ENVIRONMENTAL BIOPHYSICS

Lecture 2

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What are the atmospheric layers and their importance?

Air forms a gaseous envelope surrounds the Earth known as atmospheric envelope or atmospheric air.

Atmospheric envelope of the Earth:

It is a gaseous envelope surrounding the Earth that rotates with it around its axis and it extends for about 1000 km above sea level.

Atmospheric pressure

- We know that any matter has a mass, a volume and a weight, so the atmospheric envelope of the Earth has a weight known as the atmospheric pressure.

Atmospheric pressure

Atmospheric pressure:

It is the weight of air column of an atmospheric height on a unit area ($1m^2$).

The atmospheric pressure is measured by a unit called a bar or a millibar.

1 bar (b) = 1000 millibar (mb)

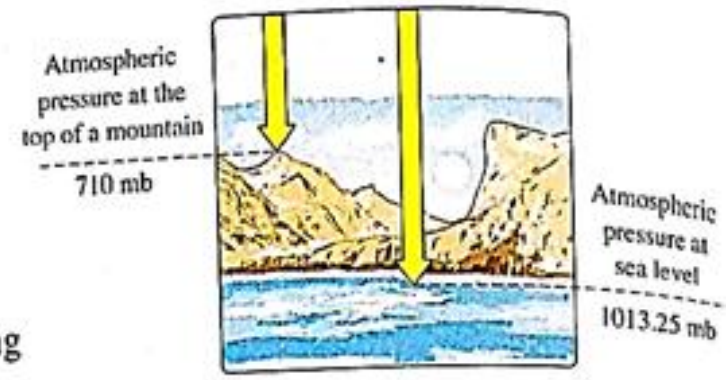
Normal atmospheric pressure:

It is the atmospheric pressure at sea level and it equals 1013.25 mb.

The change of atmospheric pressure with the change in height above sea level

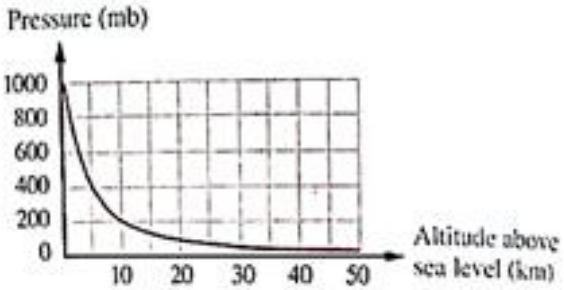
The change in the shape of clay spheres increases by increasing the number of books (or height) due to the increase in their weight (or pressure).

- The atmospheric pressure increases on going under sea level **Due to increasing the length of air column and thus its weight increases.**
- The atmospheric pressure decreases on going above sea level **Due to decreasing the length of air column and thus its weight decreases.**



The atmospheric pressure decreases on going above sea level

The atmospheric pressure differs from an area to another on the Earth's surface.
Due to the difference in the length of air column from an area to another on the Earth's surface.



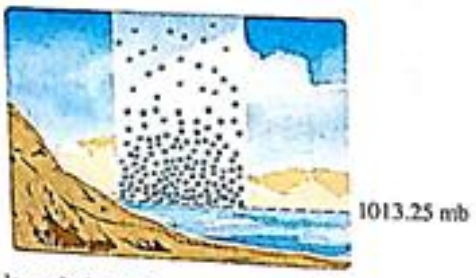
The relation between the altitude above sea level and the atmospheric pressure (Inverse relationship)

- **50% of the mass of atmospheric air** is present in the area between sea level and **3 km height.**
- **90% of the mass of atmospheric air** is present up to **16 km height** above sea level.

What happens to ... ?

The density of air on going above sea level.

➲ The density of air decreases.

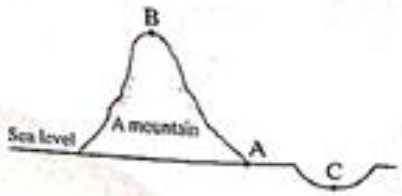


Density of air at the top of a mountain is less than its density at the foot of the mountain

From the opposite figure, at which points :

1. Atmospheric pressure is the maximum.
2. Air density is the minimum.

"Give an explanation at each case"



Answer

1. At point (C), because the atmospheric pressure increases on going under sea level.
2. At point (B), because density of air decreases on going above sea level.

