# Makerere University Department of Geography, Geo-informatics and Climatic Sciences

## COURSE ON

## Principles of Earth Systems Science

## [GEO-1104]

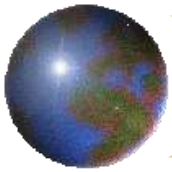
**Academic year: 2023/24**

**Course Instructor:**

**Semakula Musoke Henry, *PhD***

# Disclaimer

- The examples used in this presentation are met for academic illustrations and are not used to annoy or demean any body.
- Some slides are a bit congested because they will act as lecture notes for you.



# Intended learning outcomes for Topic 1

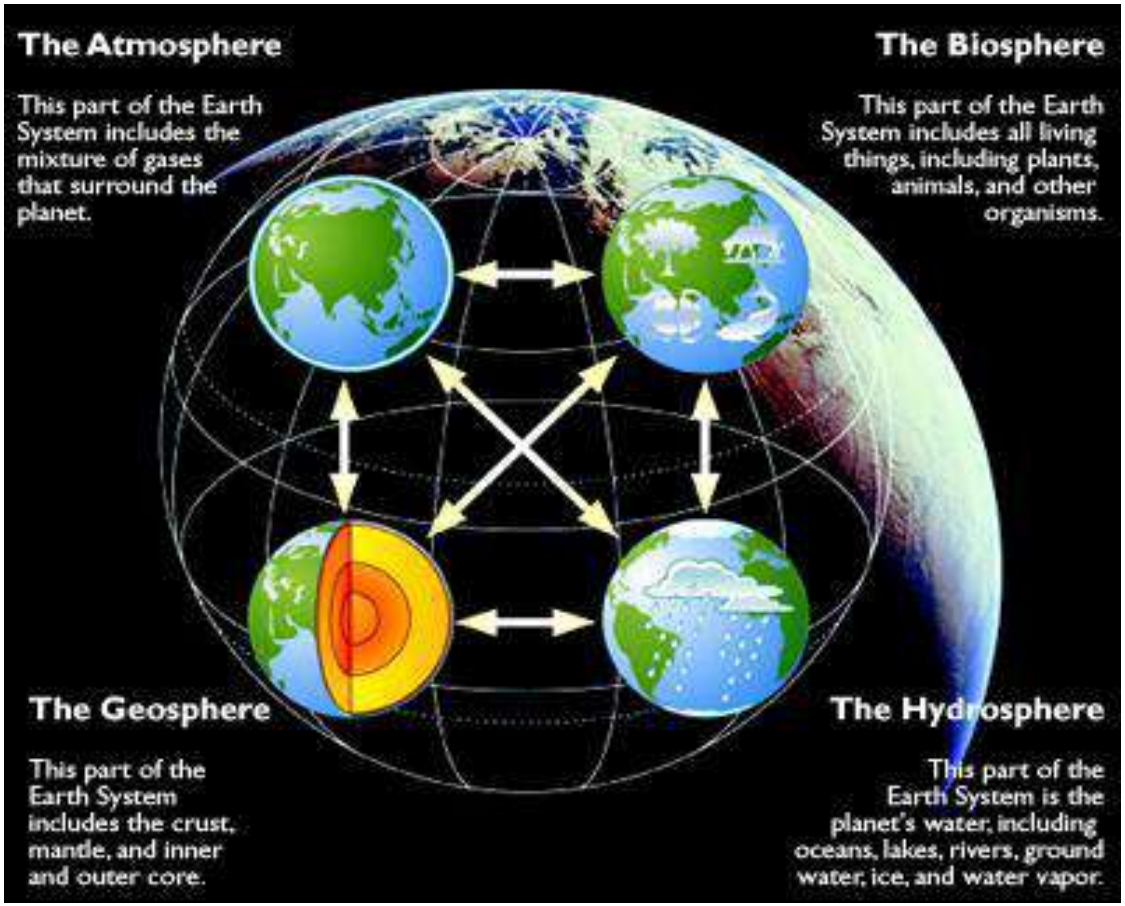
By the end of Topic 1, you should be able to:

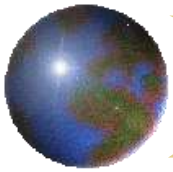
1. Define earth science and List the sciences that collectively make up Earth science.
2. Why study the Earth
3. Explain basic chemistry concepts
4. Discus the factors influencing primary production
5. Discuss the interactions between principal components of the Earth system
6. Explain the variations in the composition and characteristics of Earth's different layers.
7. Describe the structure of the atmosphere
8. Explain health problems associated with high levels of carb intake
9. Summarize the basic steps followed in many scientific investigations.

# TOPIC 1: INTRODUCTION TO EARTH SCIENCE

- The Earth is approximately **4.6 billion years old**.
- It is an integration of **four systems or spheres**:

1. Atmosphere (Air),
2. Hydrosphere (Water),
3. Lithosphere (Land)
4. Biosphere (Life)





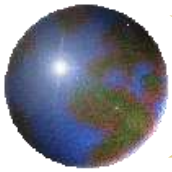
# TOPIC 1: INTRODUCTION TO EARTH SCIENCE

## Why Study Earth?

1. Earth is our home and our ***only home*** for the foreseeable future. In order to ensure that it continues to be a great place to live, we need to understand how it works.
2. We rely on Earth for ***valuable resources*** such as soil, water, metals, industrial minerals, and energy, and we need to know how to find these resources and exploit them sustainably.

Other reasons include. We can

1. Study rocks and the fossils to ***understand the evolution of our environment*** and the life within it.
2. Learn to ***minimize our risks*** from earthquakes, volcanoes, slope failures, and damaging storms.
3. Learn how and why ***Earth's climate has changed*** in the past, and use that knowledge to understand both natural and human-caused climate change.
4. Recognize ***how our activities*** have altered the environment in many ways and the climate in increasingly serious ways, and how to avoid more severe changes in the future.
5. Use our knowledge of Earth to ***understand other planets*** in our solar system, as well as those around distant stars.

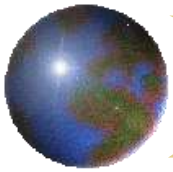


# TOPIC 1: INTRODUCTION TO EARTH SCIENCE

## ❑ What do earth scientists do?

## Earth scientists:

1) study earth processes: floods, storms and atmospheric phenomena, earthquakes, landslides, volcanic eruptions
2) explore and manage resources: marine resources, oil & gas, water, metals, rock byproducts
3) work in environmental fields: climate change, water and waste management, and resource protection
4) work in construction and engineering: archeology, urban planning, coastal and marine port management.
5) serve in national security and are involved in public health and safety.
6) study ocean basins, glaciers, predict weather patterns, and are involved in space exploration programs.
7) work in education: schools, parks, and museums



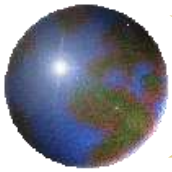
# TOPIC 1: INTRODUCTION TO EARTH SCIENCE

- Earth Science is the name for **all the sciences** that collectively seek to understand *Earth[i.e. rock and landscapes, biotic resources, oceans and water resources, and the atmosphere]* and its neighbors in space[e.g. other planets].
- A great deal of an Earth scientist's study is based on

  1) Observations

  2) Experiments conducted in the field.

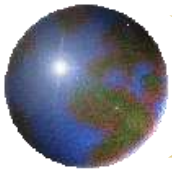
  3) Earth science can also be conducted in the laboratory. E.g. the study of various Earth materials provides insights into many *basic processes*, and the creation of complex computer models allows for the simulation of our planet's complicated climate system



# TOPIC 1: INTRODUCTION TO EARTH SCIENCE

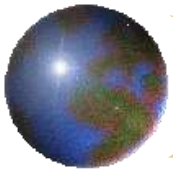
## ❖ Definition of Earth System Science

- Interdisciplinary study of the earth's naturally occurring *phenomena, its processes and evolution*.
- Earth System Science by necessity involves the marriage of a number of specialty sciences and the major one include the following:



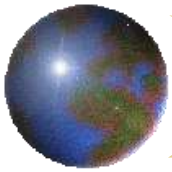
# TOPIC 1: INTRODUCTION TO EARTH SCIENCE

1. **Astronomy-** Study of the origin, evolution and composition of the *universe, solar system and planetary bodies.*
   - ***Cosmology:*** *origin of the universe*
   - ***Astrogeology****: comparison of extra-terrestrial planetary bodies with the earth*
   - ***Astrophysics:*** *quantitative study of the physical nature of the universe.*
2. **Geology-** study of the earth, its composition, origin, evolution and processes. Geology is traditionally divided into two broad areas:
   - ***Physical geology:*** *examines the materials composing Earth and seeks to understand the many processes that operate beneath and upon its surface*
   - ***Historical geology:*** *aims to understand the origin of Earth and the development of the planet through its 4.6-billion-year history.*



# TOPIC 1: INTRODUCTION TO EARTH SCIENCE

- Under geology, we have sub-studies which include:
  - **Mineralogy/Petrology:** Study of rocks and minerals
  - **Geophysics:** Study of earth physics and processes
  - **Volcanology:** Study of volcanoes
  - **Seismology**: Study of earthquakes and seismic waves
  - **Geomorphology:** Study of surface processes and landforms
  - **Paleontology/Historical Geology**: Study of past life and historical evolution of the earth through time.
  - **Plate Tectonics**: Scientific theory describing the large-scale motion of seven large plates and the movements of a larger number of smaller plates of the Earth's lithosphere.



# TOPIC 1: INTRODUCTION TO EARTH SCIENCE

3. **Meteorology:** Study of atmosphere and the processes that produce weather and climate. We have sub studies under this category and these include:
    - Climatology: study of *geographic climate patterns, processes and causes*.
    - Weather studies and weather prediction (focus is also put on Storm Prediction and Emergency Management).
    - Atmospheric Science: study *of physics and chemistry of earth's atmosphere*. It also focuses on Environmental/Air Pollution Control.
4. **Oceanography**: study of earth's ocean systems.
    - Oceanography integrates chemistry, physics, geology, and biology.
    - It includes the study of the composition and movements of seawater, as well as coastal processes, seafloor topography, and marine life

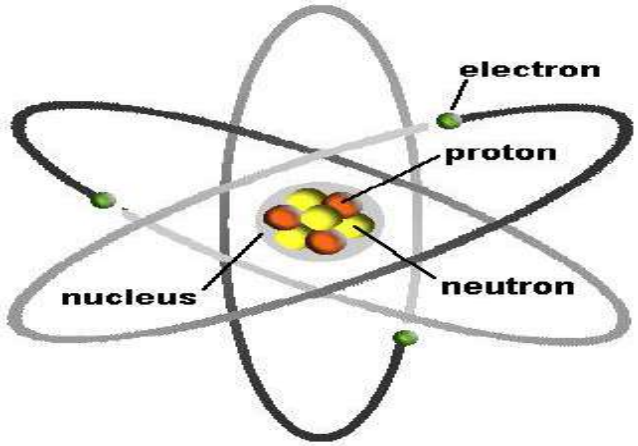
# TOPIC 1: INTRODUCTION TO EARTH SCIENCE

## ❑ Important Concepts in Chemistry

- These concepts provide basic background information that are essential to understanding the physical, biological and chemical properties of matter, particularly related to **natural earth materials** (rocks, seawater, air, organic matter, etc.).

### 1. An atom

- ✓ is the smallest unit of a chemical element.
- ✓ Atoms have ***a nucleus*** composed of *neutrons and protons* and has a **POSITIVE CHARGE**.
- ✓ **Negatively** charged electrons **ORBIT AROUND THE NUCLEUS** in shell-like layers.
- ✓ All matter is made up of atoms, and atoms are made up of atomic particles ***[electrons, protons, and neutrons]***



## ❑ Important Concepts in Chemistry

### 2) A chemical **element**

- ✓ is a ***pure chemical substance*** consisting of one type of atom distinguished by its **atomic number**, which is the **number of protons in its nucleus**.
- ✓ Elements have equal balance in numbers of positively charged protons and negatively charged electrons.
- ✓ Common examples of elements are iron, copper, silver, gold, hydrogen, carbon, nitrogen, and oxygen.

