TOPIC 1 UNIT 1
THE ATMOSPHERE

KEY TERMS

Atmosphere,

Oxygen,

Constant gases,

Inert/noble gases,

Water vapour,

Atmospheric pressure,

Ozone,

Ozone layer,

Ozone hole

Meteoroids - pieces of rock from space that bum brightly while they travel down through the atmosphere

COMPOSITION AND STRUCTURE OF THE ATMOSPHERE

1. Why is the atmosphere so important?
2. What is the composition of the atmosphere?

COMPOSITION AND STRUCTURE OF THE ATMOSPHERE

- The atmosphere is one of four important spheres (**FIGURE 30**) that overlap to form the natural environment.
- The spheres interact with one another.

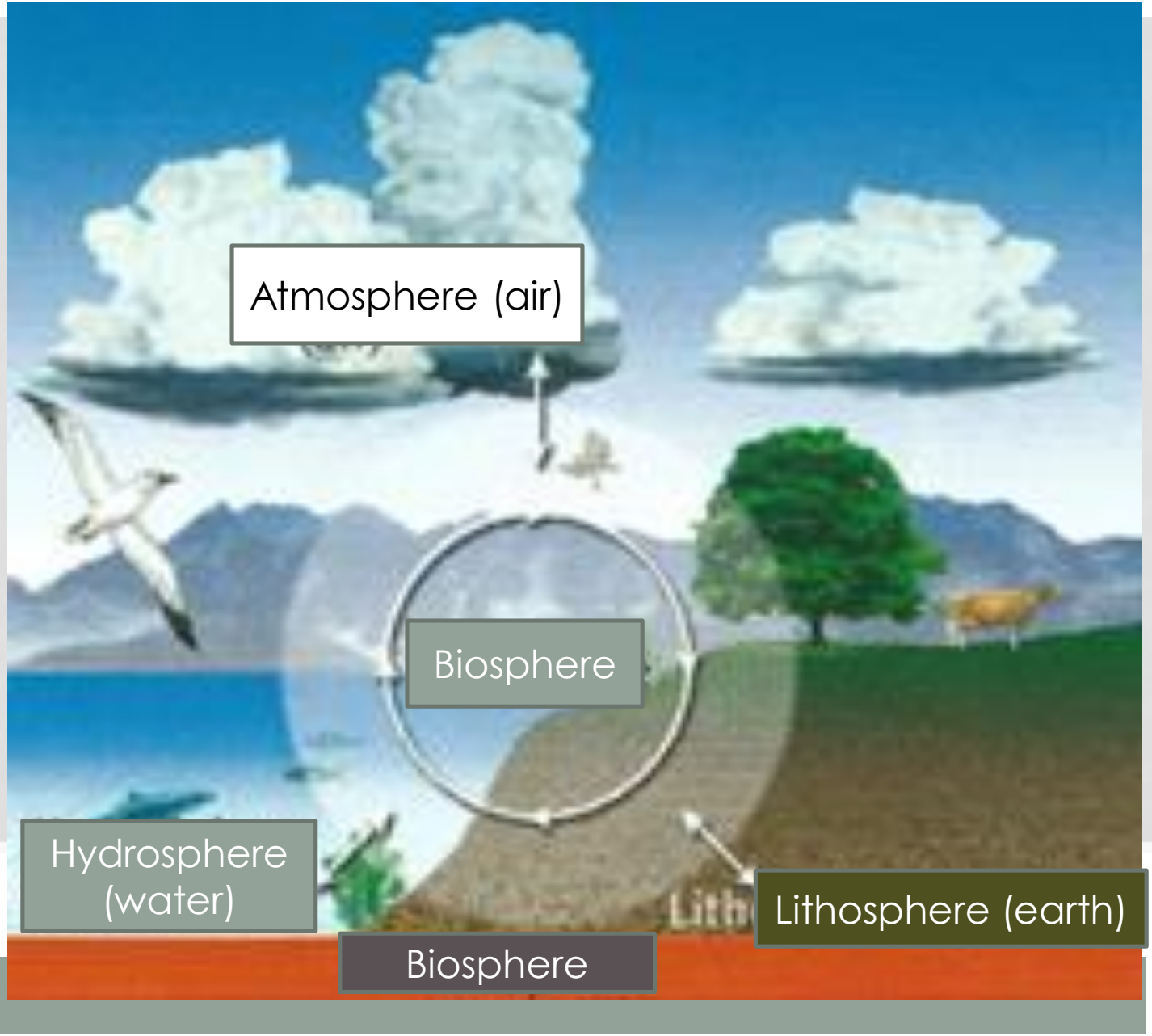


FIGURE 30

SPHERES OF THE EARTH SYSTEM

COMPOSITION AND STRUCTURE OF THE ATMOSPHERE

- Scientists classify these spheres as follows:
- **Atmosphere**: The gaseous (gas- filled) shell surrounding the Earth.
- **Lithosphere**: The layer of rock that makes up the outer 70 km of the Earth.
- **Hydrosphere**: The part of the Earth where water in all its forms, flows and is stored.
- Part of this sphere is the cryosphere (the frozen regions of the Earth, e.g. the Antarctic ice cap).
- **Biosphere**: the portion of the Earth and atmosphere that supports life.

1. WHY IS THE ATMOSPHERE SO IMPORTANT?

- The atmosphere is our life-support system.
- The oxygen in the air we breathe comes from the atmosphere.
- The atmosphere also absorbs harmful radiation from the sun and burns up meteoroids before they hit the Earth.
- The atmosphere allows just enough of the sun's rays through to warm the Earth during the day without frying us.
- At night it holds in enough of this heat to keep us from freezing. Without the atmosphere, temperatures could climb to over 93 ^{o}C during the day.
- At night, temperatures could drop quickly to more than 173 ^{o}C below freezing point (0 ^{o}C).

2. WHAT IS THE COMPOSITION OF THE ATMOSPHERE?

- The chemical composition of the atmosphere is reasonably consistent from the Earth's surface up to a height of approximately 80 km.
- In this section of the atmosphere, its constituents are well mixed by turbulence.
- This uniform bottom layer is consequently called the homosphere (**FIGURE 31**).
- Pure, dry air in the homosphere is made up of nitrogen (78,09 %) and oxygen (20,95 %).
- A small percentage (0,93 %) consists of inert or noble gases like argon.
- These gases form the permanent or constant gases.
- The concentrations of variable gases, however, change over time and from place to place (see **TABLE 1**).

2. WHAT IS THE COMPOSITION OF THE ATMOSPHERE?

- Apart from gases, there are also small solid particles in the atmosphere like dust, salt, smoke particles and pollutants.
- In the section of the atmosphere above 100 km above the Earth's surface, the chemical composition of the different gases varies.
- Hence this upper section of the atmosphere is called the heterosphere (see **FIGURE 31**).
- The surface between these divisions of the atmosphere is called the tropopause.