The instruments of measuring the atmospheric pressure

- The atmospheric pressure is measured by instruments called barometers which are shown in the following table :

Instrument	Figure	Importance
Aneroid		It is used to determine the possible day weather based on the atmospheric pressure.
Altimeter		It is used in aeroplanes to measure the elevation of navigation based on the atmospheric pressure.

The greatest atmospheric pressure could be recorded on the surface of the Earth in January, 1968 in Siyberia and it was 1080 mb, whereas the lowest atmospheric pressure was in the centre of the tropical hurricane "Typhoon" in 1979 and it was 870 mb.

Atmospheric pressure maps

Atmospheric pressure map

In atmospheric pressure maps, points of **equal pressure** are joined by curved lines known as **Isobar**.

Isobar :

It is the curved lines that join the points of equal pressure in atmospheric pressure maps.

- The centre of **high** atmospheric pressure areas is represented by "H".
- The centre of **low** atmospheric pressure areas is represented by "L".
- The wind moves from the areas of **high** atmospheric pressure to the areas of **low** atmospheric pressure.

> ***Wind moves from an area to another on the Earth's surface.***
> Due to the difference in atmospheric pressure from an area to another on the Earth's surface, where the wind moves from the areas of high atmospheric pressure to the areas of low atmospheric pressure.

Layers of the atmospheric envelope

The atmospheric envelope consists of four layers above sea level, which are classified according to :

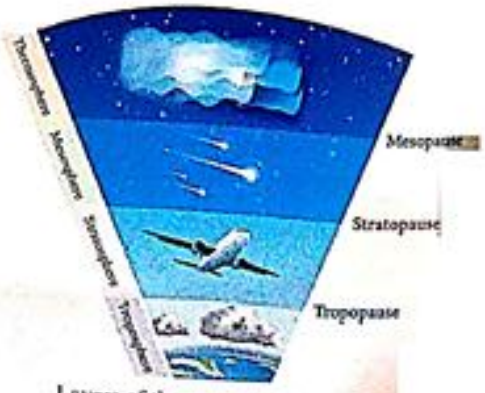
- *The change in atmospheric pressure.*
- *The change in temperature.*

Layers of the atmospheric envelope

1 Troposphere — 2 Stratosphere — 3 Mesosphere — 4 Thermosphere

There is a region between each two successive layers. In these regions, temperature remains constant.

1. **Tropopause** is the region between troposphere and stratosphere.
2. **Stratopause** is the region between stratosphere and mesosphere.
3. **Mesopause** is the region between mesosphere and thermosphere.



Layers of the atmospheric envelope

1 Troposphere

It means the **disturbed layer**

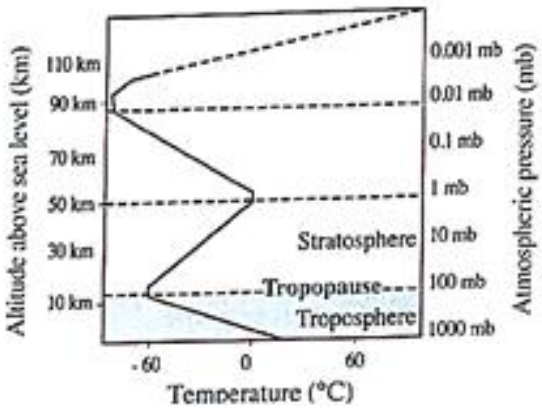
Because all atmospheric turbulences (weather changes) take place in it.

Location

It is the first layer of atmospheric envelope.

Characteristics and importance of troposphere layer :

Study the opposite figure to know the properties of troposphere layer :



Thickness

It extends for about **13 km** above sea level to the tropopause **(i.e. the thickness of troposphere layer is 13 km).**

Troposphere thickness is about 8 km above the two poles and 18 km at the equator

so, average troposphere thickness $= \frac{8 + 18}{2} = 13$ *km.*

Pressure

The atmospheric pressure in this layer **decreases** as we go up until it becomes 100 mb at its top 100 mb = 0.1 bar (0.1 of the normal atmospheric pressure at sea level).