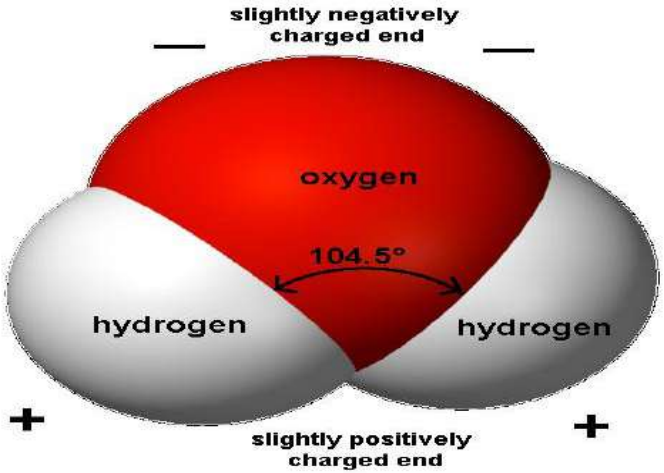
### 3) An **element**

- ✓ is a substance that ***cannot be broken down*** into simpler substances by chemical means.
- ✓ An element is composed of atoms that have the same **atomic number,** that is, each atom has the **same number of protons in its nucleus** as all other atoms of that element.
- ✓ Each element is assigned a 1-2 letter symbol to represent the element for general use, such as in the writing of chemical formulas (such as H2O used for water).

## ❑ Important Concepts in Chemistry

### 4) A **molecule**

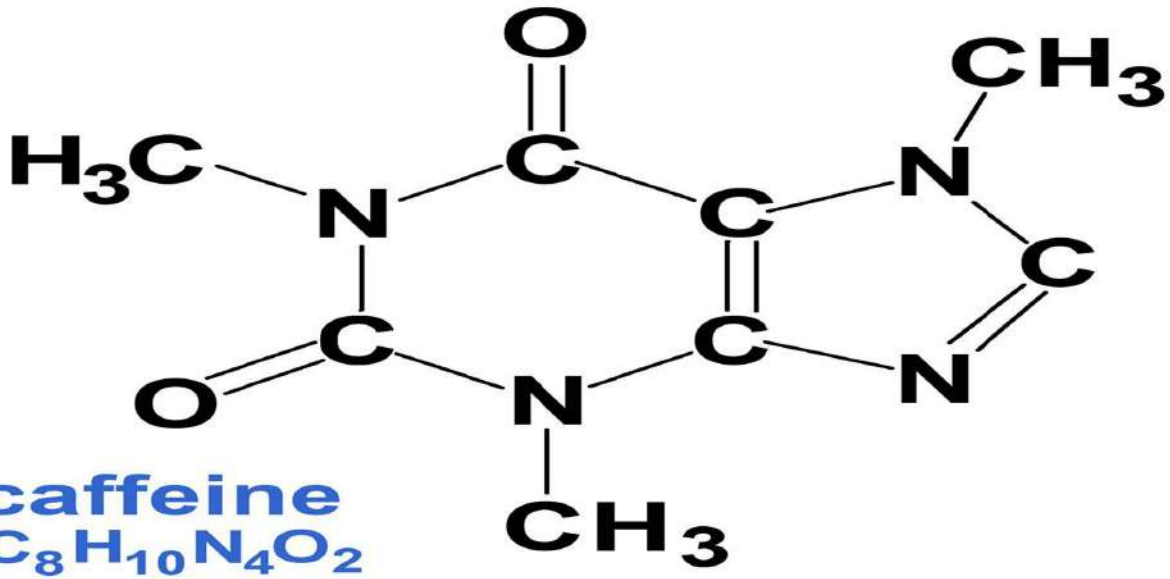
- ✓ is a group of atoms bonded together, representing the smallest fundamental unit of a chemical compound *that can take part in a chemical reaction*.
- ✓ For instance, a **molecule of water**—chemical formula, **H2O**—is made up of two hydrogen atoms and one oxygen atom.
- ✓ **Atoms** bond together to form **molecules**.



## ❑ Important Concepts in Chemistry

### 5) Chemical formulas

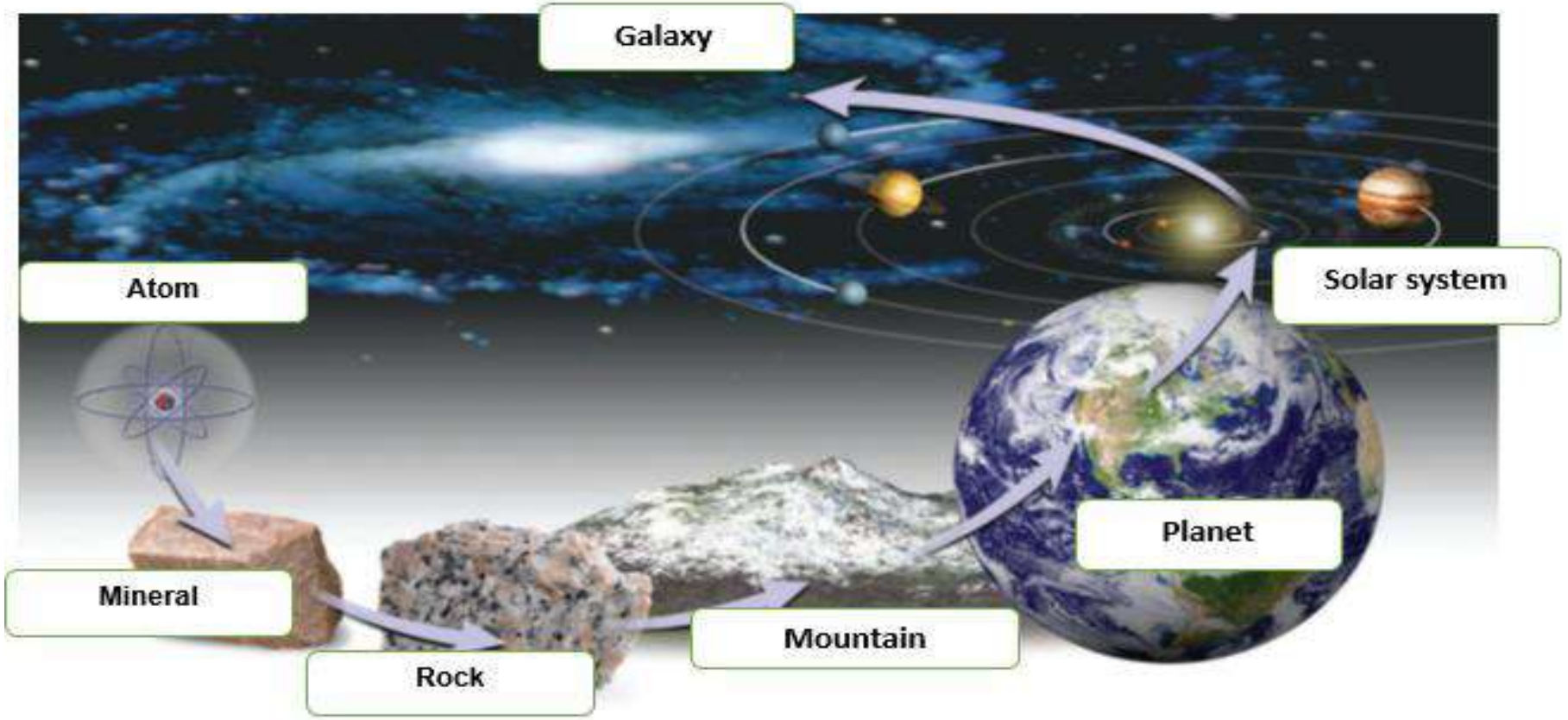
- ✓ **are used to describe compounds** such as H2O (for water), NaCl (for salt), CO2 (for carbondioxide).
- ✓ Chemical formulas may be **simple text designations showing** the ratio of elements, or may be represented by graphic means showing relationships (orientation and bonding) between elements within molecules,

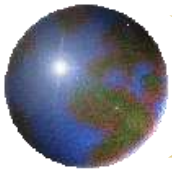



caffeine
$C_8H_{10}N_4O_2$

# TOPIC 1: INTRODUCTION TO EARTH SCIENCE

- **Scales of Space** and Time in Earth Science.
  - Earth science involves investigations of phenomena that *range in size from the atomic level to those that involve large portions of the universe* as shown in below.





# TOPIC 1: INTRODUCTION TO EARTH SCIENCE

❖ Scales of Space and Time in Earth Science.

- Some phenomena are relatively easy for us to imagine, such as the duration of an afternoon thunderstorm.
- Some of the events we study occur in fractions of a second. Lightning is an example.
- Other processes extend over spans of tens or hundreds of millions of years.

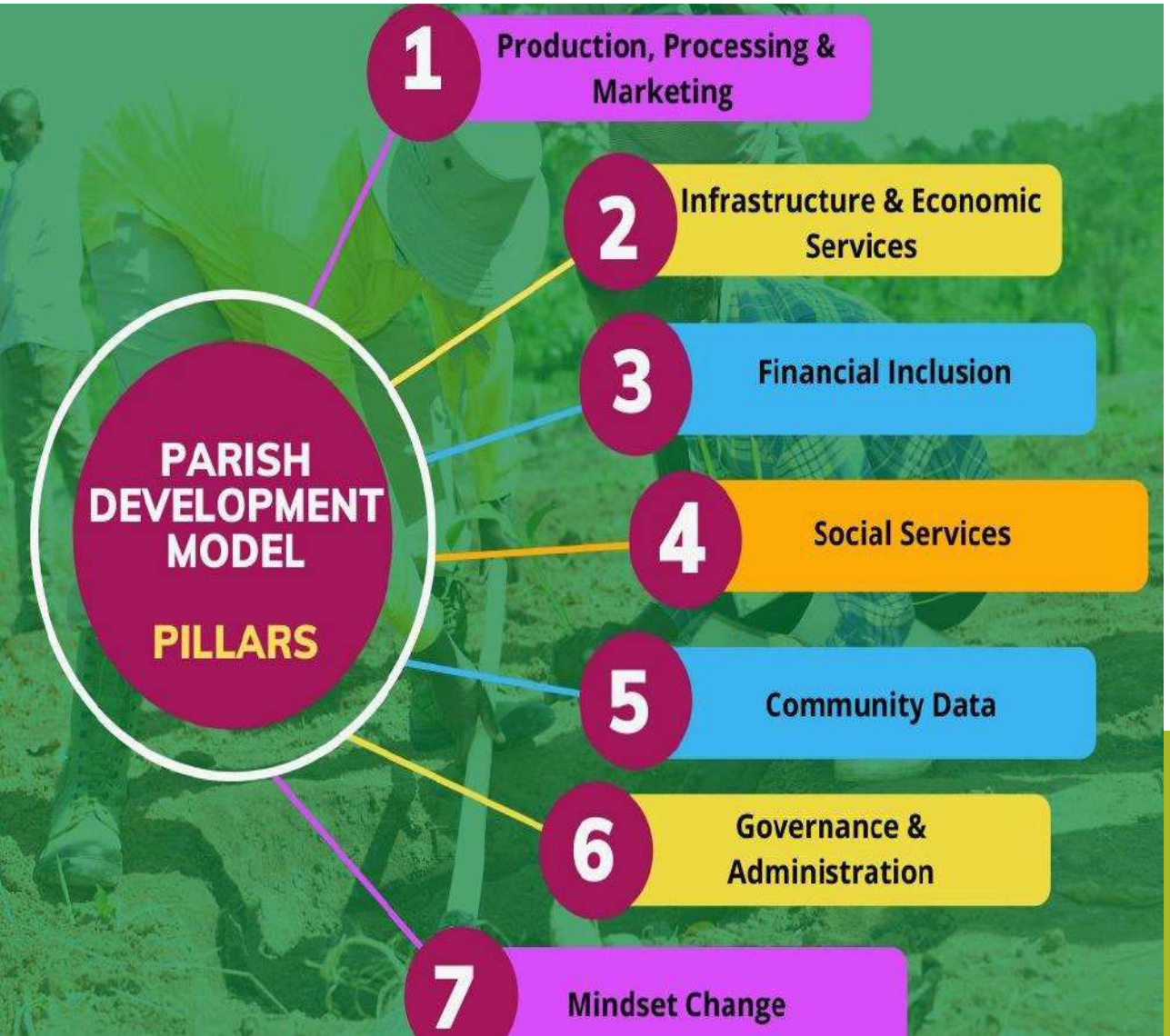
  For example, the lofty Himalaya Mountains began forming nearly 50 million years ago, and they continue to develop today.