THE REAL IMPORTANCE OF THE ATMOSPHERE BECOMES CLEAR TO US WHEN WE LEARN ABOUT THE DIFFERENT GASES IN THE ATMOSPHERE AND THEIR PARTICULAR FUNCTIONS. (SEE TABLE 1.)

Table 1 Gases in the atmosphere and their significance

Type of gas	Gas	Percentage by volume	Importance for weather and climate	Other functions/source
Constant gases	Nitrogen (N_2)	78,09	Mainly passive	Needed for plant growth
	Oxygen (0_2)	20,95		Produced by photosynthesis; reduced by deforestation

THE REAL IMPORTANCE OF THE ATMOSPHERE BECOMES CLEAR TO US WHEN WE LEARN ABOUT THE DIFFERENT GASES IN THE ATMOSPHERE AND THEIR PARTICULAR FUNCTIONS. (SEE TABLE 1.)

Table 1 Gases in the atmosphere and their significance

Type of gas	Gas	Percentage by volume	Importance for weather and climate	Other functions/source
Variable gases	Water vapour (H_2O)	0,03 (can rise to 4,0)	Source of cloud formation and precipitation; reflects/absorbs incoming radiation; keeps global temperatures constant	Essential for life on Earth; Can be stored as ice/snow
	Carbon dioxide (CO2)	0,03	Absorbs long-wave radiation from the Earth and so contributes to 'greenhouse effect'; its increase, due to human activity, is a major cause	Used by plants for photo- synthesis; increased by burning fossil fuels and by deforestation

THE REAL IMPORTANCE OF THE ATMOSPHERE BECOMES CLEAR TO US WHEN WE LEARN ABOUT THE DIFFERENT GASES IN THE ATMOSPHERE AND THEIR PARTICULAR FUNCTIONS. (SEE TABLE 1.)

Table 1 Gases in the atmosphere and their significance				
Type of gas	**Gas**	**Percentage by volume**	**Importance for weather and climate**	**Other functions/source**
Inert or noble gases	Argon (Ar)	0,93		
	Helium (He), neon (Ne), krypton (Kr)	trace		

THE REAL IMPORTANCE OF THE ATMOSPHERE BECOMES CLEAR TO US WHEN WE LEARN ABOUT THE DIFFERENT GASES IN THE ATMOSPHERE AND THEIR PARTICULAR FUNCTIONS. (SEE TABLE 1.)

Table 1 Gases in the atmosphere and their significance				
Type of gas	**Gas**	**Percentage by volume**	**Importance for weather and climate**	**Other functions/source**
Non-gases	Dust, salt and smoke particles	trace	Absorb/reflect incoming radiation; form condensation nuclei necessary for cloud formation	Come from volcanoes, meteorites, soil erosion by wind

ACTIVITY 1 PAGE 41
CONSTRUCTING A PIE CHART

1. Construct a pie chart to illustrate the composition of the atmosphere.
   - You will need a pencil, a ruler and a protractor. Use the following approximate percentages for the different gases:

a. Constant gases: nitrogen 78; oxygen 21

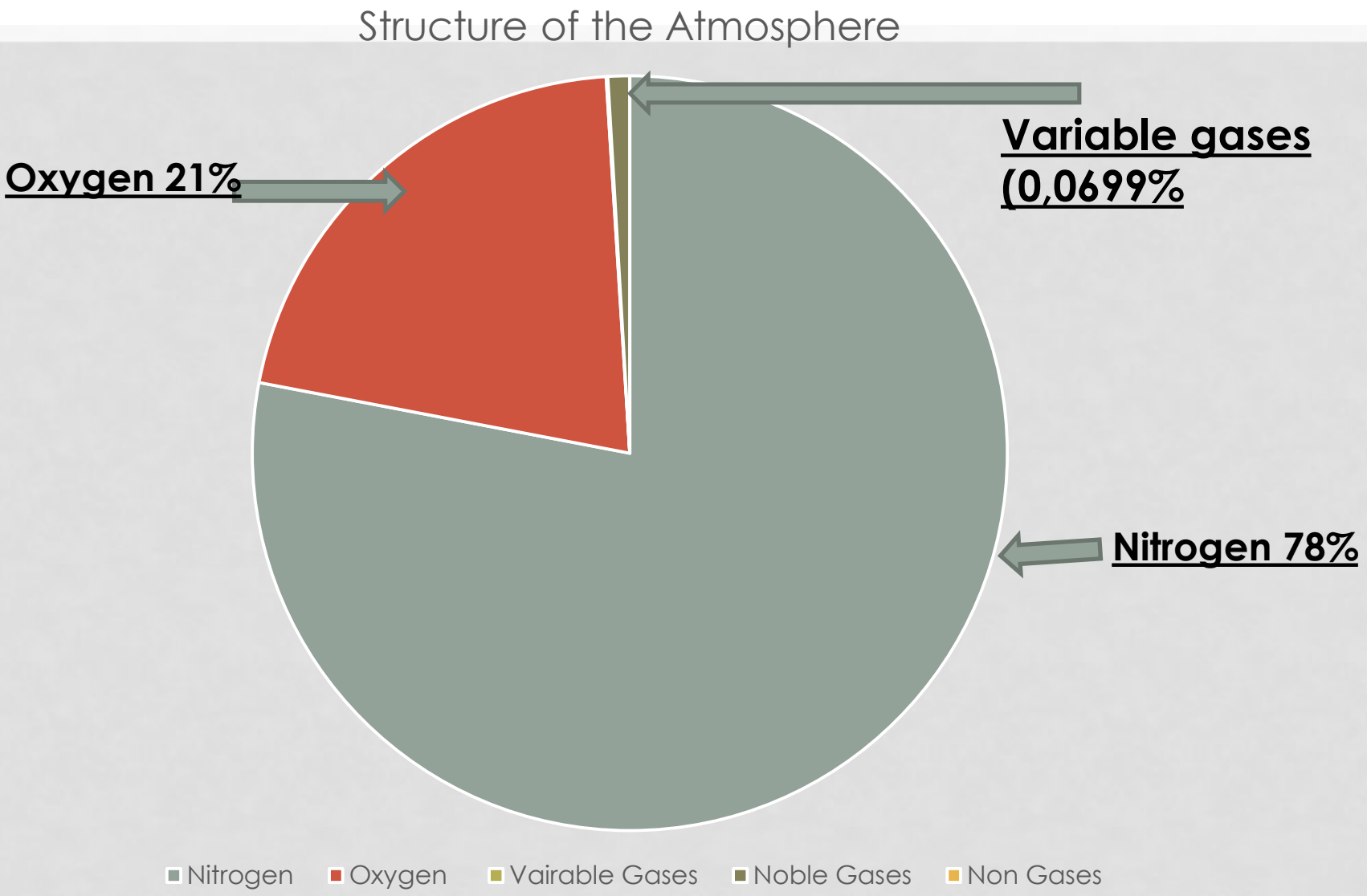
b. Variable gases: 0,0699

c. Inert/Noble gases: 0,93

d. Non-gases and pollutants: 0,0001.