Importance

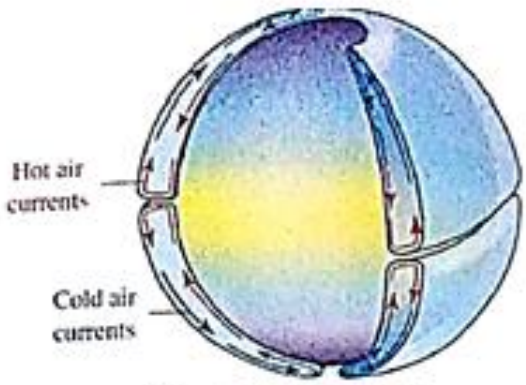
- All weather phenomena are present in troposphere layer GR.
  Because it contains about *75%* of the mass of the atmospheric air.
- Troposphere layer organizes the Earth's temperature GR.
  Because it contains *99%* of atmospheric water vapour.

Clouds and winds

Weather phenomena such as rains, wind, clouds, ... etc. take place in troposphere layer that form the weather conditions and consequently up the climate, that affect the activities of living organisms.

Air movement

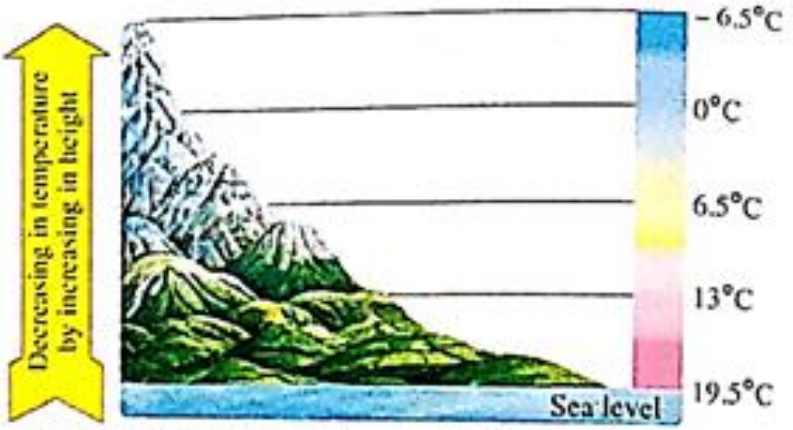
The air movement in this layer is **vertical**
Because the hot air currents (of less density) move upwards, while cold air currents (of high density) move downwards.



The movement of air currents

Temperature

The temperature of this layer decreases at a rate (6.5°C) for each (1 km) height until it reaches the lowest value of about (– 60°C) at tropopause.



Decreasing in temperature by a rate 6.5°C for each 1 km height.

We can calculate the amount of change in the temperature in troposphere layer using the following relation :

The amount of change in temperature (decrease or increase) = the height above sea level (km) × 6.5

We can calculate the temperature at the top of a mountain or at its foot from the following relations :

The temperature at the top of a mountain = the temperature at its foot – the amount of decrease in temperature

The temperature at the foot of a mountain = the temperature at its top + the amount of increase in temperature

Example 1

If the temperature at the foot of Everest mountain is 20.6°C, find the temperature at its top of height 8862 m above the Earth's surface.

Solution

- Height in kilometres = 8862 ÷ 1000 = 8.862 km
- The amount of decrease in temp. = the height above sea level (km) × 6.5
  = 8.862 × 6.5 = 57.6°C
- Temperature at the top = temp. at the foot – the amount of decrease in temp.
  = 20.6 – 57.6 = – 37°C

Example 2

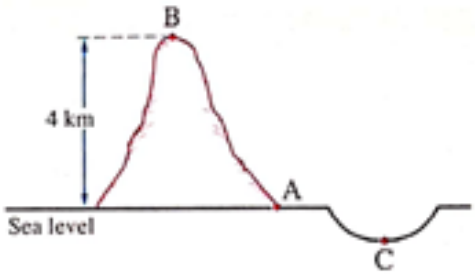
In the opposite figure, calculate :

(1) The temperature at point (A)

(2) The vertical distance between point (B) and point (C).