# TOPIC 1: INTRODUCTION TO EARTH SCIENCE

## Earth Systems Science and Planning Frameworks-Global

# TOPIC 1: INTRODUCTION TO EARTH SCIENCE

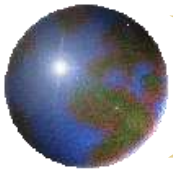
## Earth Systems Science and Planning Frameworks-Uganda




Uganda Vision 2040


**UGANDA GREEN GROWTH DEVELOPMENT STRATEGY 2017/18 – 2030/31**

(NATIONAL PLANNING AUTHORITY, CLIMATE CHANGE DEPARTMENT (MWE) AND UGGDS TASKFORCE)
WITH SUPPORT FROM UNDP



# TOPIC 1: INTRODUCTION TO EARTH SCIENCE

## THE SPHERE OR COMPONENTS OF THE EARTH

### a) The Biosphere

- It includes all life on Earth, plants, animals, both microscopic and macroscopic.
- All life on the planet is contained **within its uppermost layer** of the earth, including its atmosphere.
- The vast majority of all earthly life inhabits a zone less than ***3 miles thick***, and the total vertical extent of the life zone is less than 20 miles.

# Primary Production: The Foundation of Ecosystems

# Primary Production (1)

- **Primary production:** is the storage of **energy** through formation of **organic matter** from inorganic carbon compounds. E.g. carbon dioxide.
- It a rate with units of mass per area (or volume, if measured in water) per time. *[Amount of biomass produced per unit area over a given period of time by plants during photosynthesis]*
  - For example, primary production data are often presented as **grams carbon** per square meter per day.
- The absolute amount of plant material produced in an ecosystem is sometimes referred to as production or *yield* (mass per unit area or volume) as, for example, the total mass of corn plants generated in a field.

# Primary Production (1)

- Primary production is carried out by autotrophic organisms.
  - The term autotrophic is derived from the Greek words **autos**, meaning **SELF**, and **trophikos,** meaning pertaining to food.
  - Autotrophs are "self-feeders."
  - Higher plants *[grown ups]* as well as some microbes (e.g., algae) are autotrophs.
- Plants and algae conduct the most familiar form of primary production—**photosynthesis**—where carbon dioxide is incorporated into organic matter using energy from sunlight.
- In most ecosystems, primary production is carried out by *a variety of species* and the *diversity of autotrophs* influences **primary production**
- **Factors influencing PP summarized:**
  1. **Plant species of a particular area**
  2. **Nutrient availability/ soil fertility**
  3. **Environmental Factors[Temperature, water/rainfall, sunlight, topography, climate change]**
  4. **Human Activities *[Discus the human activities that influence primary production]***

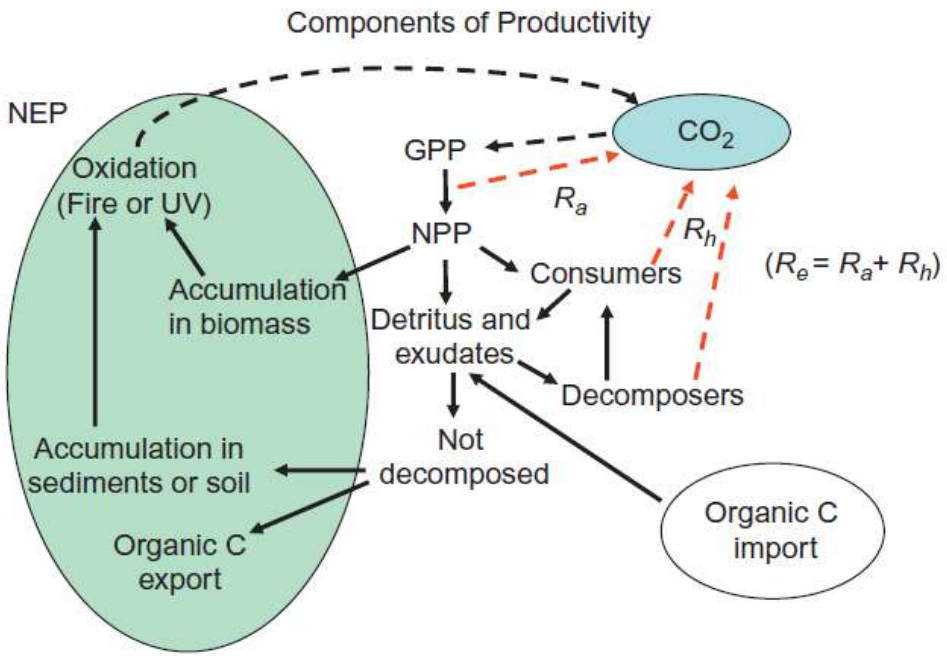
# Primary Production (2)

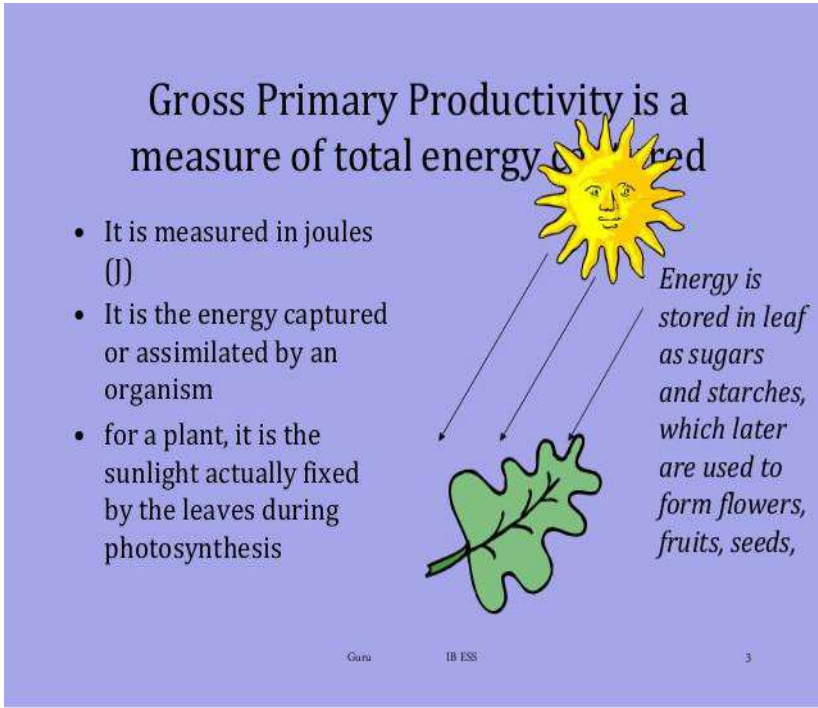
- Why do ecologists consider primary production a fundamental ecosystem process

1) The ecosystem carbon cycle begins with the fixation of carbon (i.e., incorporation of $CO_2$ into organic matter by green plants).
2) Herbivores consume this *organic carbon* produced by autotrophs to support their **growth and metabolism**.
3) Other components of the **food web** such as detritivores and predators also depend directly or indirectly on primary production for their energy supply.
4) Primary producers [Plants] require **nutrients such as nitrogen and phosphorus** to build biomolecules such as **proteins and nucleic acids.**
5) The uptake and cycling of nitrogen, phosphorus, and other elements accompanies **primary production**, and the ratio of elements that ultimately comprises primary producers influences many ecological processes.
6) The formation of organic matter by primary producers is also a key process of the global carbon cycle.
7) Primary production influences atmospheric carbon dioxide concentration

# Components Of Primary Production(a)

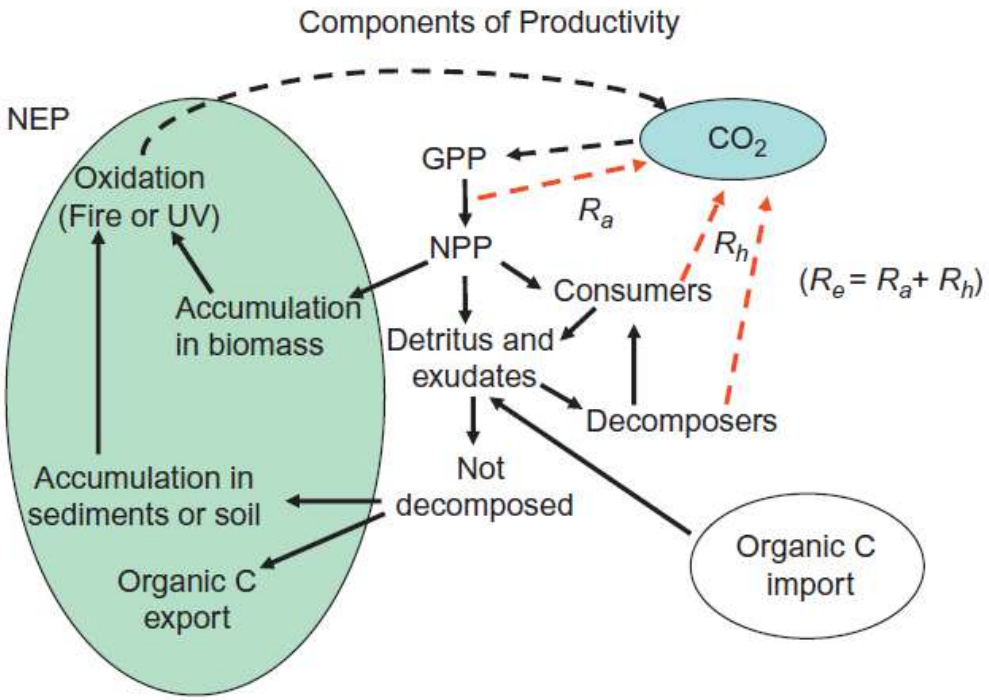
- The components of primary production are clarified by following the flow and rates of carbon through a generalized ecosystem
  - Primary production begins with the **FIXATION** of CO2 into organic matter/carbon.
  - Gross primary production (GPP) *[rate of photosynthesis or gains in energy or biomass]*represents this **FIRST STEP** accounting for all the carbon dioxide fixed into organic matter irrespective of any respiratory losses.