2. State on the diagram the importance of each of these gas groups. Use an arrow to indicate the specific sector you referring to.

CONSTRUCT A PIE CHART TO ILLUSTRATE THE COMPOSITION OF THE ATMOSPHERE.



2. STATE ON THE DIAGRAM THE IMPORTANCE OF EACH OF THESE GAS GROUPS.

- Nitrogen: Important for plant growth
- Oxygen: Essential for life
- Variable gases:
  - Water vapour : Essential for life (Water/rain)
  - Carbon dioxide: Photosynthesis resulting in Oxygen
  - Ozone: Absorbs harmful UV sunrays
- Inert/Noble gases: Provide no measurable function to the atmosphere.

3. WHAT IS THE STRUCTURE OF THE ATMOSPHERE? PAGE 42

3.1 Is the atmosphere the same everywhere?

3.1.1 Troposphere

3.1.2 Stratosphere

3.1.3 Mesosphere

3.1.4 Thermosphere

3.2 What about the atmosphere's density and pressure?

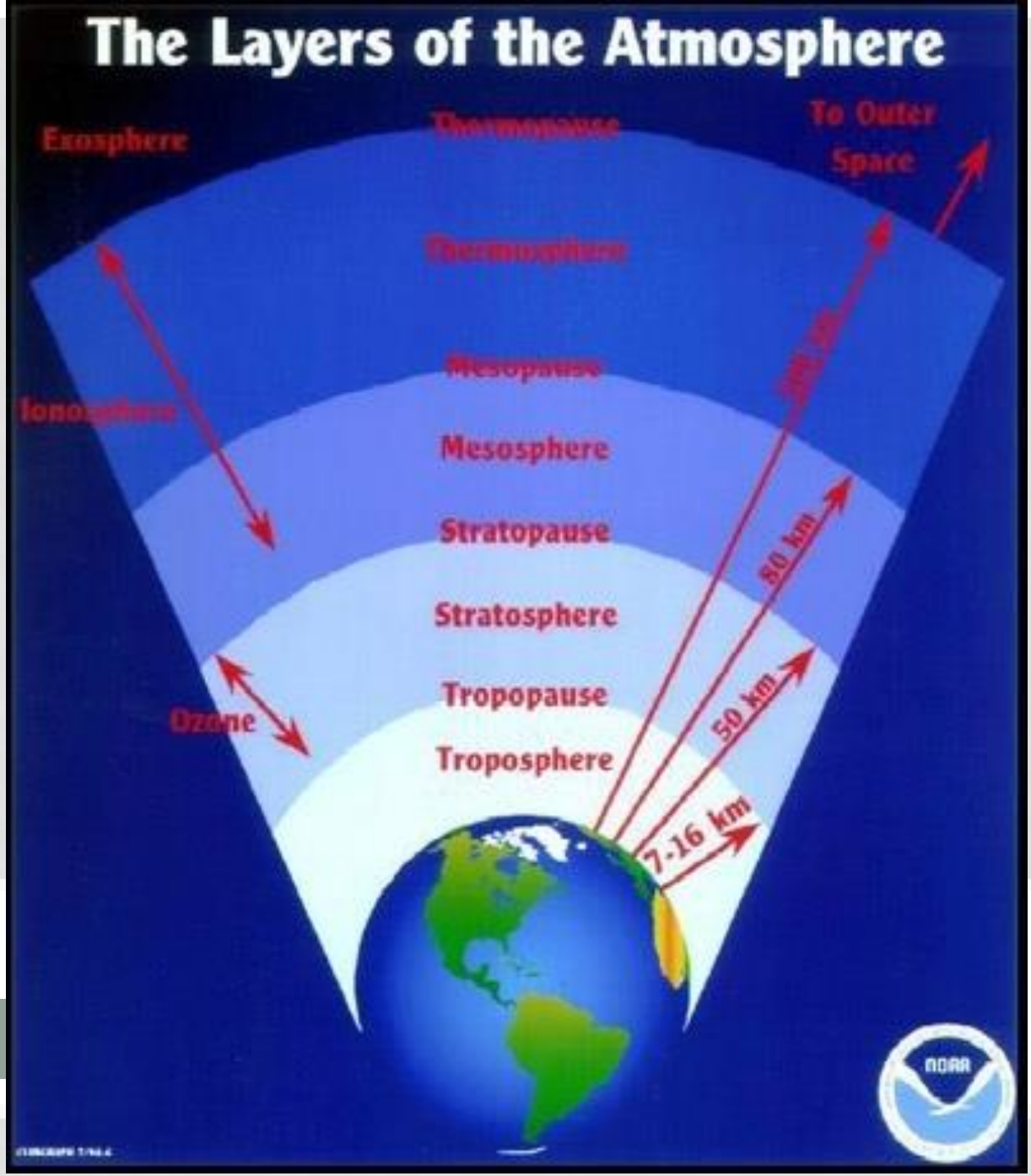
3. WHAT IS THE STRUCTURE OF THE ATMOSPHERE?

