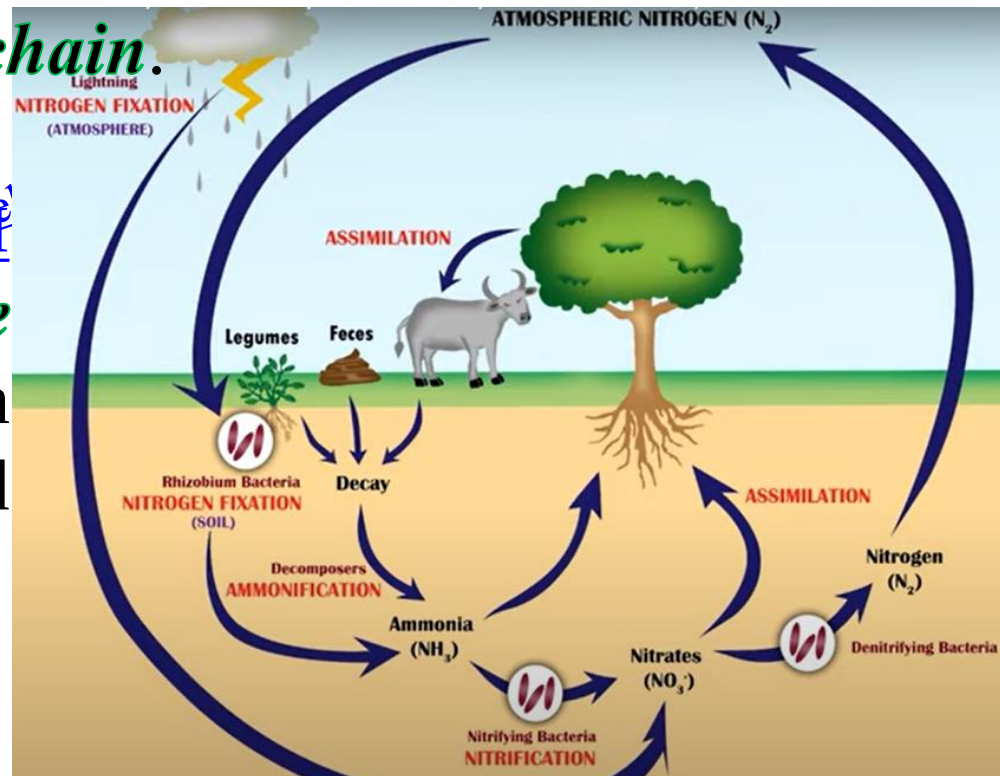
**Stratospheric values at altitudes between 11 km and 50 km are about 5 to 12 ppm.

- At the surface, there is a balance between destruction (output) and production (input) of these gases.
- For example, **nitrogen** is *removed* from the *atmosphere* primarily by *biological processes* that involve *soil bacteria*.
- **Nitrogen** is also *taken* from the *air* by *tiny ocean-dwelling plankton* that convert it into *nutrients* that help fortify the *ocean's food chain*.

<https://youtu.be/CzmLnYRn0K8>

- It is *returned to the atmosphere* mainly through the decaying of plant and animal matter.

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- *Oxygen*, on the other hand, is *removed* from the *atmosphere* when *organic matter decays* and when *oxygen combines* with *other substances*, producing *oxides*.
- It is also *taken* from the atmosphere *during breathing*, as the *lungs take* in *oxygen* and *release carbon dioxide* (CO₂).
- The *addition of oxygen* to the atmosphere occurs during *photosynthesis*.

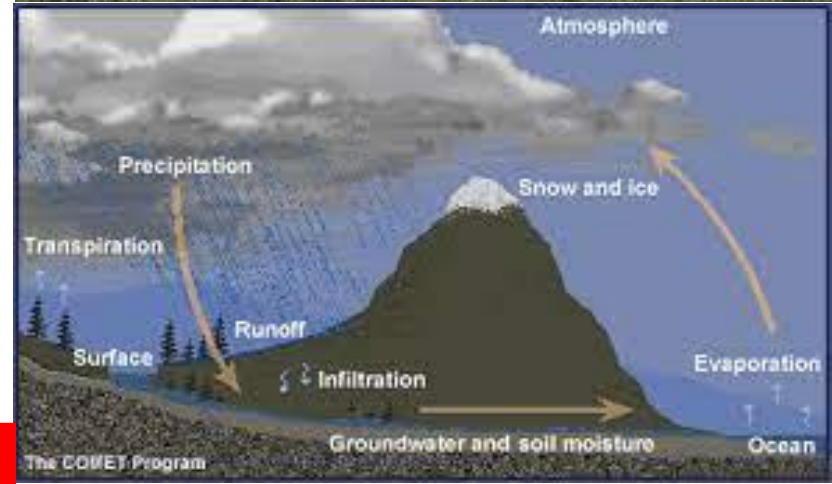
- The concentration of the invisible gas *water vapor (H₂O)* , however, *varies greatly* from place to place, and from time to time.
- *Close to the surface* in *warm, steamy, tropical locations*, *water vapor* may account for *up to 4* percent of the *atmospheric gases*, whereas in *colder arctic areas*, its concentration may *dwindle*/diminishes to a *mere fraction* of a percent.
- *Water vapor molecules* are, of course, *invisible*.
- They *become visible* only when they *transform* into *larger liquid* or *solid particles*, such as *cloud droplets* and *ice crystals*, which may *grow in size* and eventually fall to Earth as *rain* or *snow*.

➤ The changing of *water vapor* into *liquid water* is called *condensation*, whereas the process of *liquid water* becoming *water vapor* is called *evaporation*.