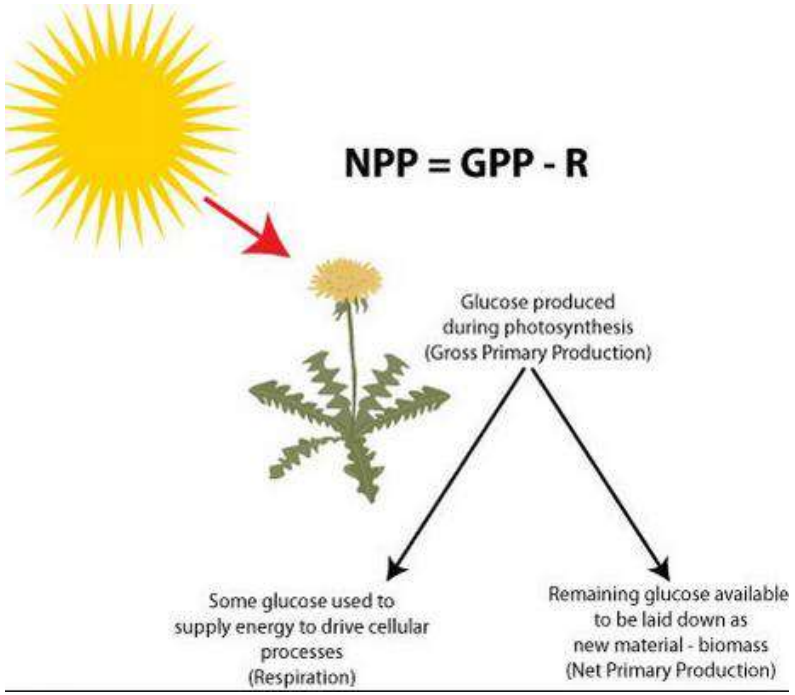


# Components Of Primary Production(b)

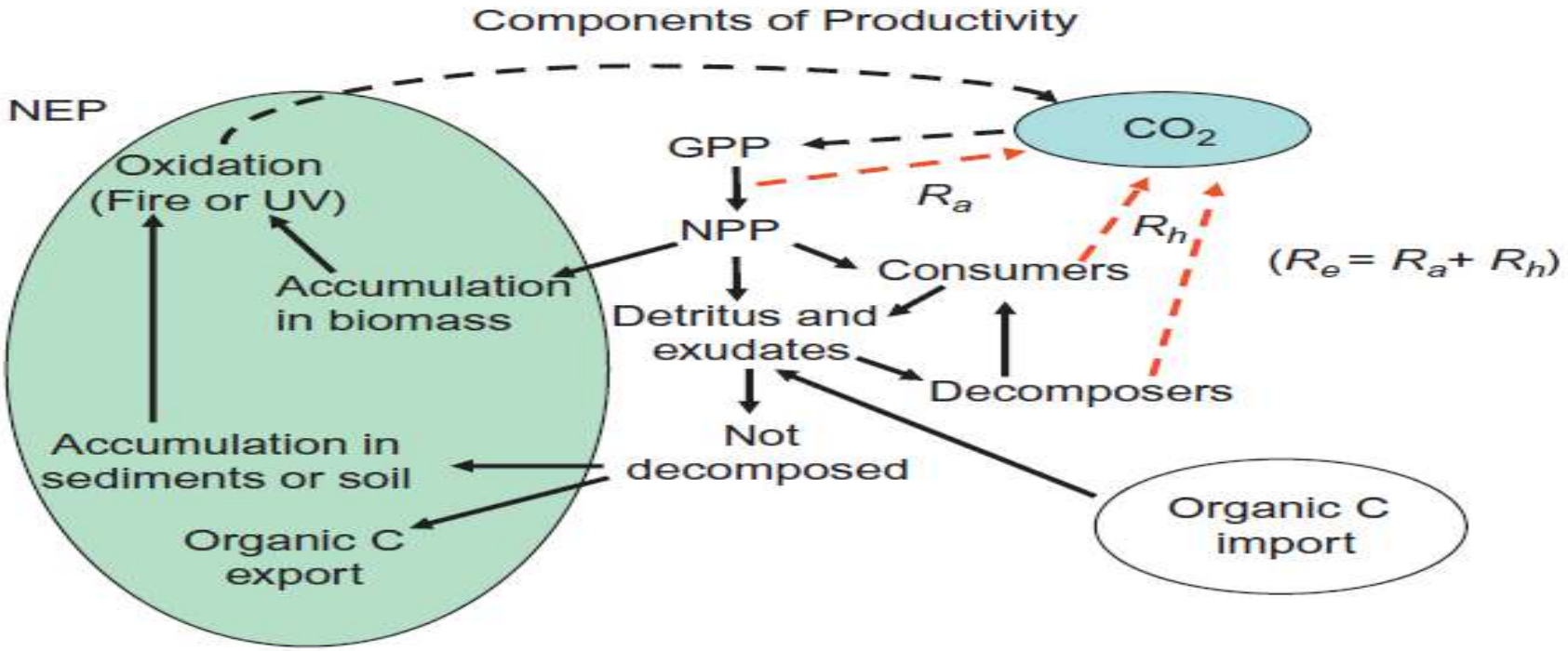
- Net primary production (NPP) is the difference between GPP and autotrophic respiration (Ra): **NPP=GPP-Ra.**
- Conceptually, NPP is the rate at which organic matter is made available for other uses beyond SIMPLY SUPPORTING ENERGY COSTS (i.e., respiration) of the primary producers.
- Net primary production is **consumed, converted to detritus [waste]**, or accumulated in biomass.



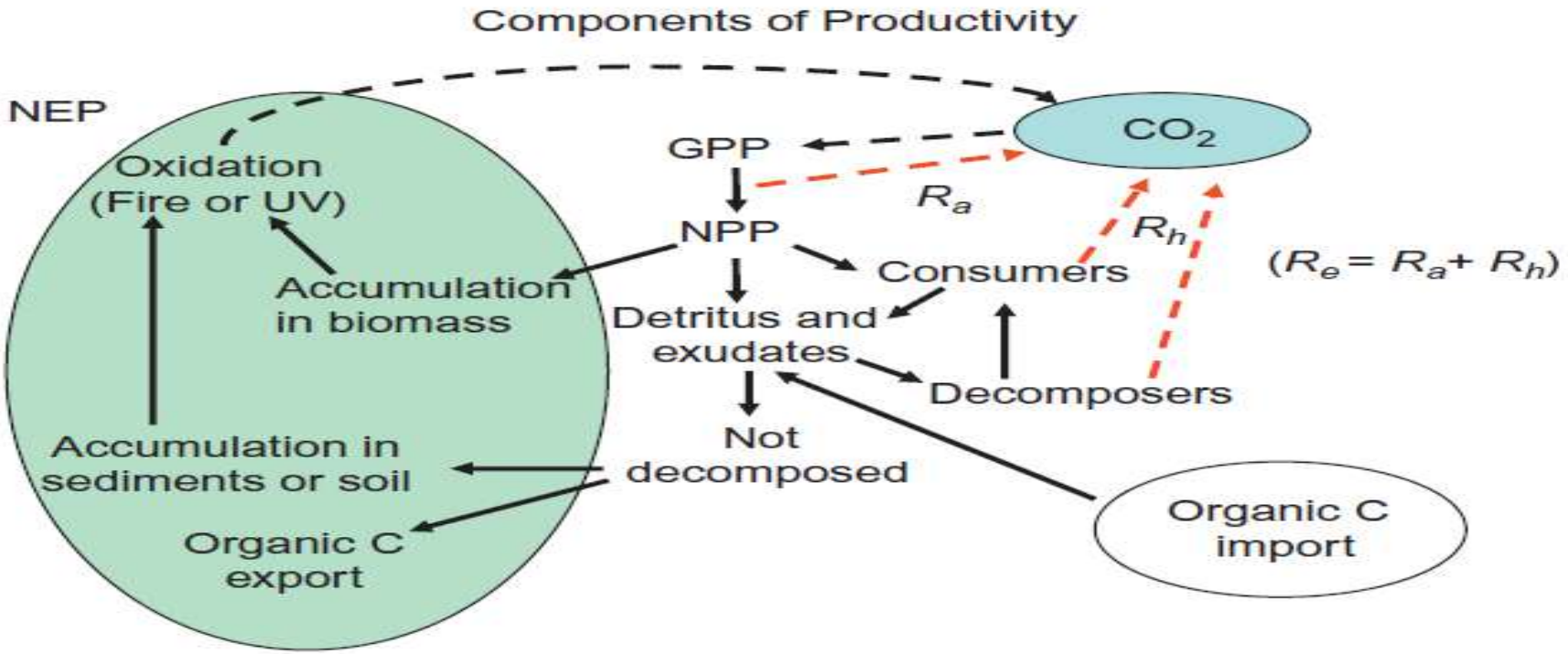
# Components Of Primary Production(c)

- The portion of the NPP that is CONSUMED AND RESPIRED by **heterotrophic organisms (Rh)** is cycled back to the atmosphere as CO2. **Ecosystem respiration** (Re) is the sum of ***Ra and Rh***.
- Ecosystem respiration typically does not consume all the organic carbon that is either produced within or imported to the ecosystem.
- Some organic carbon accumulates in biomass (e.g., wood in trees) and **detritus** (e.g., organic matter in soils and sediments).



# Components Of Primary Production(d)

- Some organic matter is **EXPORTED** (e.g., organic carbon exiting a river ecosystem and entering the ocean).
- Together these rates of **accumulation and export represent net ecosystem production (NEP)**.
- The balance of carbon flows requires that NEP is equivalent to the difference between GPP and Re: NEP=GPP-Re.

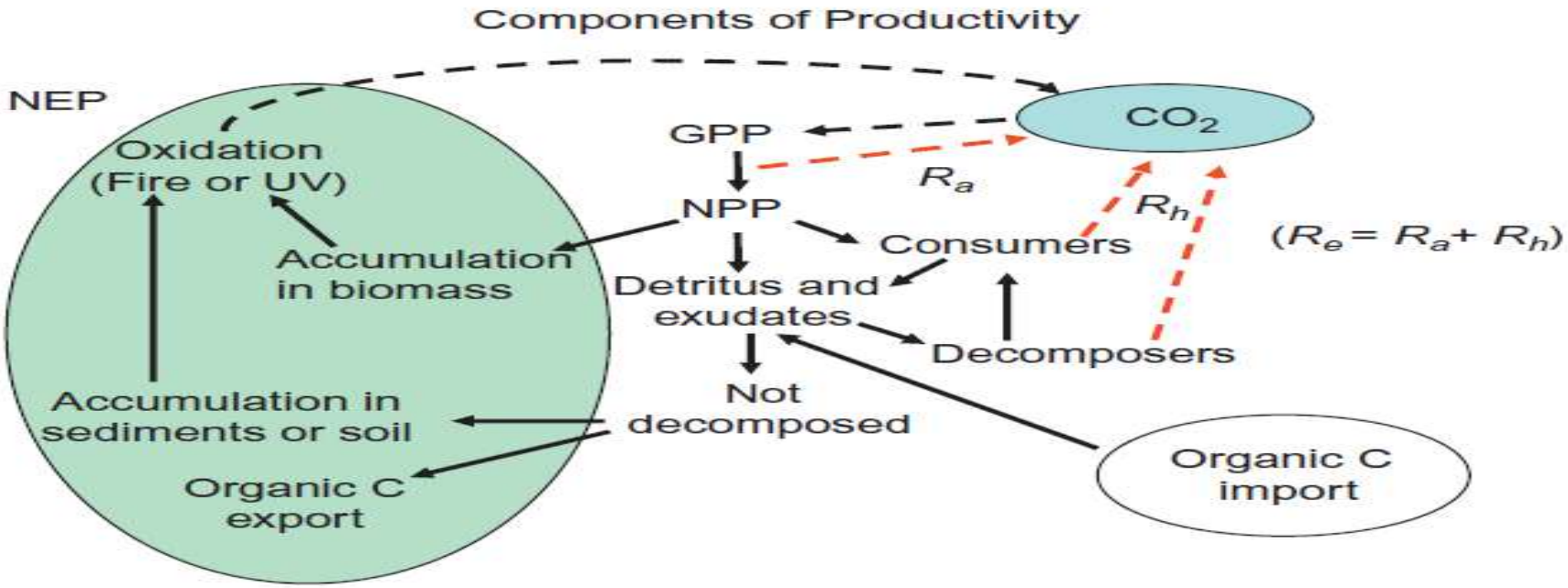


# Components Of Primary Production(e)

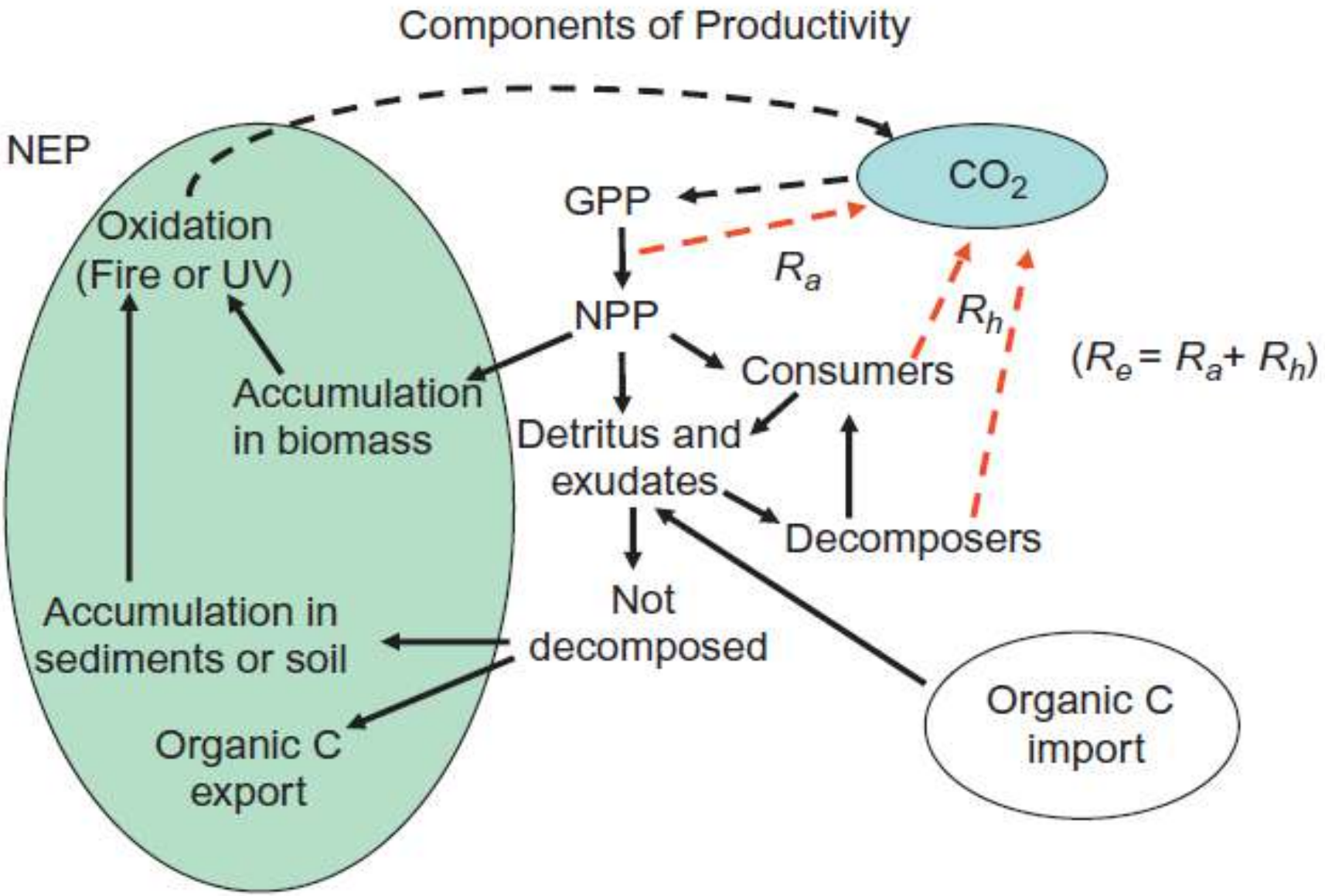
- Because Re is the sum of Ra and Rh and NPP is the difference between GPP and Ra, NEP can also be expressed as:.