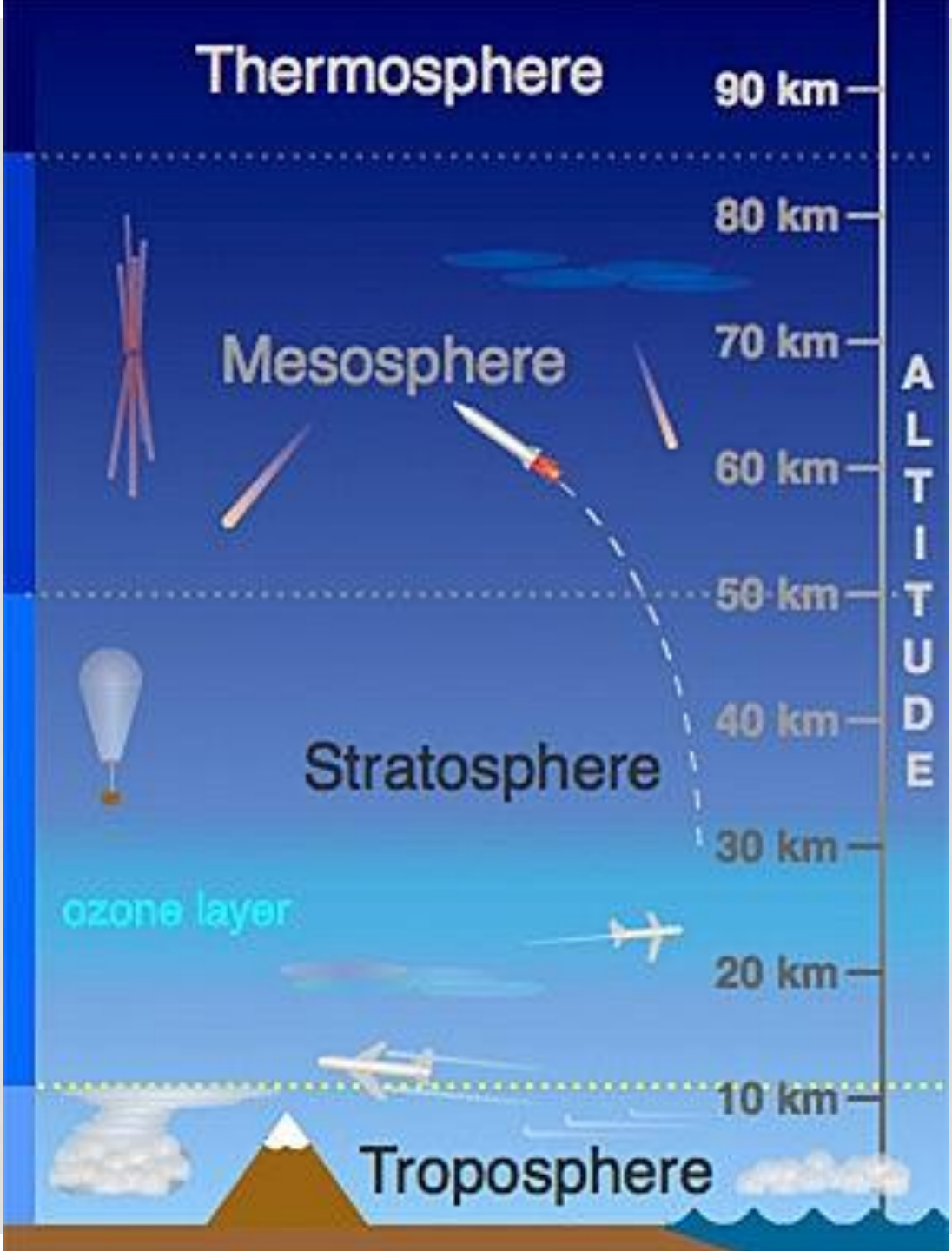
- Because soil contains air and water, the atmosphere extends from a shallow depth within the ground to a height of about 480 km.
- Most of the atmosphere and our weather are concentrated in a layer above the Earth's surface that is 16 km thick near the Equator, and 8 km thick near the poles.
- Most of the atmosphere (99 %) exists within a 40 km thick layer above the ground.

3.1 IS THE ATMOSPHERE THE SAME EVERYWHERE?

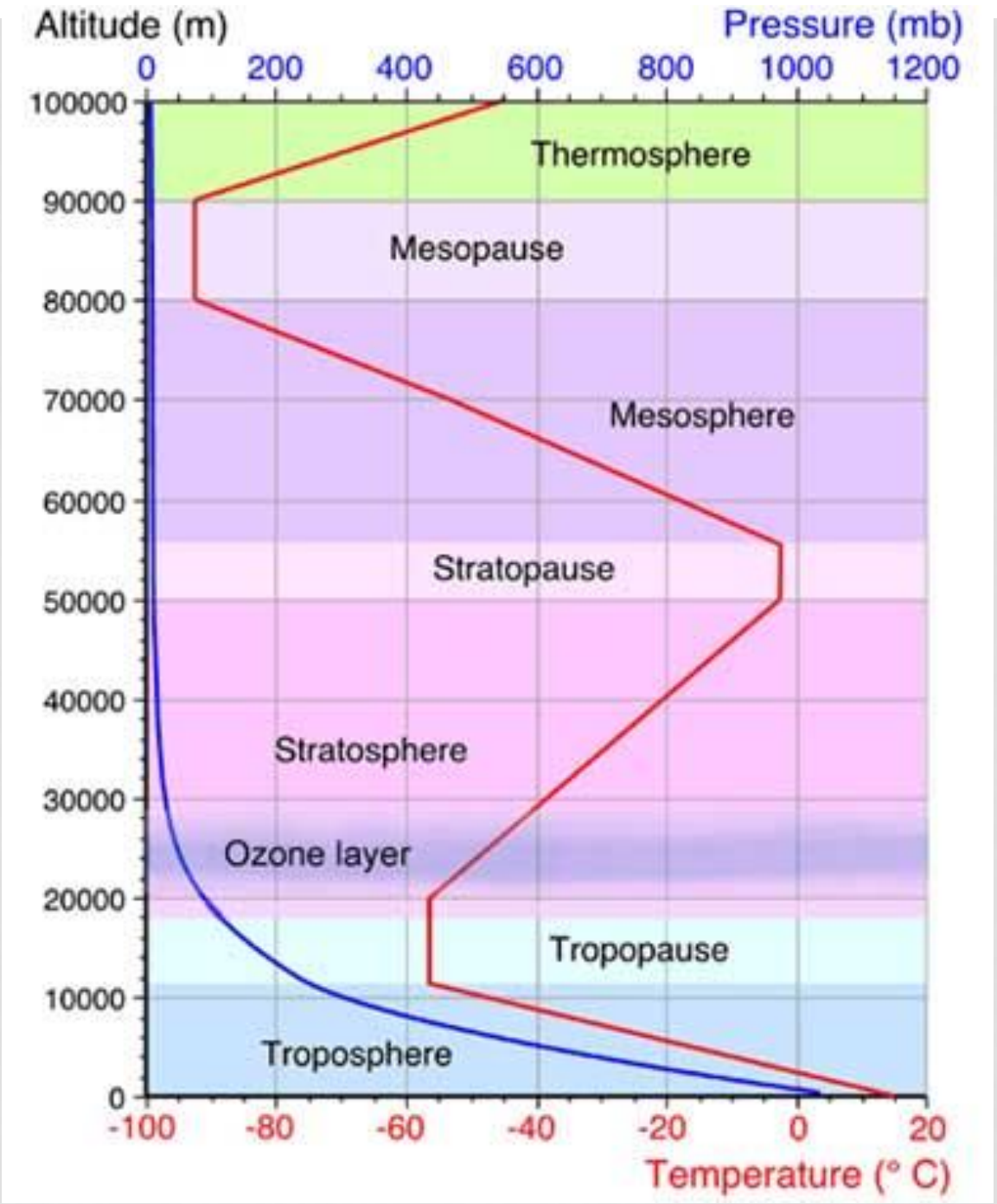
- Data from weather balloons and weather satellites indicate that the atmosphere can be divided into five distinct layers based on changes in temperature and the elements (see **FIGURE 31**).