If you know that :

- ***The temperature at point (B) = – 5°C***
- ***The temperature at point (C) = 27.5°C***



Solution

1. The amount of increase in temp. (B : A) = the height above sea level (km) × 6.5
= 4 × 6.5 = 26°C

The temp. at point (A) = the temp. at point (B) + the amount of increase in temp.
= (– 5) + 26 = 21°C

2. ∵ The amount of change in temp. (C : B) = the temp. at point (C) – the temp. at point (B)
= 27.5 – (– 5) = 32.5°C

∴ The vertical distance between point (B) and point (C)

$$= \frac{\text{the amount of change in temp.}}{6.5} = \frac{32.5}{6.5} = 5 \text{ km}$$

2 Stratosphere

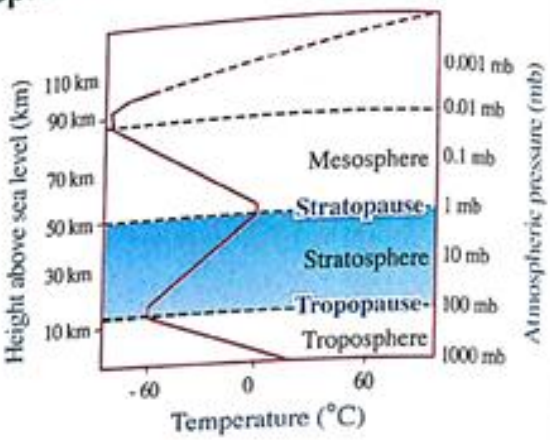
It is called **the ozonic atmospheric envelope.**

Location

It is the second layer of atmospheric envelope.

Characteristics and importance of stratosphere layer :

Study the opposite figure to know the properties of stratosphere layer :



Thickness

It extends from tropopause (at a height of **13 km** above sea level) to stratopause (at a height of **50 km** above sea level) with a thickness of **37 kilometres.**

Pressure

The atmospheric pressure in this layer **decreases** as we go up until it becomes 1 mb at its top 1 mb = 0.001 bar (0.001 of the normal atmospheric pressure at the sea level).

Importance

It contains most of ozone gas (O_3), which extends from 20 km to 40 km height above sea level so, it is called **the ozonic atmospheric envelope.**

Air movement

The lower part of such layer does not contain clouds or weather disturbances and the air movement is **horizontal,** so pilots prefer to fly their planes in this layer.

Flying in stratosphere

Temperature

At the lower part, the temperature is constant and measure **(– 60°C)**, then **increases** gradually until it reaches **(0°C)** at the top of the layer GR.

This is due to the absorption of ultraviolet rays (emitted from the Sun) by ozone layer which is present at the upper part of this layer.

3 Mesosphere

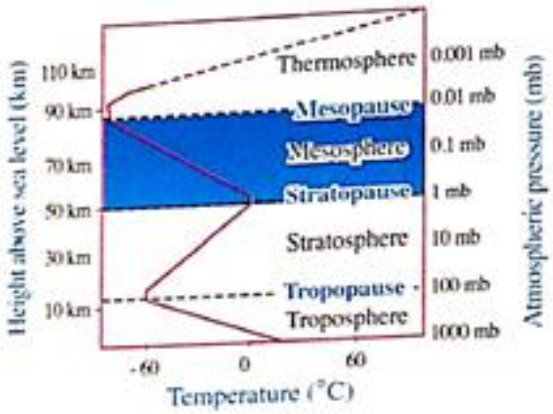
It is the middle layer, so it called mesosphere (**meso** means **middle**).

Location

It is the third layer of atmospheric envelope.

Characteristics and importance of mesosphere layer :

Study the opposite figure to know the properties of mesosphere layer :



Thickness

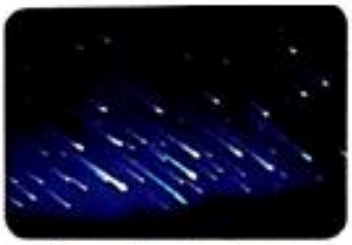
It extends from stratopause (at a height of **50 km** above sea level) to mesopause (at a height of **85 km** above sea level) with a thickness of **35 kilometres**.

Pressure

The atmospheric pressure in this layer **decreases** as we go up, until it becomes **0.01 mb** at its top.