**NEP=GPP-Ra -Rh=NPP-Rh**

- In other words, *NEP is the portion of gross primary production that is not respired by autotrophs or heterotrophs*.
- This residual production either **ACCUMULATES** as carbon in biomass or detritus, is **EXPORTED** from an ecosystem, or is **LOST** through fire or photo-oxidation**.**



# Components Of Primary Production(f)



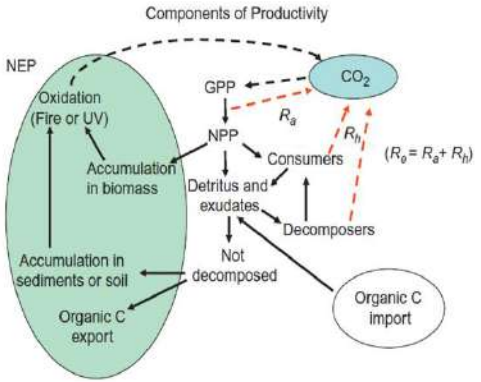
# NEP Positive or Negative(1)

- Interestingly, NEP **[Net Ecosystem Production] CAN BE EITHER** positive or negative. How is this possible?
  - One way this can occur is if the primary production of an ecosystem is **STOPPED** or severely reduced (NEP=GPP-Re), but **the respiration of stored organic matter** continues. For instance, consider a forest that has just been clear-cut so that there is little or no primary production but DECOMPOSERS are still consuming (and respiring) the organic matter in the forest floor.
  - Another way that negative NEP can occur is if an ecosystem imports organic carbon, and these imports are **RESPIRED BY HETEROTROPHS** along with the carbon produced within ***an ecosystem.***
- In both cases the **total respiration of the ecosystem** exceeds gross primary production (Re> GPP), thus NEP is negative.
- Ecosystems with **negative NEP** are referred to as **heterotrophic ecosystems: (ecosystem using MORE ENERGY than it is CREATING)**
  - These systems respire **more carbon** than they produce and the excess respiration either depletes carbon stored in the system or is **subsidized** by imports of carbon from outside the ecosystem.
  - Ecosystems with negative NEP include many **lakes, streams, rivers, and estuaries**

# NEP Positive or Negative(2)

- In contrast, ecosystems with positive NEP are **autotrophic ecosystems.** ***(ecosystem CREATING MORE ENERGY than it is USING)***
- We can also consider NEP in the context of **organic carbon accumulation** (dCorg) in an ecosystem by considering a mass balance of inputs and losses:

**dCorg =GPP+I -Re –Ex-Oxnb**




- where the new terms are:

  I=imported organic carbon

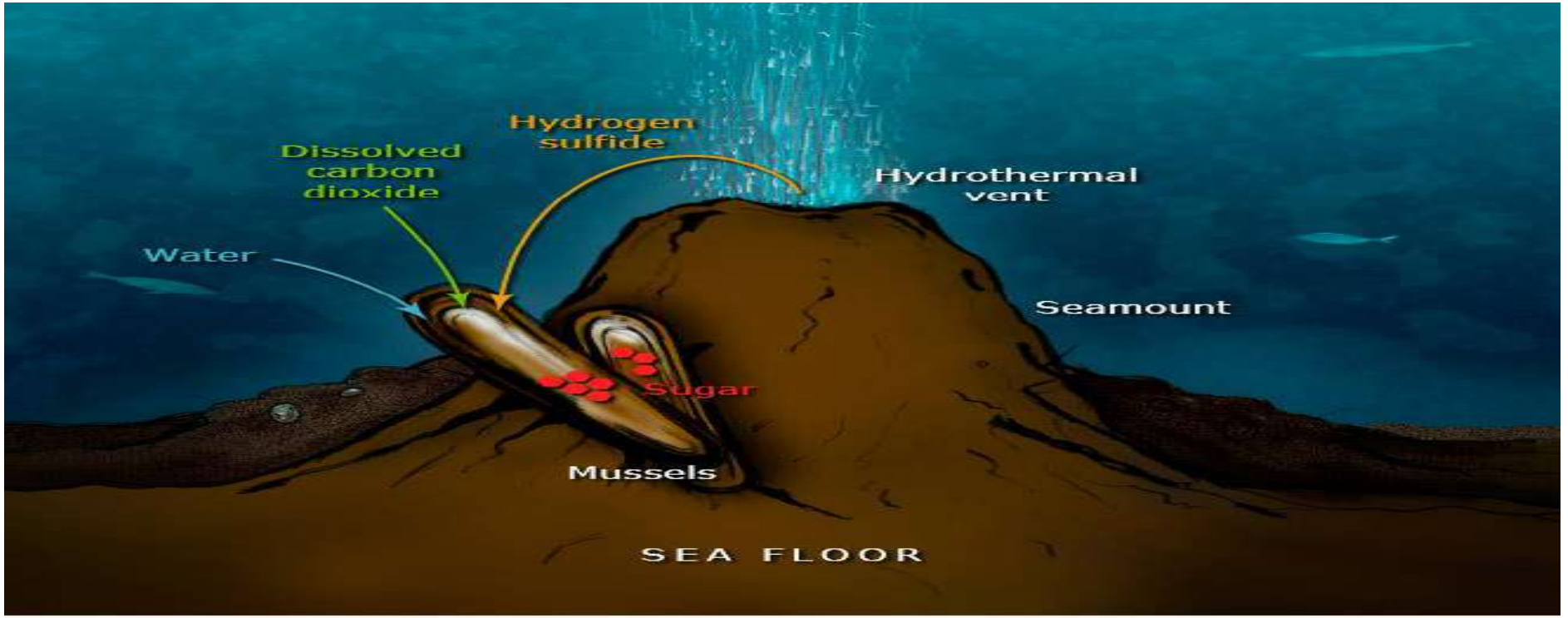
  Ex=exported organic carbon

  Oxnb=nonbiological oxidation of organic carbon (e.g., fire or photo-oxidation)

- Since NEP is equal to GPP  Re, the above equation can be rewritten as: **dCorg =NEP+I –Ex-  Oxnb**
- Organic carbon accumulation (dCorg) in ecosystems sequestered over long time periods (centuries to millennia) provides **A SINK FOR ATMOSPHERIC CO2** and is very important to those studying global carbon budgets

# NEP Positive or Negative(3)

- Not all primary production **RESULTS** from aerobic photosynthesis where water is split and oxygen is produced in the fixation of carbon.
- Under **anoxic conditions** ***[without oxygen]***, some microorganisms can fix carbon, for example, using hydrogen sulfide (H2S) *[foul odor of rotten eggs]* instead of water and producing **SULFUR** instead of **oxygen.**

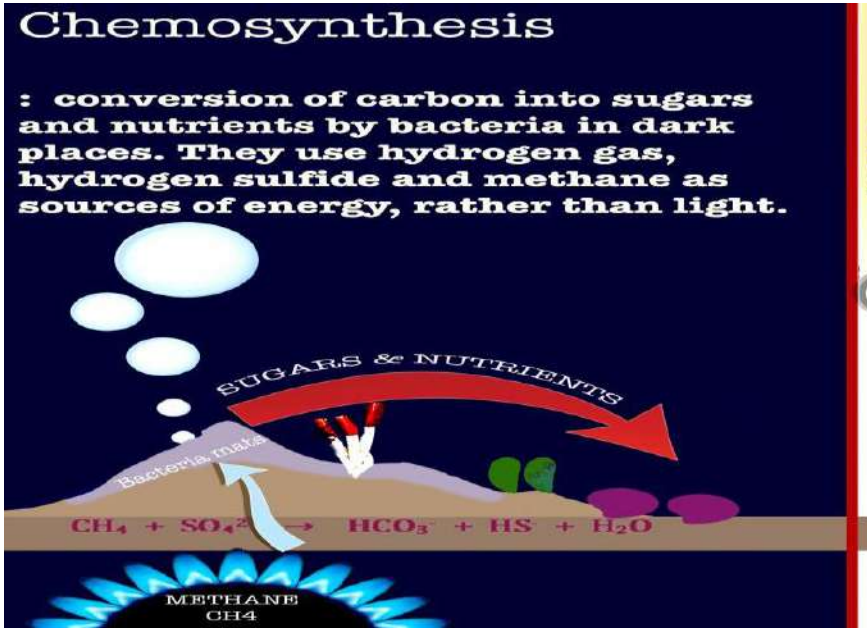


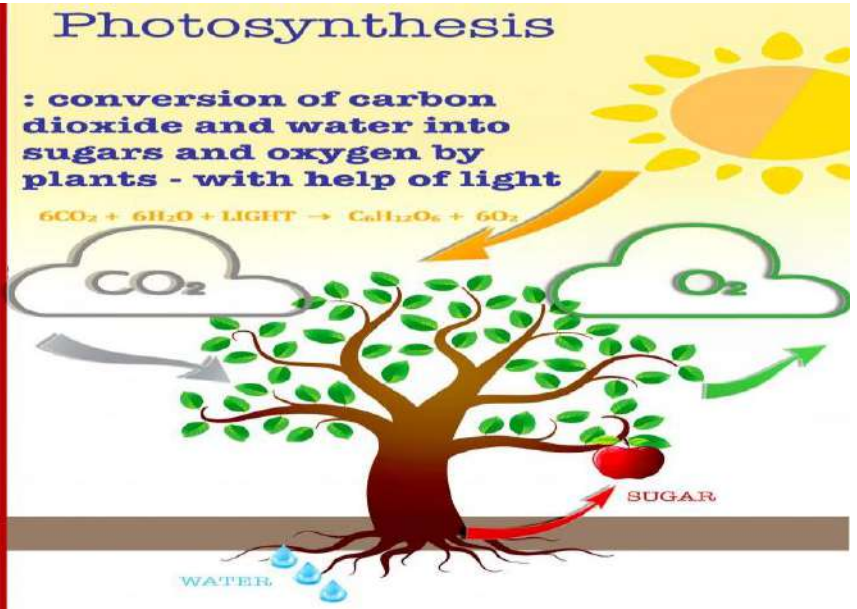

$$6CO_2 + 6H_2O + 3H_2S \longrightarrow C_6H_{12}O_6 + 3H_2SO_4$$

Carbon dioxide + Water + Hydrogen sulfide → Sugar + Sulfur compounds

# NEP Positive or Negative(4)

- Further, some microorganisms, primarily bacteria, have **chemosynthetic abilities** and are also primary producers.




- There are many types of chemosynthetic reactions but all oxidize inorganic molecules to produce energy, which is used to fix CO2 as organic matter.
  - For example, nitrifying bacteria convert ammonia to nitrite or nitrite to nitrate, and in the process derive energy sufficient to convert CO2 to organic matter.