STRUCTURE OF THE ATMOSPHERE

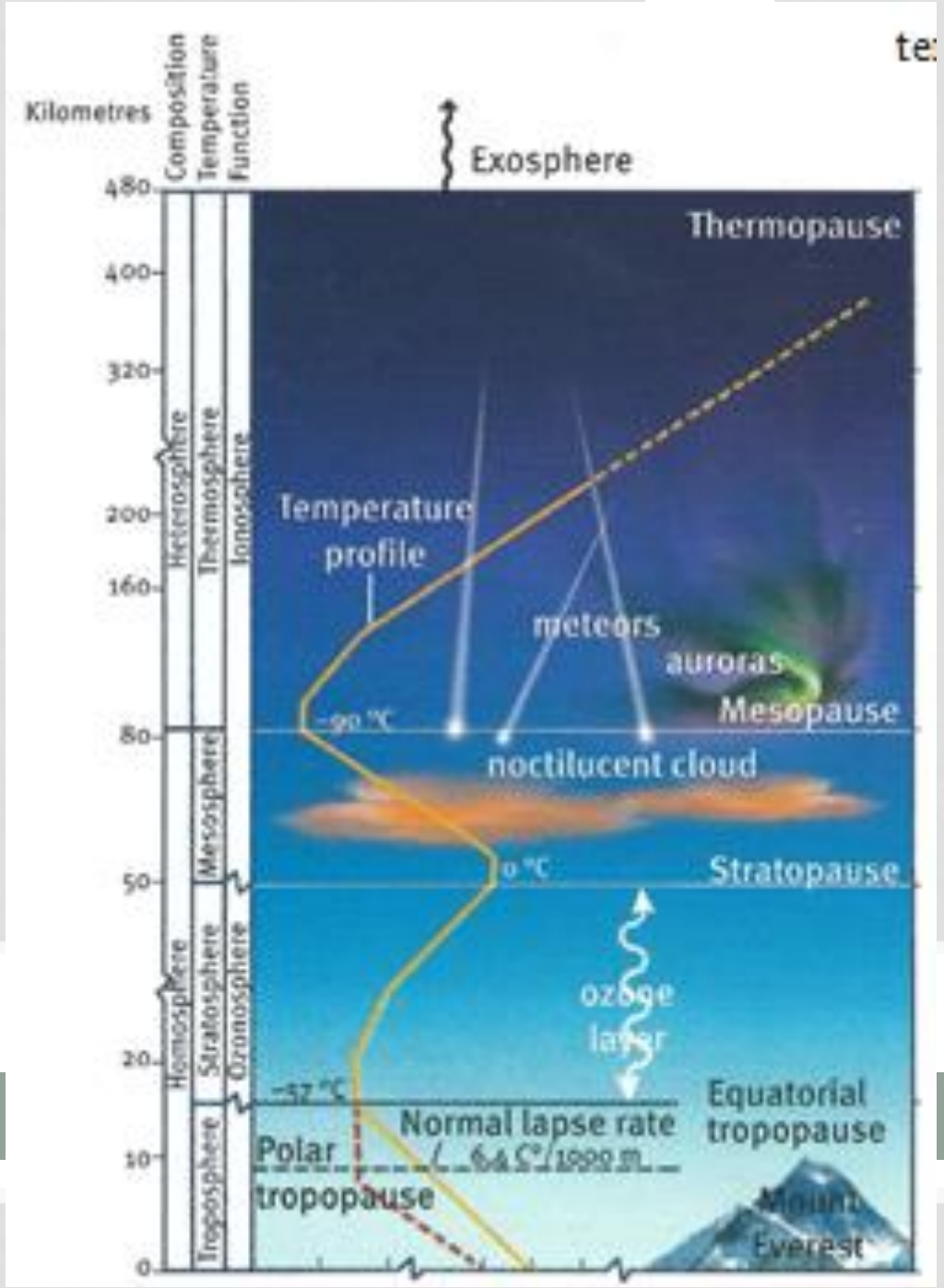



Thermosphere
90 km
80 km
Mesosphere
70 km
60 km
50 km
40 km
Stratosphere
30 km
ozone layer
20 km
10 km
Troposphere
ALTITUDE

Temperature and pressure changes in the layers of the atmosphere



STRUCTURE OF THE ATMOSPHERE



3.1.1 TROPOSPHERE

- This is the lowest layer of the atmosphere.
- It extends up from the surface for about 12 km.
- It is warmed by Earth's long-wave radiation.
- Temperature decreases with increasing altitude.
- The change in temperature is called the environmental or normal lapse rate. The average temperature drops 6,4 ^{o}C with every 1000 m increase in altitude (see **FIGURE 31**).
- Air pressure falls as gravity decreases (see **FIGURE 32**).
- This layer contains most of the water vapour, cloud, dust and pollution. Weather-related processes occur here.
- The tropopause forms the upper limit of the layer. Temperatures here remain constant even with an increase in height.

3.1.2 STRATOSPHERE

- This layer extends in altitude from 12 to 50 km.
- It is characterised by an increase in temperature caused by a concentration of ozone. The area with the highest concentration of ozone (roughly between 15 and 35 km above the ground) is also called ozonosphere.
- This layer is important to life on Earth because ozone absorbs incoming ultraviolet (DV) radiation.
- This layer protects us from incoming meteorites.
- Temperature is constant in the stratopause.

3.1.3 MESOSPHERE

- This layer extends in altitude from about 50 to 80 km.
- Temperatures fall rapidly because there is little water vapour, cloud, dust or ozone to absorb the solar energy. The layer experiences the atmosphere's lowest temperatures (-90 °C).
- This layer has the atmosphere's strongest winds (up to 3 000 km/h).
- The mesosphere sometimes receives meteoric dust. The dust forms nuclei around which ice crystals can form. When light reflects off these ice crystals, it forms unusual night clouds called noctilucent cloud (see **FIGURE 31**).

3.1.4 THERMOSPHERE

- This is the upper layer of atmosphere, extending from about 80 to about 480 km above the ground.
- There is a rapid increase in temperature with an increase in height - perhaps to 1 500 ^{o}C.
- High temperatures result from the very strong solar radiation and an increasing proportion of atomic oxygen. The oxygen, like ozone, absorbs incoming UV radiation.
- The resulting vibration of the 02 molecules allows radio waves from one location to be received beyond the horizon.