Importance

It protects the planet Earth from celestial rocky masses that enter the atmospheric envelope of Earth, where some of them burn completely as a result of their friction with air molecules forming luminous meteors.



Formation of meteors in mesosphere

Mesosphere layer is much vacuumed (highly rarefied).
Because it contains limited quantities of helium and hydrogen gases only.

Temperature

Mesosphere is considered the coldest layer
Because the temperature in this layer decreases at a high rate as we go up until it reaches (– 90°C) at its top.

Although meteors are burnt in mesosphere layer, spaceships can't be burnt during passing in it because their conical fronts disperse the heat and their tails are made of an insulated material.

4 Thermosphere

It is called **the thermal layer** GR.

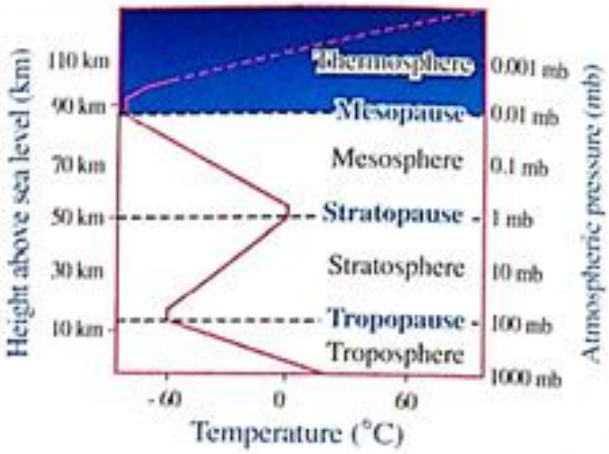
Because it is the hottest layer of atmospheric envelope.

Location

It is the fourth layer of atmospheric envelope.

Characteristics and importance of thermosphere layer :

Study the opposite figure to know the properties of thermosphere layer :



Thickness

It extends from mesopause (at a height of **85 km** above sea level) to a height of **675 km** above sea level with a thickness of **590 kilometres.**

Temperature

The temperature of this layer **increases** at a high rate as we go up until it reaches **(1200°C)** at its top so, it is called the thermal layer.

Ionosphere layer

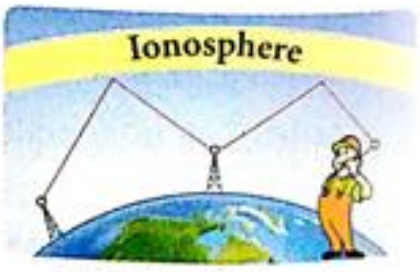
Ionosphere layer:

It is a layer that contains charged ions and it exists in the upper part of thermosphere and extends up to 700 km above sea level.

Importance

It is very important in wireless communications and broadcasting

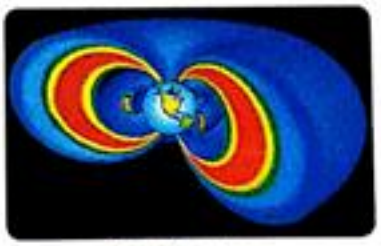
Because it reflects radio waves transmitted by radio stations and communication centres.



Reflection of radio waves

Van-Allen belts

Ionosphere is surrounded by two magnetic belts known as **Van-Allen** belts which is related to the scientist Van-Allen who discovered them.



Van-Allen belts

Van-Allen belts:

They are two magnetic belts surrounding ionosphere.

Importance

These belts play an important role in scattering of harmful charged cosmic radiations away from the Earth which causes the occurrence of **Aurora** phenomenon.

Scattering of harmful charged cosmic radiations away from the Earth

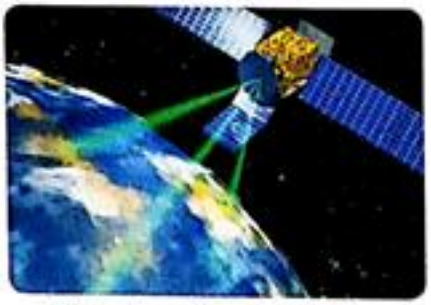
Aurora phenomenon:

It is a phenomenon that appears as brightly coloured light curtains seen at both poles (the north and south poles) of the Earth.

Exosphere layer

Exosphere:

It is a region in which the atmospheric envelope is inserted in outer space.