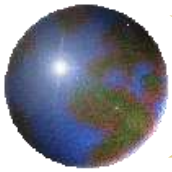
# Chemosynthesis(1)

- Chemosynthesis exploits **chemical energy** to convert inorganic carbon compounds into organic matter, in contrast with photosynthesis, which exploits the **energy of light** to produce organic matter.
- Chemosynthetic reactions are carried out by ***prokaryotic microorganisms, principally bacteria and archaea.***
- Energy is produced in chemosynthetic reactions from oxidizing reduced compounds.
- There are a variety of chemosynthetic bacteria that carry out these reactions.
  1. Nitrifying bacteria (oxidizing $NH_4$ or $NO_2$),
  2. ***Sulfur bacteria (oxidizing $H_2S$, S, and other sulfur compounds),***
  3. Hydrogen bacteria (oxidizing $H_2$),
  4. Methane bacteria (oxidizing $CH_4$),
  5. iron and manganese bacteria (oxidizing reduced iron and manganese compounds), and
  6. carbon monoxide bacteria (oxidizing CO).

# Chemosynthesis(2)

- Chemosynthetic reactions often occur at the interface of aerobic and anaerobic environments where the end-products of anaerobic decomposition as well as oxygen are available.
- Thus, these reactions are most often apparent in soils and sediments where oxygen is depleted.
- For example, methane is produced by anaerobic bacteria that convert fermentative end-products like acetate to methane.

# Secondary Production and Consumer Energetics



# Introduction (1)

- In this section, we will explore the basic energy budget of consumers and its ecological significance,
- We will discuss the controls and prediction of secondary production, a particularly important and well studied part of consumer energetics.
- Finally, we will discuss briefly aspects of **nutrient flow** through consumer populations.

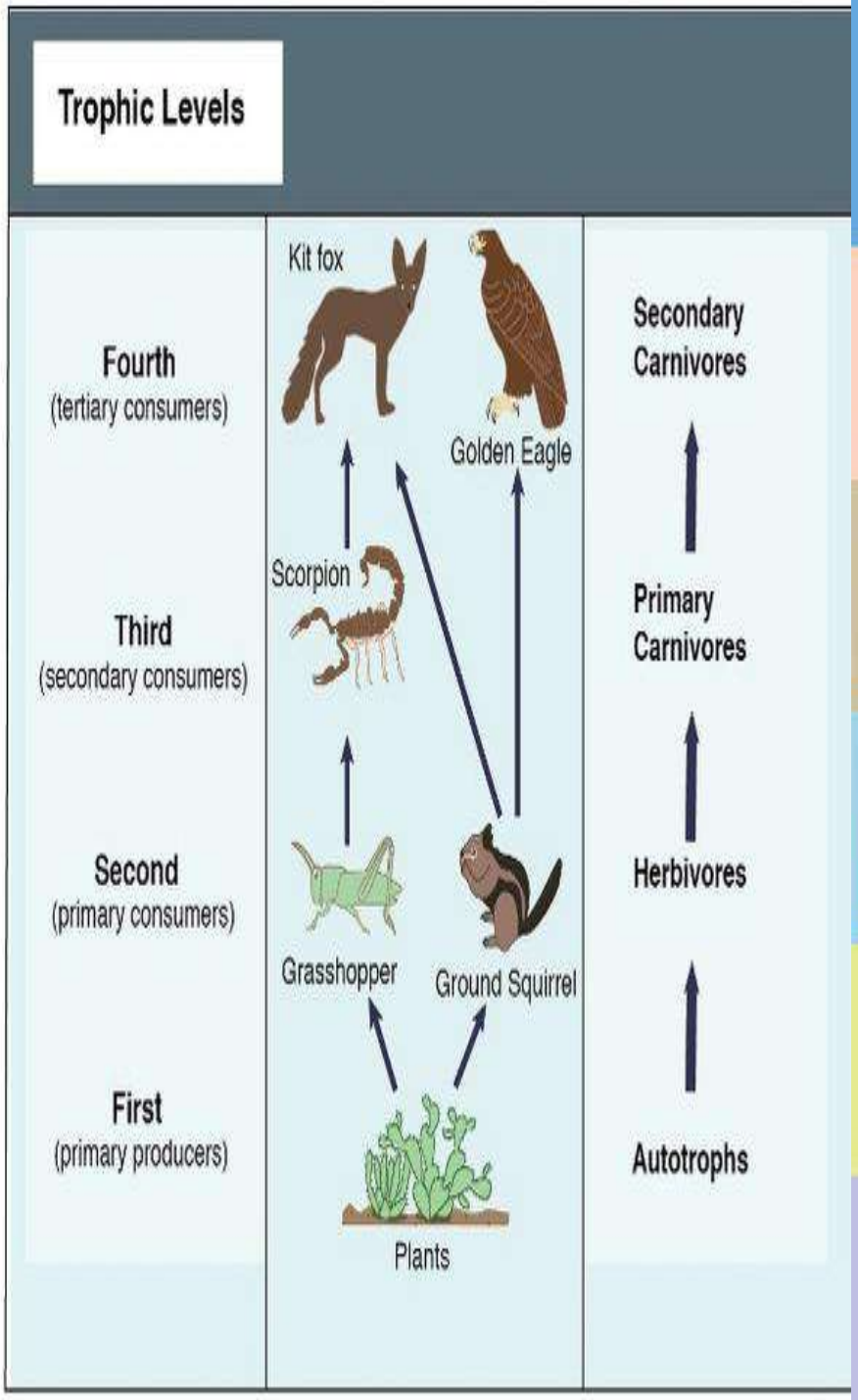
# Introduction (2)

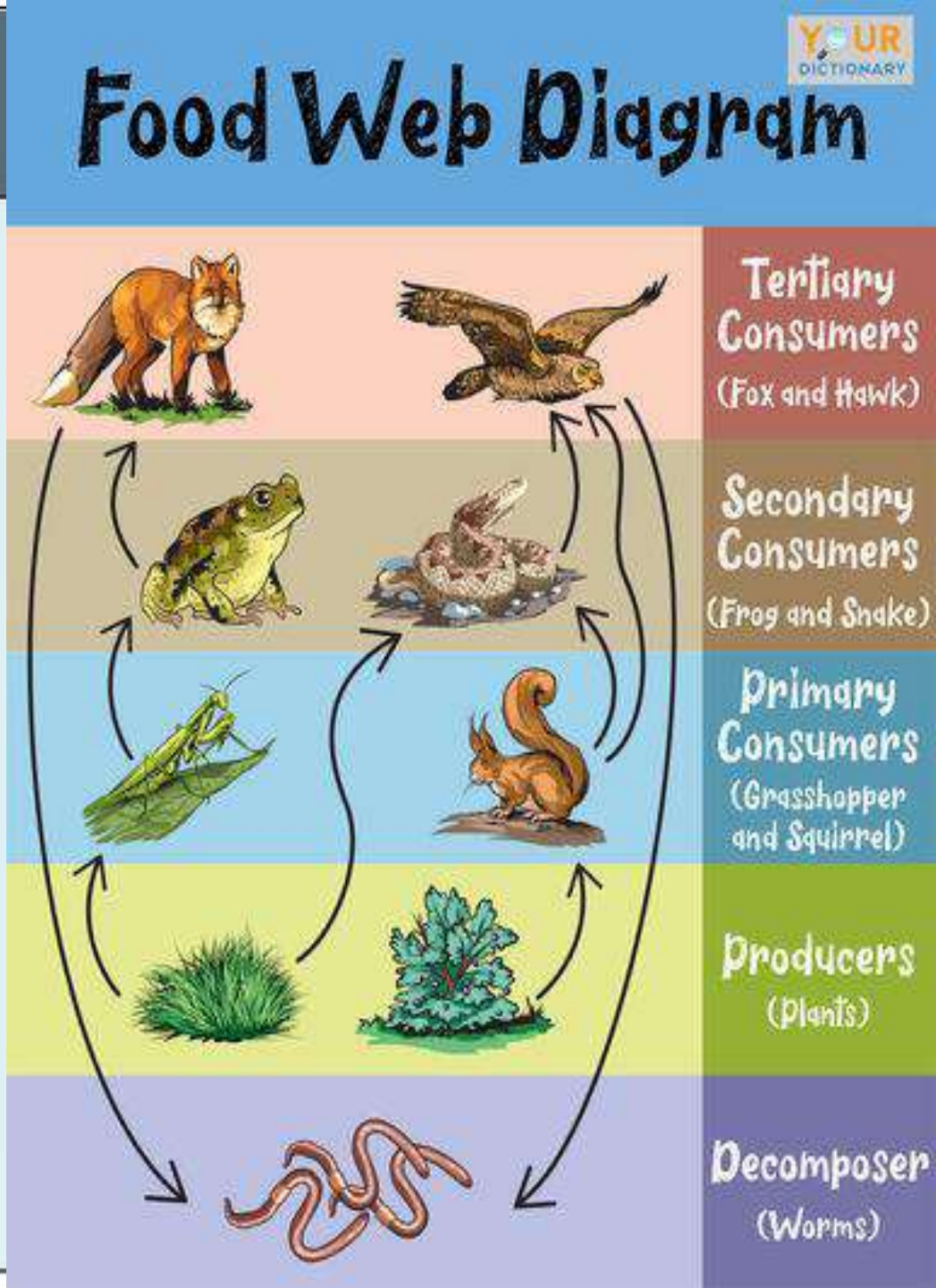
- The energy captured by **primary production** supports animals, fungi, and heterotrophic bacteria and protozoans, which together constitute the community of CONSUMERS in ecosystems
- These consumers include species that we harvest from the wild, species that we value for recreational or aesthetic reasons, and nuisance species.
- Consumers play two key roles in ecosystem energetics.

1. Their respiration destroys the organic matter that serves as the medium of energy exchange in ecosystems, and thereby **regenerates** nutrients trapped in organic matter.

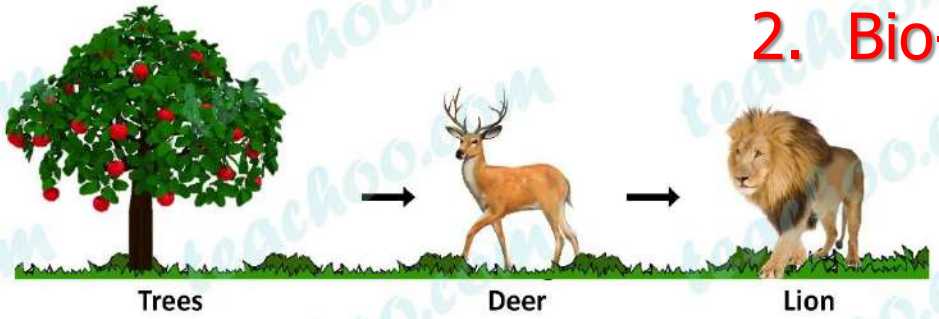
   However, **NOT ALL** the organic matter that a consumer **EATS** is respired; some is captured and used for growth and reproduction of the consumer, which we call **secondary production**.