➤ The *falling rain* and *snow* is called *precipitation*.

➤ In the lower atmosphere, water is everywhere.

➤ It is the *only substance that exists as a gas, a liquid*, and a *solid* at those temperatures and pressures normally found near Earth's surface



- **Water vapor** is an extremely important gas in our atmosphere.
- Not only does it form into both liquid and solid cloud particles that grow in size and fall to Earth as precipitation, but it also *releases large amounts of heat*—called *latent heat*—when it changes from *vapor* into *liquid water* or *ice*.
- *Latent heat* is an important source of *atmospheric energy*, especially for storms, such as *thunderstorms* and *hurricanes*.
- Moreover, water vapor is a potent greenhouse gas because it strongly absorbs a portion of Earth's *outgoing radiant energy* (somewhat like the glass of a greenhouse prevents the heat inside from escaping and mixing with the outside air).

- This *trapping of heat energy close to Earth's surface* called the *greenhouse effect* keeps the average air temperature near the surface much warmer than it would be otherwise.
- Thus, *water vapor* plays a significant role in *Earth's heat-energy balance*.

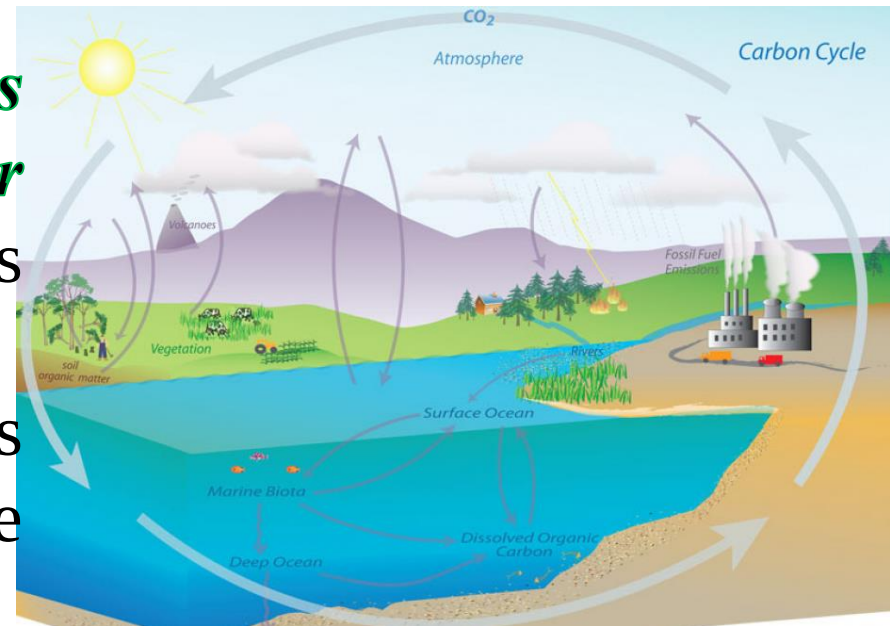
- **Carbon dioxide (CO₂)**, a natural component of the atmosphere, occupies a small (but important) percent of a volume of air, about 0.04 percent.
- **CO₂** enters the atmosphere mainly from the *decay of vegetation*, but it also comes from *volcanic eruptions*, the *exhalations of animal life*, from the *burning of fossil fuels* (*such as coal, oil, and natural gas*), and from *deforestation*.
- The *removal of CO₂* from the *atmosphere* takes place during *photosynthesis*, as plants consume CO₂ to produce green matter [*Chlorophyll*].
- The **CO₂** is then stored in *roots*, *branches*, and *leaves*.

➤ *Rain* and *snow* can react with *silicate minerals* in *rocks* and *remove CO₂* from the atmosphere through a process known as *chemical weathering*.