3.2 WHAT ABOUT THE ATMOSPHERE'S DENSITY AND PRESSURE?

- The Earth's gravity pulls the gases, liquids and solids towards the ground.
- So, there are more gas molecules closer to the ground and fewer as you move away.
- The Earth's atmosphere is denser at the surface and gets less dense as altitude increases (see **FIGURE 32**).
- You can imagine atmospheric pressure as the weight of the overlying column of air.
- Unlike temperature, pressure decreases rapidly with altitude (see **FIGURE 32** again).
- Eighty per cent of the atmosphere's mass is contained within the 18 km closest to the surface.

PRESSURE AND DENSITY DECREASE RAPIDLY WITH ALTITUDE.

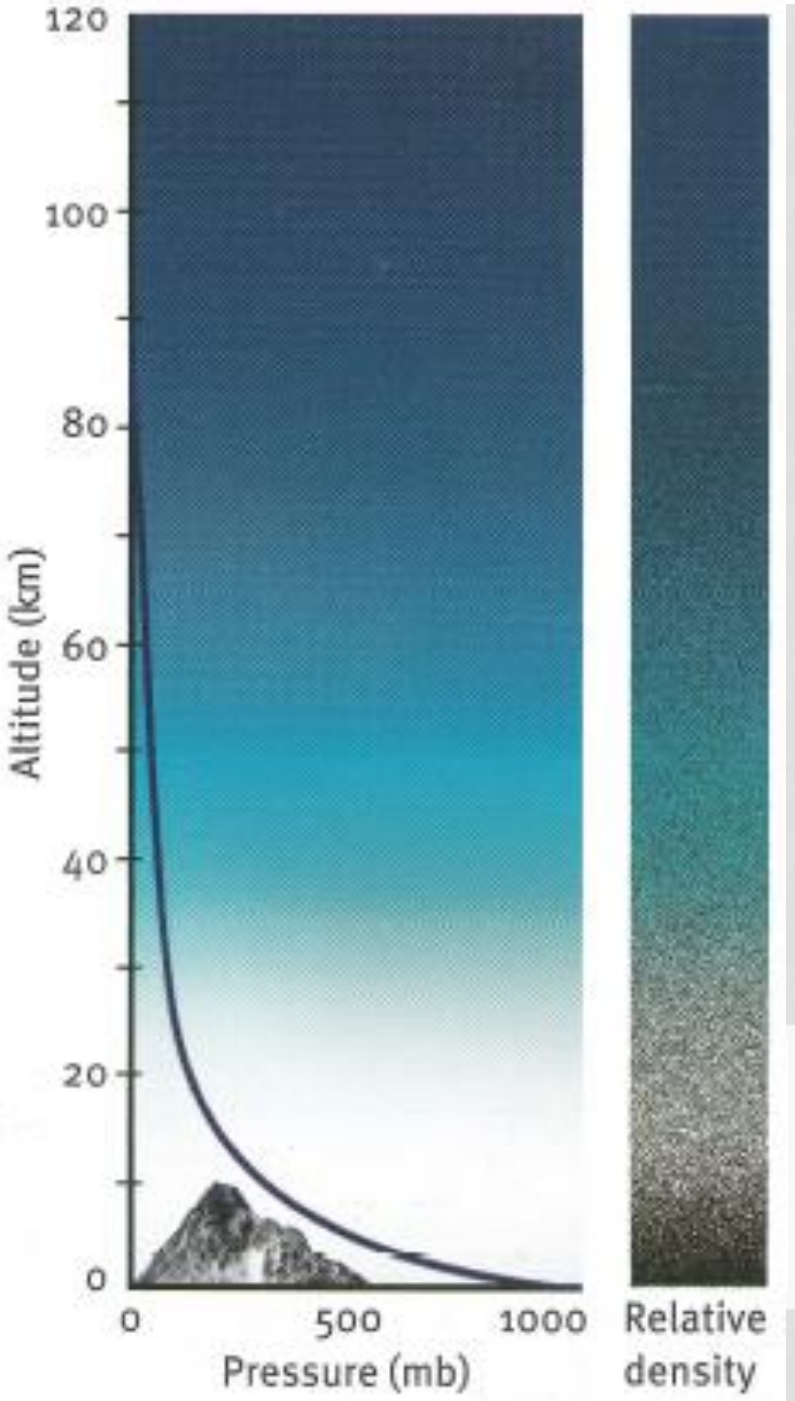


FIGURE 32

ACTIVITY 2
THE ATMOSPHERE'S STRUCTURE

1. Study **FIGURE 31** showing the structure of the atmosphere.

a. Why is the atmosphere important for life on the Earth?

b. Name the layer of air in which humans, animals and plants live.

c. Which atmospheric processes occur in this layer?

d. Explain why passenger airlines fly in the upper region mentioned in (b)?

e. What is the transition zone to the next layer above (b) called?

f. State the name of the layer above the transition zone mentioned in (e).

g. Use an atlas to work out on which continent and in which country the mountain in **FIGURE 31** is found. How high is South Africa's highest mountain and where is it situated?

h. If it is 32 DC, what will the temperature be 10 km above the Earth's surface?

2. Work with the learner next to you to identify the elements humans release as pollution into the atmosphere. Make a list of the sources of pollution near your school and at home. In a presentation, refer to possible causes, consequences and solutions or strategies.

1A. WHY IS THE ATMOSPHERE IMPORTANT FOR LIFE ON THE EARTH?

- It contains gasses essential for the existence of animals and plants.
- Need Oxygen for breathing , plants need Carbon Dioxide to produce food during photosynthesis
- Ozone layer protect us from harmful UV rays

1B. NAME THE LAYER OF AIR IN WHICH HUMANS, ANIMALS AND PLANTS LIVE.

- Troposphere

1c. Which atmospheric processes occur in this layer?

- All weather processes e.g. air currents, precipitation, Temperature.
- With increase in altitude, the temperature drops at Normal Lapse Rate of 6.4°C / km

1D. EXPLAIN WHY PASSENGER AIRLINES FLY IN THE UPPER REGION MENTIONED IN (B)?

- To prevent hailstorms, strong cross winds, vacuums, thunderstorms impacting their flight.

1e. What is the transition zone to the next layer above (b) called?

- Tropopause

1F. STATE THE NAME OF THE LAYER ABOVE THE TRANSITION ZONE MENTIONED IN (E).

- Stratosphere

1g. Use an atlas to work out on which continent and in which country the mountain in FIGURE 31 is found. How high is South Africa's highest mountain and where is it situated?

- Mt. Everest is in Nepal, Asia
- Drakensberg, Thabana Ntlenjana, 3482m above sea level, It is on the eastern escarpment of South Africa

1H. IF IT IS 32 °C, WHAT WILL THE TEMPERATURE BE 10 KM ABOVE THE EARTH'S SURFACE?