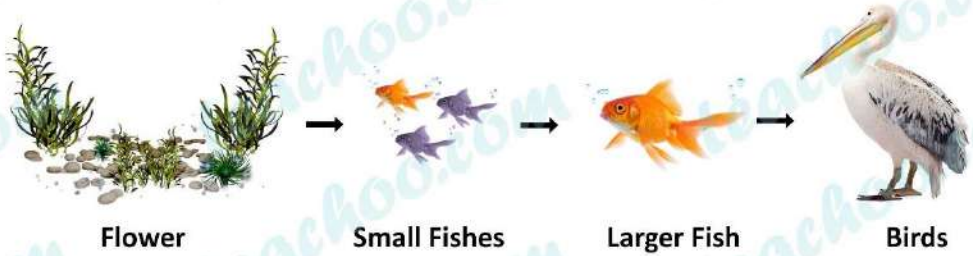
2. This material is available to move up the **food web**

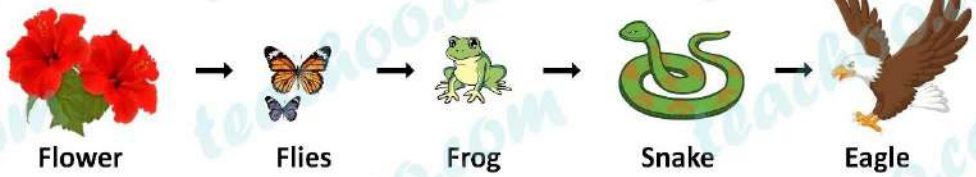

Trophic Levels
Fourth
(tertiary consumers)
Third
(secondary consumers)
Second
(primary consumers)
First
(primary producers)
Kit fox
Golden Eagle
Scorpion
Grasshopper
Ground Squirrel
Plants
Secondary
Carnivores
Primary
Carnivores
Herbivores
Autotrophs


Food Web Diagram
Tertiary
Consumers
(Fox and Hawk)
Secondary
Consumers
(Frog and Snake)
Primary
Consumers
(Grasshopper
and Squirrel)
Producers
(Plants)
Decomposer
(Worms)

# Food Chain



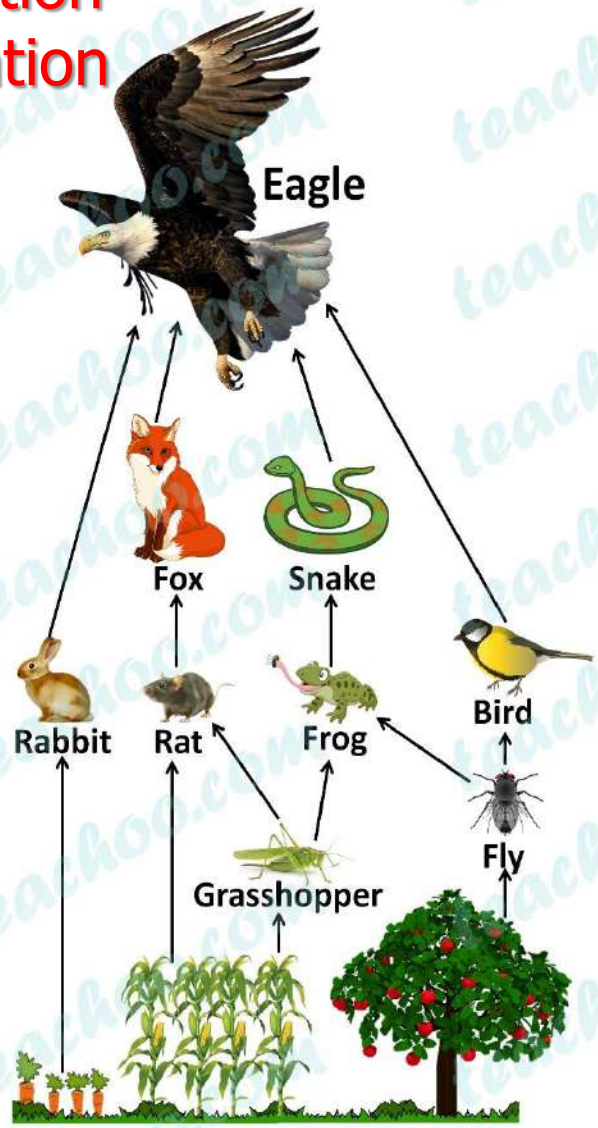




# Food Web

1. Bio-accumulation
2. Bio-magnification

VS



# Secondary Production (1)

- Ecologists have focused on secondary production for two reasons.

1) It is at least much easier to estimate terms ***[Respiration, Assimilation, growth, Excretion etc.]*** in the energy budgets of free-ranging organisms. Various methods have been developed to estimate **Assimilation Or Respiration** of free-ranging organisms but these are more or less experimental and have not been widely used by ecologists.
2) Second, there is a strong and persistent idea among ecologists that the "purpose" of **a food web** is to **transfer matter** and energy into higher trophic levels, which may be useful to humans.

# Secondary Production Defined (2)

- Secondary production is all heterotrophic production (=growth), regardless of its fate. It includes the production of heterotrophic bacteria, fungi, protozoans, and animals. ***[Amount of new biomass produced per unit area over a given time by CONSUMERS]***
- This definition of secondary production is commonly misinterpreted, in two ways.
  1) First, secondary production is sometimes confused with **yield or biomass accumulation**. To see the difference between **PRODUCTION AND BIOMASS** accumulation, consider an example.

- Suppose there are **10 rabbits** in a field. Over the course of a year, 40 rabbits are born and grow to adult size, but **20 rabbits** are run over by cars, **10 are** eaten by foxes and owls, ***and 10 die of broken hearts*** (rabbits are very sensitive).
- After a year, there will again be **10 rabbits in the field**, so there has been **NO ACCUMULATION OF RABBIT BIOMASS.** But secondary production **(summed growth)** of rabbit tissue was 40 rabbits.
- This **TISSUE** was grown by the rabbits and became available to consumers of rabbits. We might be tempted to argue that **gross production** was 40 rabbits, but net production (which might be what counts) **was zero.** There is no such thing as gross and net secondary production.

# Secondary Production Defined (3)

- The **equivalent** of gross secondary production (i.e., net secondary production plus consumer respiration) is assimilation by consumers.
- Further, note that accumulation of consumer biomass is inconveniently *scale-dependent and tends to approach zero over large scales of space and time* (otherwise we'd be up to our necks in rabbits), so is not often an interesting thing to study.
- As a result, ecologists rarely think about or measure biomass accumulation of consumers.

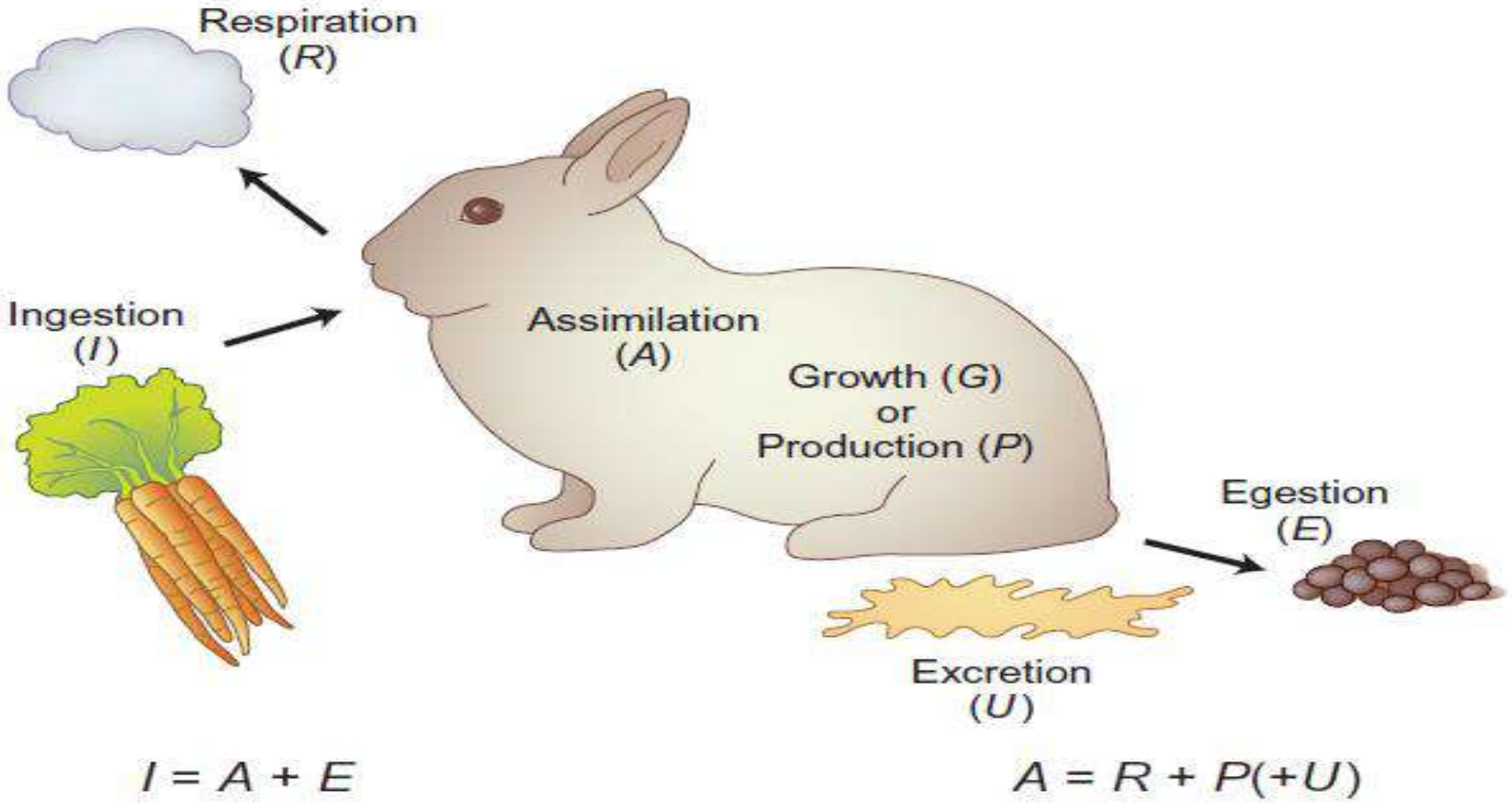
2. Less commonly, secondary production is defined as the production of **primary consumers, with the production of their predators being referred to as tertiary production**. This definition is based on an outdated view of food webs, in which microbes and omnivory were regarded as ***INSIGNIFICANT.***

If it is desirable to distinguish among the levels of the traditionally defined (nonmicrobial) food web, it may be helpful to refer to them as the second, third, and fourth trophic levels.

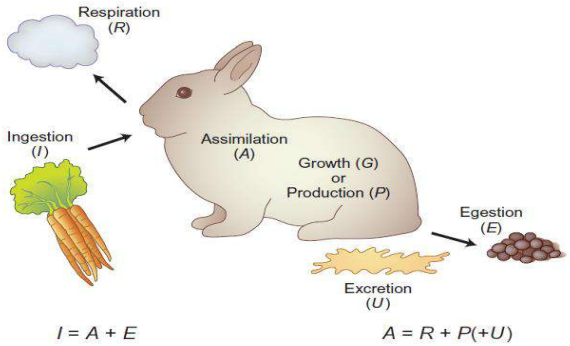
# Consumer Energetics (1)

## ❑ The Energy Budget of Consumers

- Although there are many possible ways to **budget energy flow** through a consumer, a useful and widely used scheme is shown in Fig. below

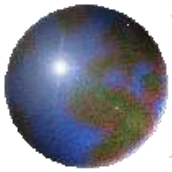


# Consumer Energetics (2)




## ❑ The Energy Budget of Consumers

- Energy in food ingested ***(I)*** *[swallowed]* by a consumer may be either ***assimilated*** ***(A)*** or lost through ***egestion*** (***E,*** sometimes called ***F,*** for feces).
- Assimilated energy may be ***lost as respiration*** ***(R),*** **excreted** as the energy contained in **nitrogenous wastes** (usually called ***U, for*** urine), or used for growth ***(G).***
- Growth often is called production ***(P),*** (production includes both **growth** and **reproduction** of the consumer).
- Bacteria and fungi don't "ingest" *[swallow]* food, so the energy budget starts with assimilation. *[absorption and digestion of food]*
- NB: Terms like **consumption or demand**, although sometimes used in energy budgets, are undesirable because they could refer to **MORE THAN ONE TERM** in the energy budget.