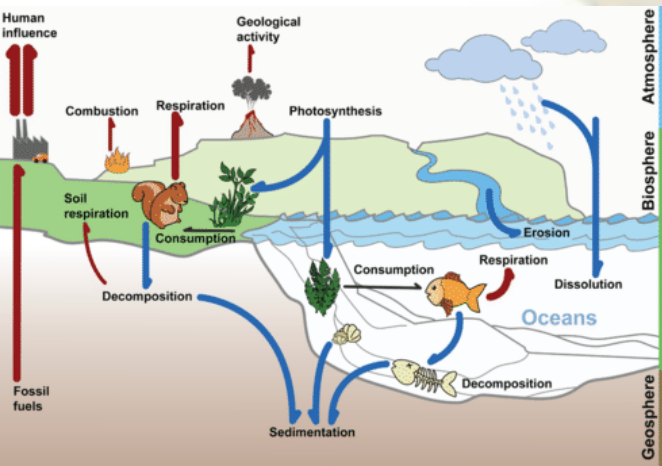
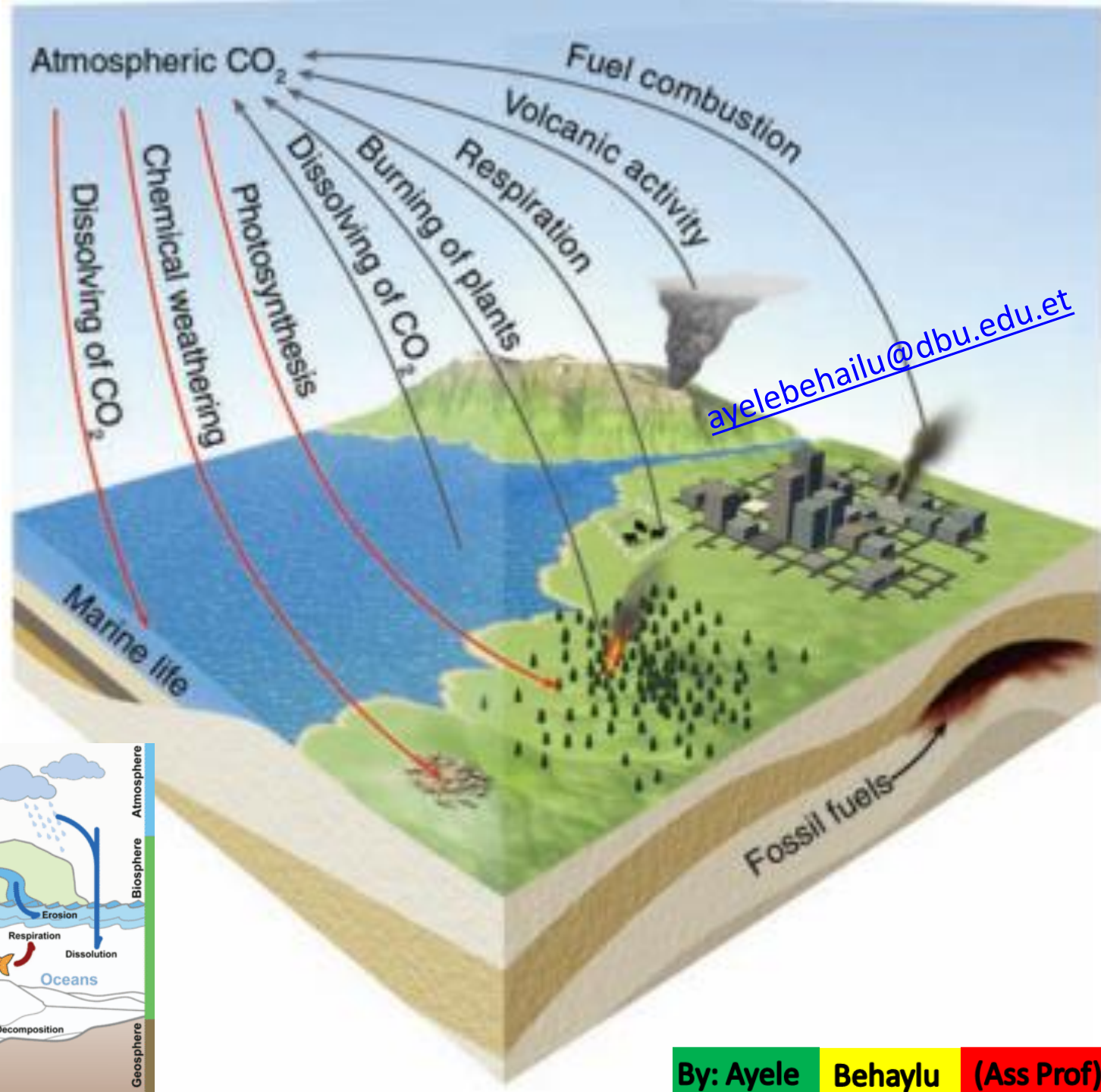
➤ The *oceans* act as a *huge reservoir for CO₂*, as *phytoplankton* (tiny drifting plants) in surface water *fix CO₂* into organic tissues.

➤ *Carbon dioxide* that *dissolves* directly into *surface water* mixes downward and circulates through greater depths.

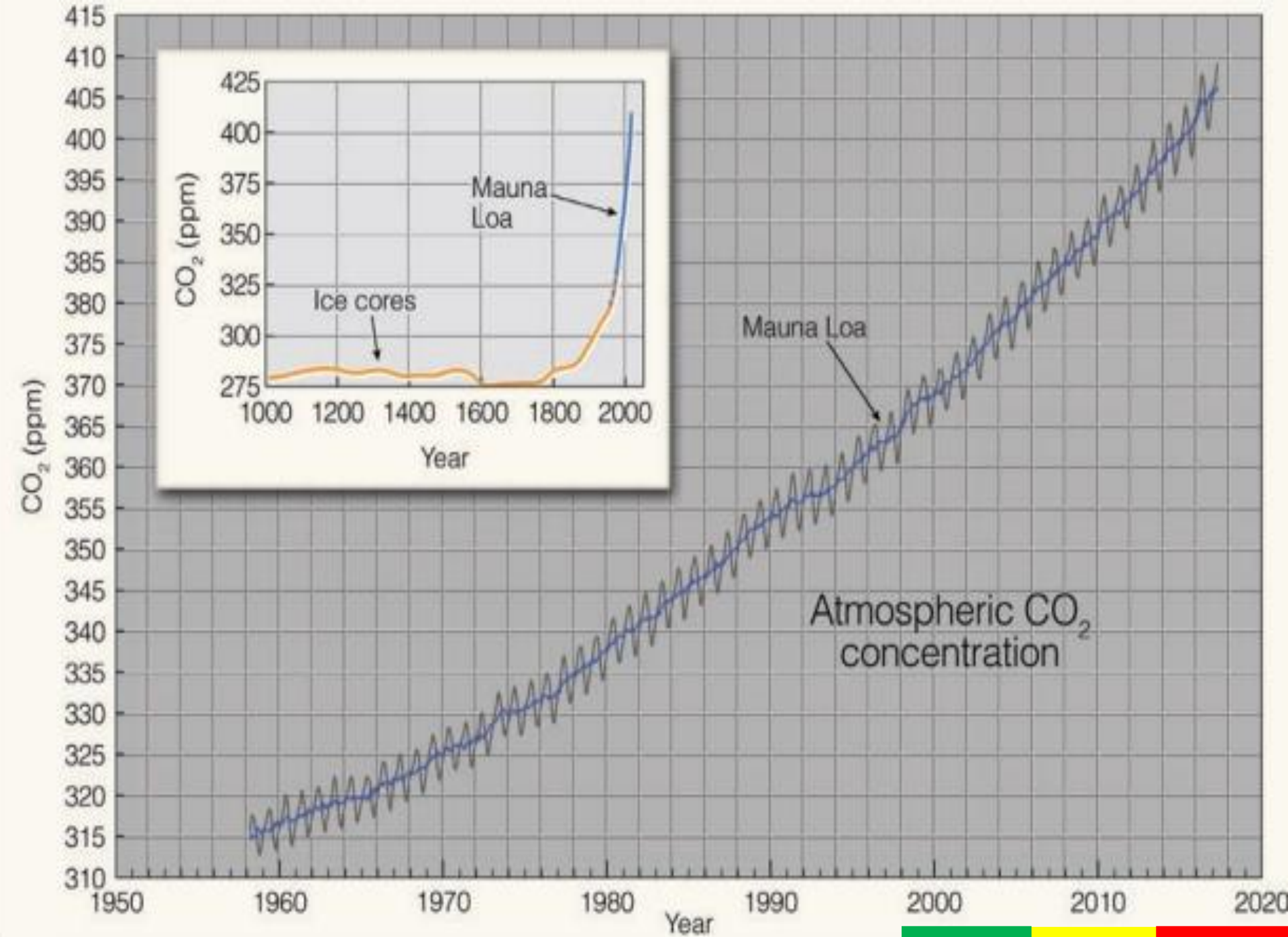
➤ Estimates are that the oceans hold more than 50 times the total atmospheric CO₂ content.