- -32°C

2. Work with the learner next to you to identify the elements humans release as pollution into the atmosphere. Make a list of the sources of pollution near your school and at home. In a presentation, refer to possible causes, consequences and solutions or strategies.

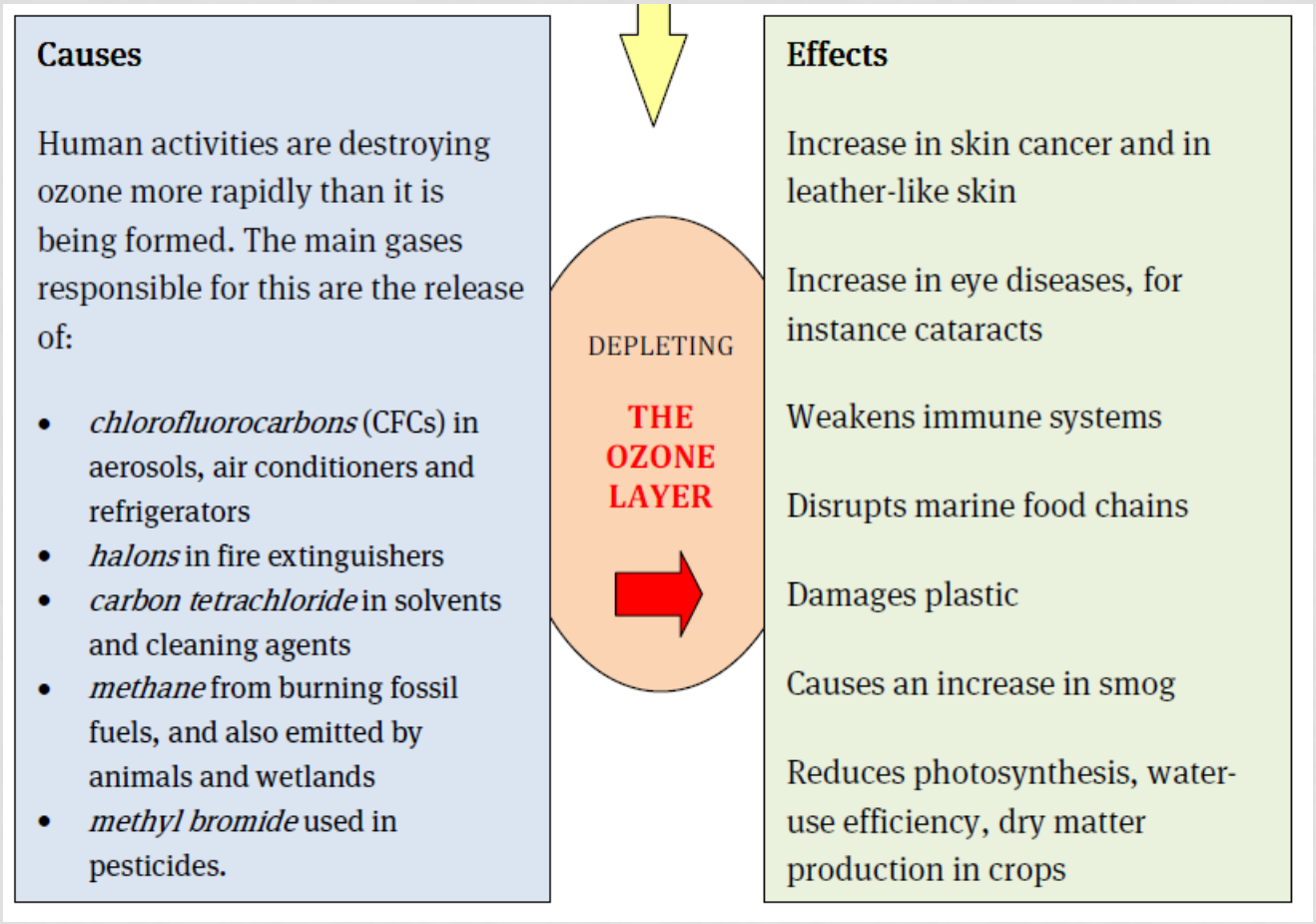
- Dust from excavations, mining, playing on sportsfields
- Exhaust fumes from vehicles
- Factory chimneys

4. THE OZONE LAYER IN THE STRATOSPHERE (PAGE 44)

- Found in the stratosphere
- **Essential for absorbing harmful UV radiation from the sun**
- Any thinning of the ozone layer, will allow more radiation to reach the earth's surface, and this is **dangerous** to us. Since the 1970's, scientists reported that ozone depleting substances were causing serious damage to the ozone layer,

5. CAUSES AND EFFECTS OF OZONE DEPLETION (PAGE 44)

- *See table on next slide*


Causes
Human activities are destroying ozone more rapidly than it is being formed. The main gases responsible for this are the release of:
• *chlorofluorocarbons* (CFCs) in aerosols, air conditioners and refrigerators
• *halons* in fire extinguishers
• *carbon tetrachloride* in solvents and cleaning agents
• *methane* from burning fossil fuels, and also emitted by animals and wetlands
• *methyl bromide* used in pesticides.
DEPLETING
THE OZONE LAYER
Effects
Increase in skin cancer and in leather-like skin
Increase in eye diseases, for instance cataracts
Weakens immune systems
Disrupts marine food chains
Damages plastic
Causes an increase in smog
Reduces photosynthesis, water-use efficiency, dry matter production in crops

ACTIVITY 3: THE OZONE LAYER P45

- 1) a) Stratosphere, 12-50km above surface
- 1b) Ozone Layer absorbs UV rays from the sun, this increases the heat the higher you go up in the Stratosphere.
- 1c) Mesosphere: The higher up the colder the temperature, because it does not absorb UV rays, and it is further away from Earth's atmosphere
- Thermosphere: The higher up, the warmer. It is closer to the sun/ under more direct influence of the sun rays