Role of satellites in wireless communications

Importance

Satellites float in exosphere [around the Earth] are used to transmit weather condition information and TV programs.

Enrichment information

The Egyptian satellite (Nile sat) transmits a number of different educational channels which you can watch through the digital space channels.

Choose the correct answer :

1. The height of atmospheric envelope is about ..... above sea level.
   a. 1000 km b. 1000 m c. 1000 mb d. 13 km
2. Atmospheric pressure is the ..... of air column of an atmospheric height on a unit area.
   a. mass b. volume c. weight d. density
3. The measuring unit(s) of atmospheric pressure is (are) .....
   a. bar. b. newton. c. millimetre. d. both (a) and (c).
4. A device that is used in measuring the atmospheric pressure is .....
   a. barometer. b. voltmeter. c. ammeter. d. (b) and (c).
5. The normal atmospheric pressure equals ..... mb at sea level.
   a. 76 b. 1013.25 c. 1.013 d. 760
6. As the density of air increases, the atmospheric pressure .....
   a. increases. b. decreases. c. doesn't change. d. (a) or (b).
7. ..... is an instrument used by pilots in aeroplanes to measure their elevation above sea level based on atmospheric pressure.
   a. Altimeter b. Barograph c. Aneroid d. Metallic barometer
8. A decrease in temperature at any height in troposphere is given by .....
   a. height in metres × 6.5 b. height in km + 6.5
   c. height in km × 6.5 d. height in km ÷ 6.5
9. Temperature decreases by ..... at 2 km above sea level.
   a. 6.5°C b. 13°C c. 5.6°C d. 9.75°C
10. All the atmospheric phenomena on the Earth like rains, winds and clouds take place i ..... layer.
    a. mesosphere b. stratosphere c. thermosphere d. troposphere
11. Water vapour in troposphere ..... the temperature on the Earth.
    a. organizes b. decreases c. increases d. has no effect on
12. ..... is the second layer of atmospheric envelope.
    a. Thermosphere b. Stratosphere c. Troposphere d. Mesosphere
13. ..... is the region between stratosphere and mesosphere.
    a. Thermopause b. Mesopause c. Stratopause d. Tropopause

14. Ozone layer is found in ..... layer.
a. troposphere b. stratosphere c. mesosphere d. thermosphere

15. The air moves ..... in the stratosphere layer.
a. horizontally b. vertically
c. inclined d. no correct answer

16. Pilots prefer to fly their planes in the lower part of stratosphere, because .....
a. no clouds exist. b. there are no weather disturbances.
c. air moves horizontally. d. all the previous answers.

17. The coldest atmospheric layer in the atmospheric envelope is .....
a. troposphere. b. stratosphere. c. mesosphere. d. thermosphere.

18. The thickness of mesosphere layer is ..... km.
a. 1000 b. 13 c. 37 d. 35

19. The temperature at the top of mesosphere layer reaches .....
a. 76°C b. – 90°C c. – 60°C d. 1200°C

20. The ..... layer is much vacuumed layer.
a. troposphere b. stratosphere c. mesosphere d. thermosphere

21. 🕮 Luminous meteors are formed in ..... layer.
a. ionosphere b. stratosphere c. mesosphere d. exosphere

22. The hottest atmospheric layer in atmospheric envelope is .....
a. troposphere. b. stratosphere. c. thermosphere. d. mesosphere.

23. Ionosphere layer is surrounded by two ..... belts.
a. electric b. ionic c. magnetic d. thermal

24. Ionosphere layer is located in the upper part of ..... layer.
a. stratosphere b. troposphere c. mesosphere d. thermosphere

25. The charged cosmic radiations are dispersed in the ..... layer.
a. troposphere b. stratosphere c. mesosphere d. ionosphere

Choose from column (B) what suits it in column (A) :

(1)

(A)	(B)
1. Barometer	a. The coldest layer in atmospheric envelope.
2. Altimeter	b. The layer that is suitable for aeroplanes.
3. Troposphere	c. An instrument used to measure atmospheric pressure.
4. Mesosphere	d. The layer that contains all weather conditions.
5. Stratosphere	e. An instrument used to determine the altitudes of navigation.
6. Thermosphere	f. The hottest layer in atmospheric envelope.