The ways
CO₂ enters
and leaves
the
atmosphere



- The atmospheric concentration of CO₂ has risen by around 30 percent since 1958, when regular measurements began at Mauna Loa Observatory in Hawaii.
- This increase means that CO₂ is entering the atmosphere at a greater rate than it is being removed.
- The increase is caused mainly by the burning of fossil fuels; however, **deforestation** also plays a role, as cut timber, burned or left to rot, releases CO₂ directly into the air.
- In addition, these dead trees no longer remove CO₂ from the atmosphere.
- Deforestation accounts for about 10 to 15 percent of the observed CO₂ increase in recent years. Measurements of CO₂ also come from ice cores.

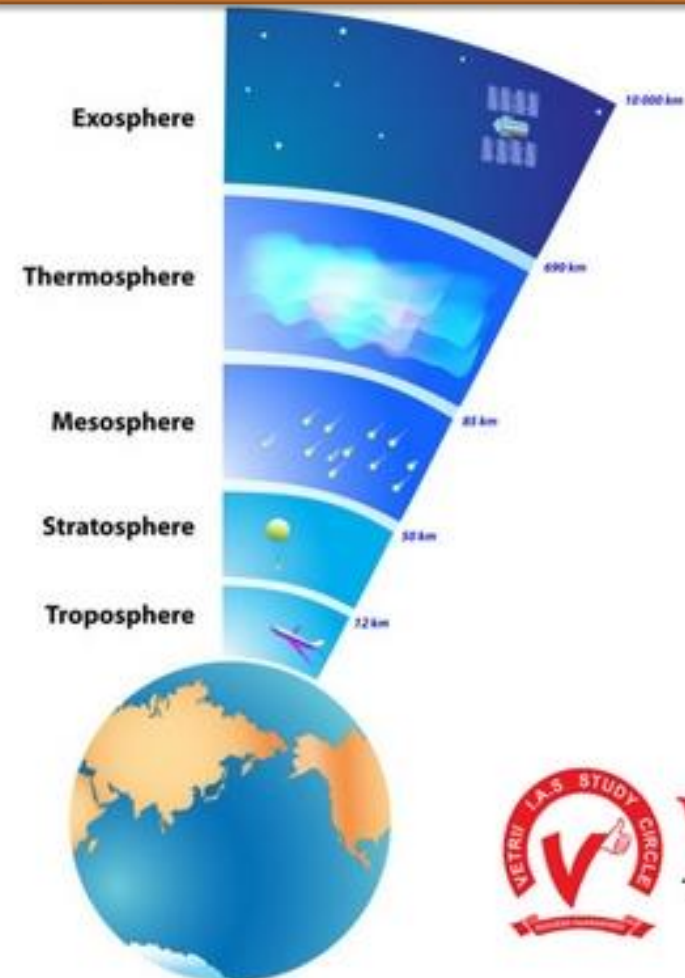


- Like *water vapor*, *carbon dioxide* is an important greenhouse gas that *traps* a portion of Earth's outgoing energy.
- Consequently, with everything else being equal, as the atmospheric concentration of *CO2 increases*, so should the average *global surface air temperature*. In fact, over the last 100 years or so, Earth's average surface temperature has warmed by about 1.0 0c (1.8 F).
- Mathematical climate models, which predict future atmospheric conditions, estimate that if concentrations of CO2 (and other greenhouse gases) continue to increase at or beyond their present rates, Earth's surface could warm by an additional 3 0c (5.4 F) or more by the end of this century.
- Consequences of this type of climate change (such as rising sea levels and the rapid melting of polar ice) will be felt worldwide.

Carbon dioxide and water vapor are not the only greenhouse gases. Others include *methane* (CH₄), *nitrous oxide* (NO₂), and *chlorofluorocarbons* (CFCs).