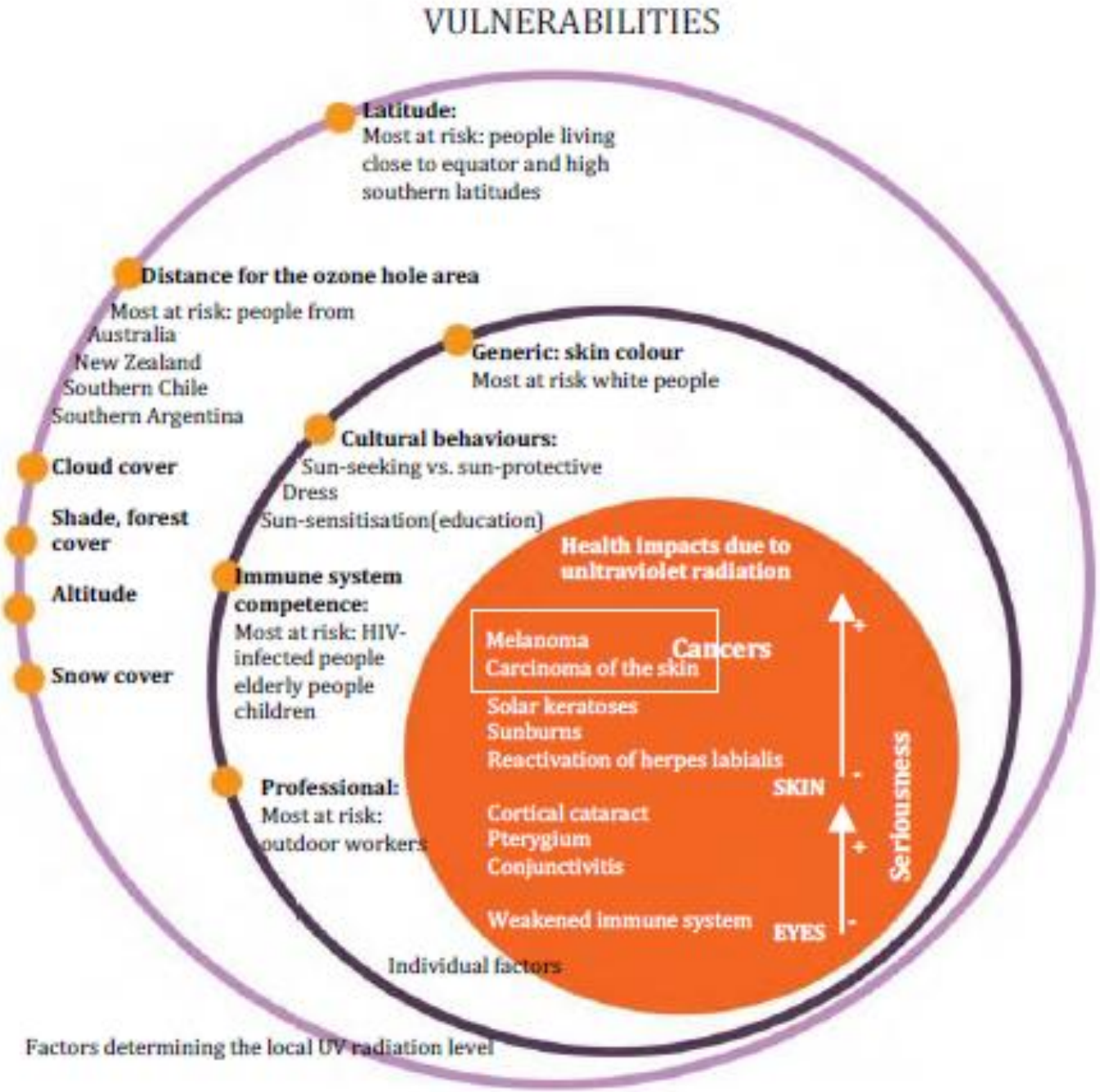
- 1d) CFC's and halons rise through the troposphere over a period of years. UV rays break down the CFC's and halons, releasing chlorine and bromide, which change ozone into oxygen. (Breaking down the ozone)
- 2a) Hole above Antarctica (South Pole), areas along the equator and areas along the Arctic region (North Pole)
- 2b) The atmosphere above South Africa has 300 Dobson units of ozone, which is halfway between normal and high depletion.

6. Ways to reduce ozone depletion (p. 46)

- The depletion of ozone causes:
  - Increase in skin cancer
  - Production of wrinkled, leather-like skin
  - Increase in eye-diseases
  - Weakened immune systems
  - Disruption of marine food chain
  - Ocean plankton and other fish populations decline
  - Damage to some materials such as plastic
  - Increasing amounts of smog

Factors determining the local UV radiation level	Individual factors determining own exposure to UV radiation	Health impacts if at risk
Latitude, altitude Distance from the ozone hole Cloud cover Shade or forest cover, snow cover	Genetic skin colour Cultural behaviour Immune system competence Profession	Sun burn Cancer Leather skin

Fig. 36
page 47



Activity 4: Tabulation and investigation p47

- 1) Minister Barbara Creecy
- 2)

Human and animals	Plants	Non-living things
Increase in skin cancer Produces wrinkled skin Eye diseases Animals: Cancer of the eyes Weakened immune system Increase in malaria	Reduced photosynthesis Reduced water usage efficiency Reduced leaf area Decline in plankton More sensitive to drought stress Disruption of marine food chain Modified flowering	Damages materials .e.g. plastic Intensification of smog

- 3) Pretoria 50% exposed, dark skin less risk, light skin more risk, not too young or old

Unit 1 Questions: Answers

- 1) A – Troposphere, B – Stratosphere, C – Mesosphere, D – Thermosphere.
- 2a) Stratopause
- B) Mesopause
- 3) They fly just above most of the weather processes in the troposphere.
- 4) 10 km: -55°C; 50km: 20°C; 90km: -83°C
- 5) Troposphere: decrease in temperature – moving away from Earth which is responsible for heating of the atmosphere.
- Stratosphere: increase in temperature – ozone layer absorbs UV rays from sun.
- Mesosphere: decrease in temperature – even further away from the Earth (source of heating atmsosphere).
- Thermosphere: increase in temperature – much nearer to insolation from sun.

- 6) Homosphere: sphere in which the chemical (gas) composition of the atmosphere remains uniform – includes troposphere, stratosphere, mesosphere.
- Heterosphere: chemical composition in this sphere varies – includes mainly the thermosphere.
- 7a) Ozone layer
- B) It absorbs harmful ultraviolet rays of the sun.
- C) Chlorofluorocarbons, halons, carbon tetrachloride, methane, methyl bromide.
- D) People: increase of skin cancer; produces wrinkled skin; eye diseases like cataracts; weakened immune system.
- Plants: enhanced plant fragility; growth limitation; yield reduction.
- E) Minimise production of ozone-depleting substances; deliberately minimise impact of factors that may increase your vulnerability.

- 8a) Nitrogen (N_2)
- B) Oxygen (O_2)
- C) Produced by photosynthesis; reduced by deforestation
- D) Variable gases
- E) Source of cloud formation and precipitation; reflects/absorbs incoming radiation; keeps global temperatures constant.
- F) 0,03
- G) Used by plants for photosynthesis; increased by burning fossil fuels and by deforestation
- H) Ozone (O_3)
- I) Inert or noble gases
- J) Dust, salt and smoke particles
- K) Affects radiation; causes acid rain
- L) From industry, power stations and car exhausts.