2.2. Composition and vertical structure of the Atmosphere

- When we examine the atmosphere in the vertical, we see that it can be divided into a *series of layers*.
- Each layer may be defined in a number of ways: by the manner in which the air temperature varies through it, by its gaseous composition, or even by its electrical properties.



- At any rate, before we examine these various atmospheric layers, we need to look at the vertical profile of two important atmospheric variables: *air pressure* and *air density*.
- *Air molecules* (as well as everything else) are held near Earth by *gravity*.
- This strong, invisible force pulling down on the *air squeezes (compresses)* air molecules closer together, which causes *their number in a given volume to increase*.
- The *more air above a level*, the *greater* the squeezing effect or *compression*.

- Gravity also has an effect on the ***weight of objects***, including air.
- In fact, weight is the force acting on an object due to ***gravity***.
- Weight is defined as the ***mass of an object times the acceleration of gravity***; thus

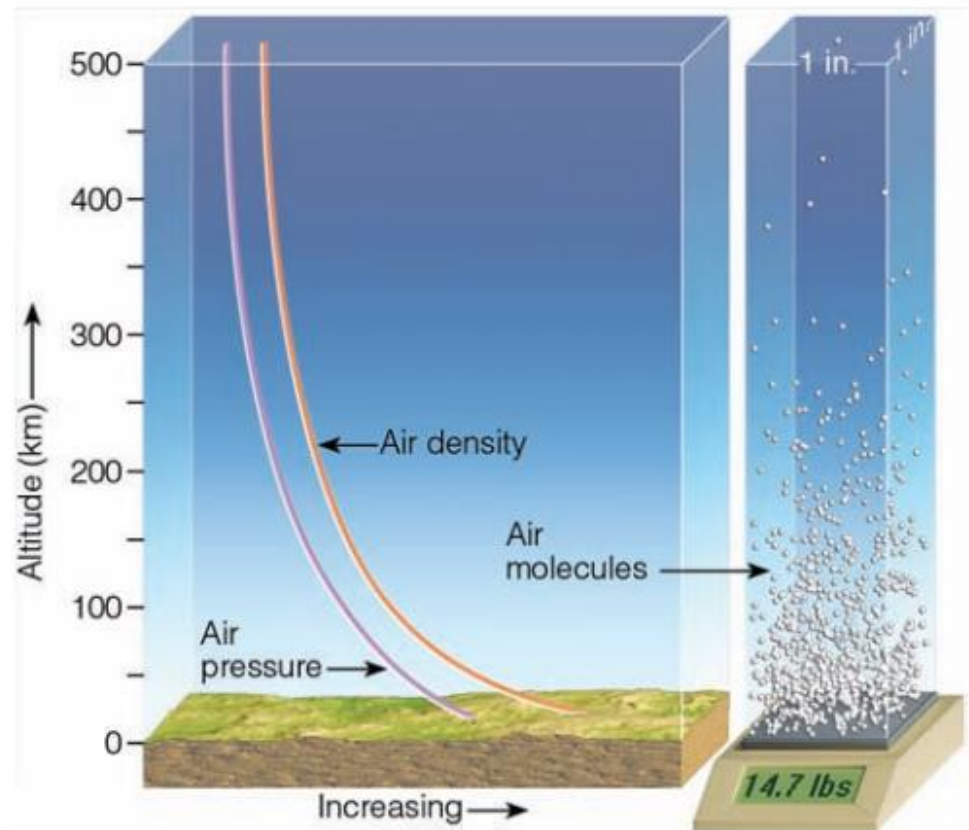
$$\text{weight} = \text{mass} * \text{gravity}$$

- An ***object's mass*** is the ***quantity of matter*** in the object.
- Consequently, the ***mass of air*** in a rigid container is the same ***everywhere*** in the universe.
- However, if you were to instantly travel to the moon, where the acceleration of gravity is much less than that of Earth, the ***mass of air in the container would be the same***, but its ***weight would decrease***.

- The *density of air* (or *any substance*) is determined by the *masses of atoms* and *molecules* and the *amount of space* between them.
- In other words, *density* tells us *how much matter is in a given space (volume)*.
- We can express *density* in a variety of ways.
- The *molecular density* of air is the *number of molecules* in a given *volume*.
- *Most commonly*, however, density is given as the *mass of air* in a given *volume*; thus

$$\text{density} = \frac{\text{mass}}{\text{volume}}$$

➤ Because there are appreciably *more molecules within the same size volume of air near Earth's surface* than at higher levels, *air density* is *greatest* at the *surface* and *decreases* as we *move up* into the *atmosphere*.

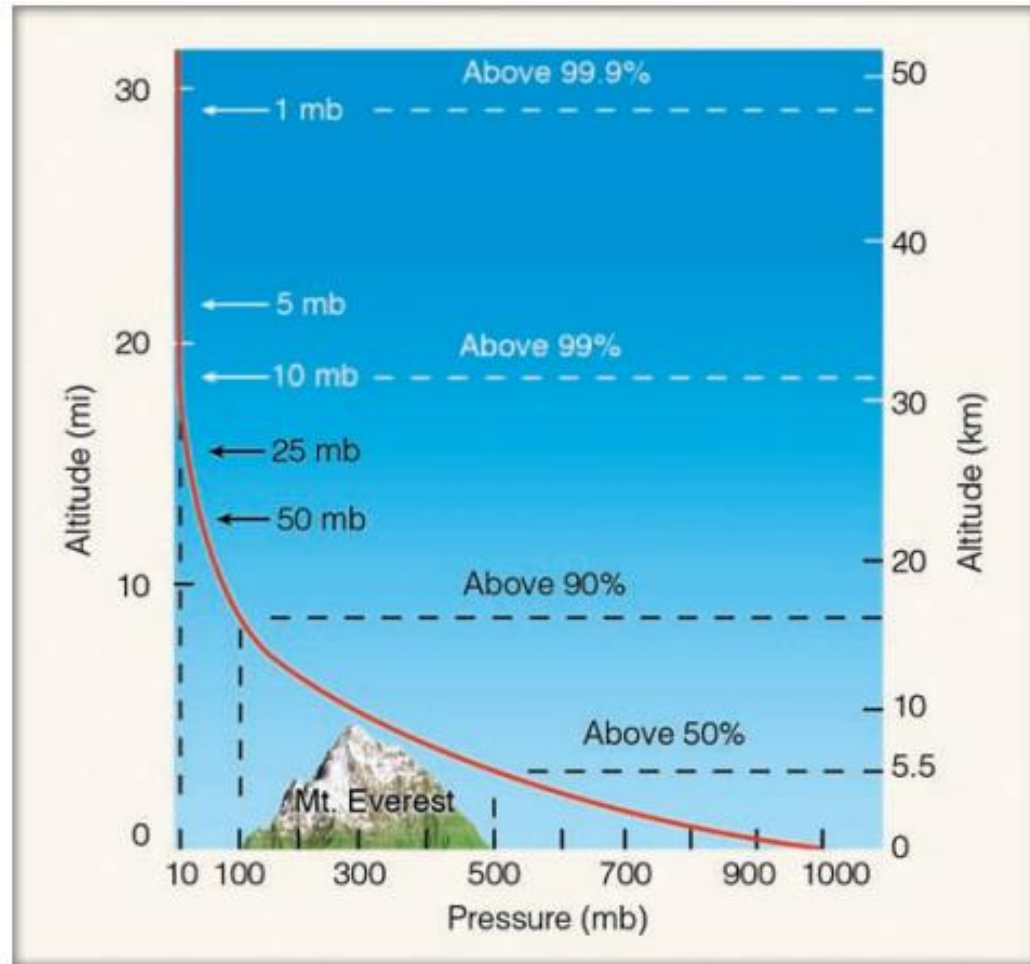


Both air pressure and air density decrease with increasing altitude. The weight of all the air molecules above Earth's surface produces an average pressure near 14.7 lb/in.²

- Air molecules *not only take up space* (freely darting, twisting, spinning, and colliding with everything around them), but— these same molecules have weight.
- In fact, *air* is surprisingly *heavy*.
- The *weight of all the air* around Earth is a staggering 5600 trillion tons, or roughly 5.08×10^{18} kg.
- The weight of the air molecules acts as a force upon Earth.
- The *amount of force* exerted over an area of surface is called *atmospheric pressure* or, simply, *air pressure**.

*Because air pressure is measured with an instrument called a barometer, atmospheric pressure is often referred to as *barometric pressure*

- The pressure at any level in the atmosphere may be measured in terms of the total mass of air above any point.
- As we climb in elevation, fewer air molecules are above us; hence, atmospheric pressure always decreases with increasing height.
- Like air density, air pressure decreases rapidly at first, then more slowly at higher levels.



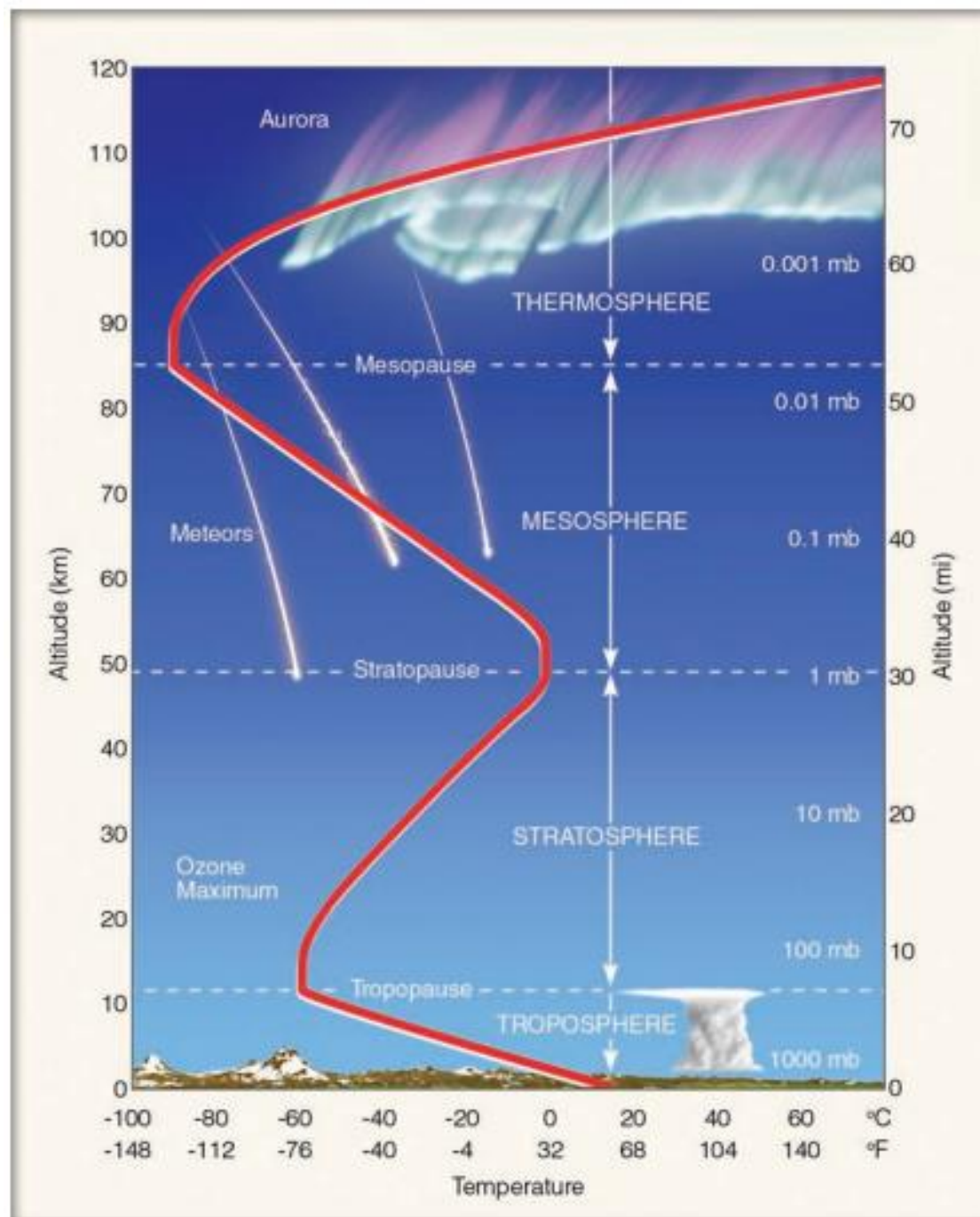
Atmospheric pressure decreases rapidly with height. Climbing to an altitude of only 5.5 km, where the pressure is 500 mb, would put you above one-half of the atmosphere's molecules.

- Up to this point, we've looked at how both ***air pressure*** and ***density decrease*** with ***height*** above Earth rapidly at first, then more slowly.
- Air temperature, however, has a more complicated vertical profile.
- Air ***temperature normally decreases*** from ***Earth's surface up to*** an altitude of about ***11 km***, which is nearly 36,000 ft, or 7 mi.
- This decrease in air temperature with increasing height is due primarily to the fact that ***sunlight warms Earth's surface***, and the ***surface***, in turn, ***warms the air above it***.
- The rate at which the ***air temperature decreases*** with ***height*** is called the ***temperature lapse rate***.
- The ***average*** (or standard) ***lapse rate*** in this region of the lower atmosphere is about 6.5°C for every 1000m increase in altitude.

- Keep in mind that these values are ***only averages***.
- On some days, the air becomes colder more quickly as we move upward. This would increase or steepen the lapse rate. On other days, the air temperature would decrease more slowly with height, and the lapse rate would be less.
- Occasionally, the air temperature may actually increase with height, producing a condition known as a ***temperature inversion***.
- Thus, the ***lapse rate fluctuates***, varying from day to day, season to season, and place to place.

- The region of the atmosphere from the surface up to about 11km, contains all of the weather we are familiar with on Earth.
- Also, this region is kept well stirred by rising and descending air currents, and it is common for air molecules to circulate through a depth of more than 10 km in just a few days.
- This region of circulating air extending upward from Earth's surface to where the air stops becoming colder with height is called the *troposphere*— from the Greek tropein, meaning “**to turn**” or “**to change**”.

- Just above 11 km the air temperature normally stops decreasing with height.
- Here, the ***lapse rate*** is ***zero***.
- This region, where, on average, the air temperature remains constant with height, is referred to as ***an isothermal*** (equal temperature) zone.
- The bottom of this zone marks the top of the troposphere and the beginning of another layer, the **stratosphere**.



- The boundary separating the troposphere from the **stratosphere** is called the *tropo-pause*.
- The height of the tropo-pause varies.
- It is normally found at higher elevations over equatorial regions, and it decreases in elevation as we travel poleward.
- Generally, the tropo-pause is higher in summer and lower in winter at all latitudes.
- In some regions, the tropo-pause “breaks” and is difficult to locate and, here, scientists have observed tropospheric air mixing with stratospheric air and vice versa.
- These breaks mark the position of jet streams—high winds that meander in a narrow channel, like an old river, often at speeds exceeding 100 knots. (For reference, a knot is a nautical mile per hour, where one knot equals 1.15 miles per hour [mi/hr] or 1.85 kilometers per hour [km/hr].)

- The ***stratosphere*** is the second major strata of air in the atmosphere. It extends above the tropopause to an altitude of about 30 miles (50 km) above the planet's surface. The air temperature in the stratosphere remains relatively constant up to an altitude of 15 miles (25 km).
- Then it increases gradually to up to the stratopause. Because the air temperature in the stratosphere increases with altitude, it does not cause convection and has a stabilizing effect on atmospheric conditions in the region.

- Water vapor in this layer is almost absent, and hence clouds will not form in this layer. In this layer, temperature increases with height; just opposite to that in troposphere.
- This temperature increase with height prevents the vertical winds. Only horizontal winds are observed.
- These horizontal winds flow almost always parallel to the earth's surface. Absence of vertical winds and the existence of horizontal winds parallel to earth's surface result in relatively calm atmosphere (absence of turbulence).
- This ensures smooth travel for flight. Absence of clouds also provide with good visibility for pilots. All the above features led to the operation of jet air planes in this layer.

- Ozone plays the major role in regulating the thermal regime of the stratosphere, as water vapor content within the layer is very low.
- Temperature increases with ozone concentration. Solar energy is converted to kinetic energy when ozone molecules absorb ultraviolet radiation, resulting in heating of the stratosphere.
- *Ozonosphere*, a very important layer is found within this stratosphere.
- Ozone present in the ozonosphere prevents the harmful ultra-violet rays from reaching the earth, thereby protecting the life.
- Thus, *ozonosphere* acts as a *protective umbrella*.

- The ozone layer is centered at an altitude between 10-15 miles (15-25 km). Approximately 90 % of the ozone in the atmosphere resides in the stratosphere. Ozone concentration in this region is about 10 parts per million by volume (ppmv) as compared to approximately 0.04 ppmv in the troposphere. Ozone absorbs the bulk of solar ultraviolet radiation in wavelengths from 290 nm - 320 nm (UV-B radiation).
- These wavelengths are harmful to life because they can be absorbed by the nucleic acid in cells. Increased penetration of ultraviolet radiation to the planet's surface would damage plant life and have harmful environmental consequences. Appreciably large amounts of solar ultraviolet radiation would result in a host of biological effects, such as a dramatic increase in cancers.

Mesosphere

- The mesosphere starts from the edge of the stratopause, just at an approximate height of 52 km from earth's surface.
- It extends to height of 80 km from the ground; is characterized by decreasing temperatures.
- In this layer, temperature decreases with height as in troposphere. The coldest temperatures in Earth's atmosphere occur at the top of this layer, the mesopause, especially in the summer near the pole.
- This layer, as such does not have any impact on life.
- But, it gains importance as it plays crucial role in radio communication. How does it exhibit its influence? Sunlight passing through this layer, converts the individual molecules to individual charged ions i.e. ionization.

- The mesosphere has sometimes jocularly been referred to as the "*ignorosphere*". Ionized particles are concentrated as a zone called the **D-layer**. This D-layer reflects radio waves sent from earth. But this D-layer blocks the communications between earth and astronauts.
- In this layer, during summer, at night times, a spectacular display of wispy clouds can be seen sometimes over high latitudes. It is presumed that meteoric dust particles coated with ice crystals reflect the sunlight resulting in wispy clouds. Just above the mesosphere lies, mesopause, in which temperature neither decreases nor increases.

Thermosphere

- The thermosphere is found approximately above 80 km from earth's surface. It extends to the edge of space at about 60,000 km from earth's surface. Temperature keeps rising with altitude in this layer. It is likely to reach 900°C at an altitude of 350 km. However, these high temperatures are not felt as in lower layers. This increase in temperature is due to the absorption of intense solar radiation by the limited amount of remaining molecular oxygen. At this extreme altitude gas molecules are widely separated. As a result, these temperatures really apply to individual molecules only. In this layer too, ionization of molecules take place. It results in individual charged ions. This process produces two ionized belts, viz **E**-layers and **F**-layers.

- These layers also reflect radio waves and have influence over radio communications. In the upper thermosphere, further concentration of ions are seen that comprise the Van Allen radiation belts. This layer is sometimes called, ***magnetosphere***. It is thus called as earth's magnetic field has more influence over the movement of particles rather than earth's gravitational field.
- Above 60 miles (100 km) from Earth's surface the chemical composition of air becomes strongly dependent on altitude and the atmosphere becomes enriched with lighter gases (atomic oxygen, helium and hydrogen). Also at 60 miles (100 km) altitude, Earth's atmosphere becomes too thin to support aircraft and vehicles need to travel at orbital velocities to stay aloft. This demarcation between aeronautics and astronautics is known as the Karman Line. Above about 100 miles (160 km) altitude the major atmospheric component becomes atomic oxygen. At very high altitudes, the residual gases begin to stratify according to molecular mass, because of gravitational separation.

Exosphere

- The exosphere is the most distant atmospheric region from Earth's surface.
- In the exosphere, an upward travelling molecule can escape to space (if it is moving fast enough) or be pulled back to Earth by gravity (if it isn't) with little probability of colliding with another molecule.
- The altitude of its lower boundary, known as the thermopause or exobase, ranges from about 150 to 300 miles (250-500 km) depending on solar activity.
- The upper boundary can be defined theoretically by the altitude (about 120,000 miles, half the distance to the Moon) at which the influence of solar radiation pressure on atomic hydrogen velocities exceeds that of the Earth's gravitational pull.
- The exosphere observable from space as the geocorona is seen to extend to at least 60,000 miles from the surface of the Earth.

According to the *concentration of the gases*, atmosphere is divided into:

1. *Homosphere*: the *lower region*, extending from the *surface of the earth* to a height of *80 to 100 km* above the earth.

➤ In this layer, gases are more or less uniform in their chemical composition.

2. *Heterosphere*: it starts from the *upper portion* of *homosphere* and extends to height of *60,000 km* above the earth.

➤ In this layer, chemical composition changes with height.

➤ *Concentration of gases keep decreasing* as one goes up.

➤ Inter molecular distance increases with height and hence, concentration decreases.

2.3. Atmospheric Variation with Altitude, Latitude and Season

- *Temperature change with Altitude*
- *Rainfall change with Altitude*
- *Pressure change with Altitude*
- *Moisture change with Altitude*
- *Temperature change with latitude*
- *Rainfall change with latitude*
- *Pressure change with latitude*
- *Moisture change with latitude*
- *Temperature change with Altitude*
- *Rainfall change with Altitude*
- *Pressure change with Altitude*
- *Moisture change with Altitude*

These and other atmospheric/weather and climate components are going to be discussed in the following chapters

2.4. Significance of the Atmosphere

- The atmosphere is an important part of what makes Earth livable.
- It blocks some of the Sun's dangerous rays from reaching Earth.
- It traps heat, making Earth a comfortable temperature.
- And the oxygen within our atmosphere is essential for life.
- Atmosphere contains **oxygen** which is essential for *animals* to *breathe* and get energy from food.
- It also contains carbon dioxide which is used by the plants to make their own food.
- Thus, atmosphere is **essential to sustain life on the Earth**