# Consumer Energetics (3)

## ❑ The Energy Budget of Consumers

- Although I presented the energy budget as it applies to an ***individual organism***, it is possible to write an **analogous budget [comparable]** for **a population of consumers**, a group of populations, or even the entire community of consumers in an ecosystem.
- It is just **MORE DIFFICULT** to estimate the terms in the energy budget for a population or community than for an individual organism.
- Two aspects of **energy budgets** are especially interesting to ecologists:
  1) the **MAGNITUDE** of the flows and
  2) the way energy is **PARTITIONED** among the flows**.**

# Consumer Energetics (4)

## ❑ The Energy Budget of Consumers

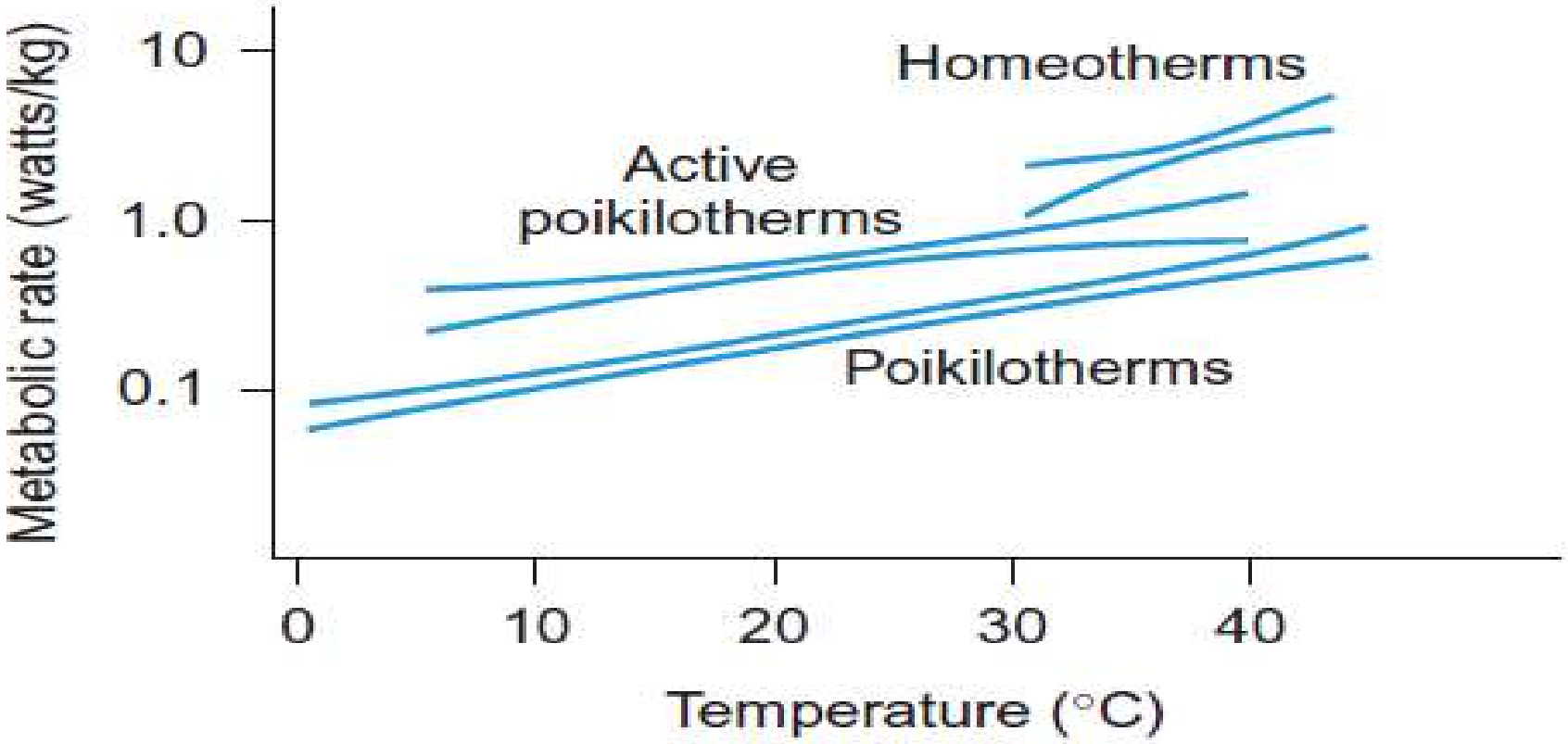
- The different **TERMS** of the energy budget each have special **ecological significance**.
  - Ingestion: describes the effect of the consumer on its food resource,
  - Egestion: gives the input to the detritus pool,*[waste or debris of any kind]*
  - Respiration: is energy that is lost from the ecosystem, and
  - Production shows both the **amount of energy** that is available to the consumer to **support growth and reproduction** and the energy that is **available to predators**.

*Qn: Using relevant examples, explain the ecological significance of the different consumer energy budget terms*

# The magnitude of the flows (1)

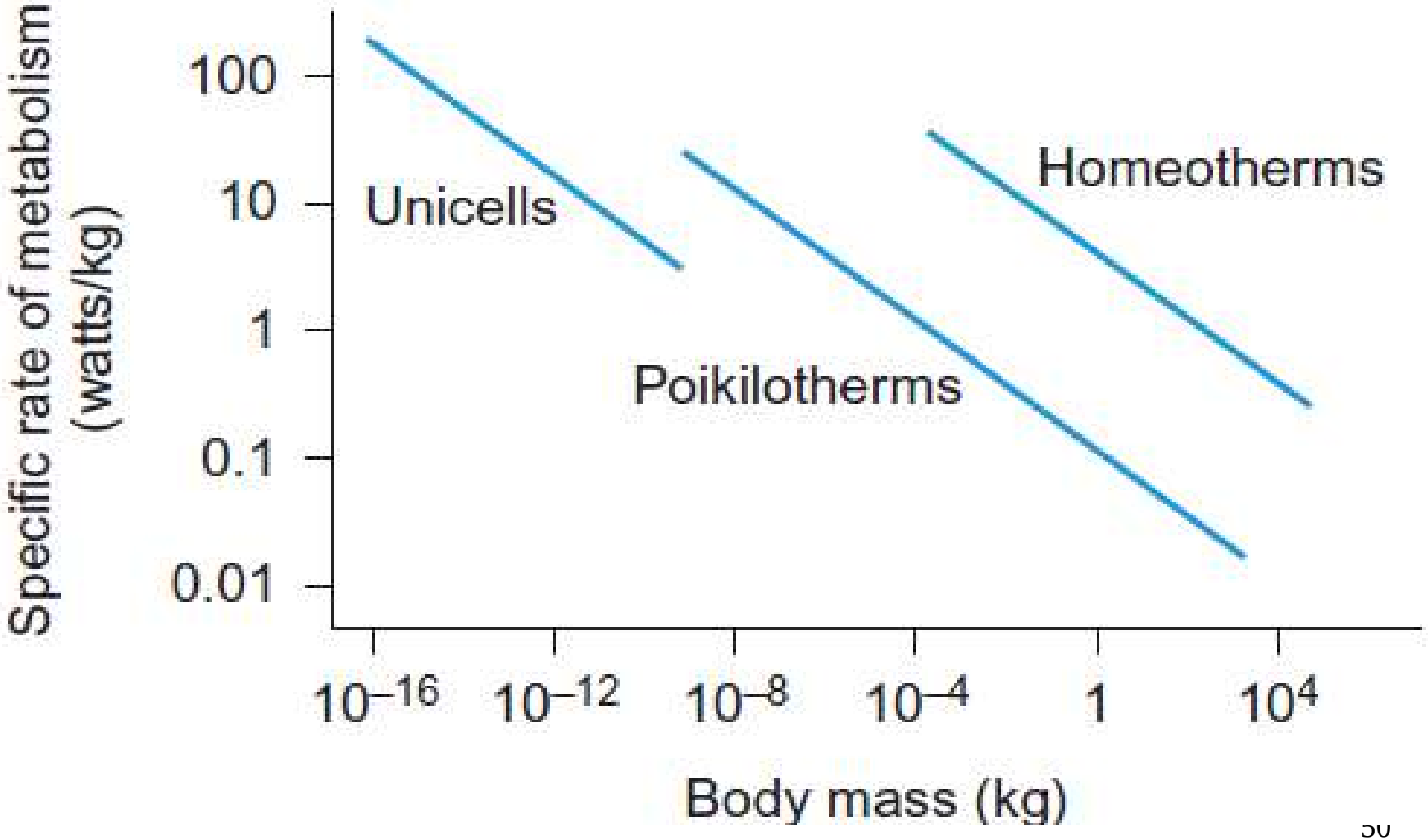
- Several factors affect the **MAGNITUDE** of all of these terms *[I, E,P, R]* in individual organisms

1. *Mass-specific metabolic rates* rise with **INCREASING TEMPERATURE** and are higher for homeotherms *[warm blooded" species]* than poikilotherms ***[cold-blooded" species].***



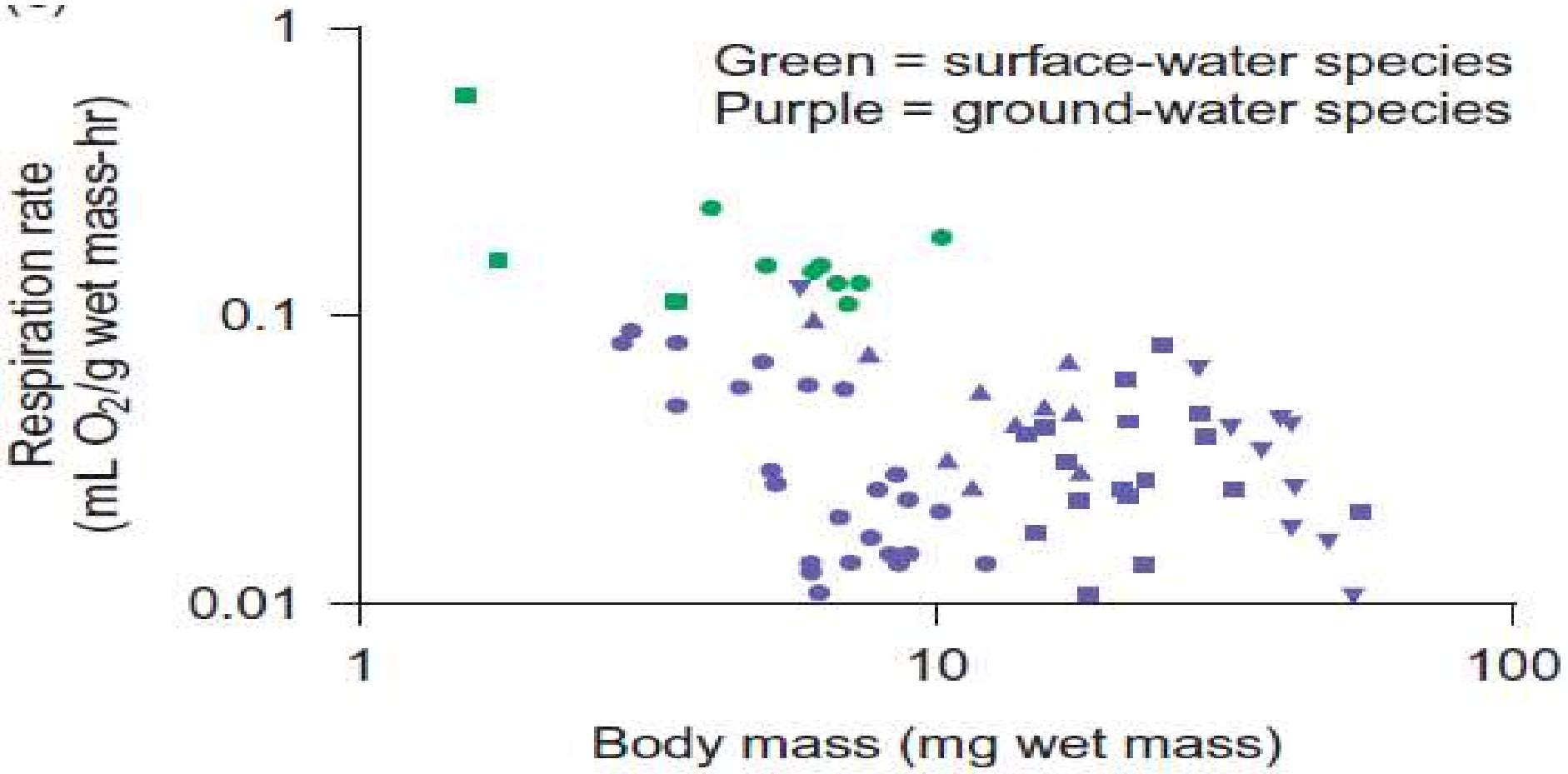
# The magnitude of the flows (2)

2. *Mass-specific metabolic rates a*re **HIGHER** in small organisms than in large organisms,



# The magnitude of the flows (3)

3. Respiration (and of necessity, A, I, and E) is **much higher** in homeotherms than in poikilotherms. **Livestock and mosquitoes**

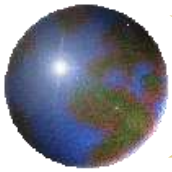


# The magnitude of the flows (4)

4. Finally, metabolic rates are under ***evolutionary control***, so they can respond to environmental and ecological pressures.

- For example, animals that live in ground waters, which are very poor in food, have lower metabolic rates than would be predicted from their ***body masses and temperatures.***

- ***Usng relevant examples, explain the factors affecting the magnitude of flows in a consumer energy budget***



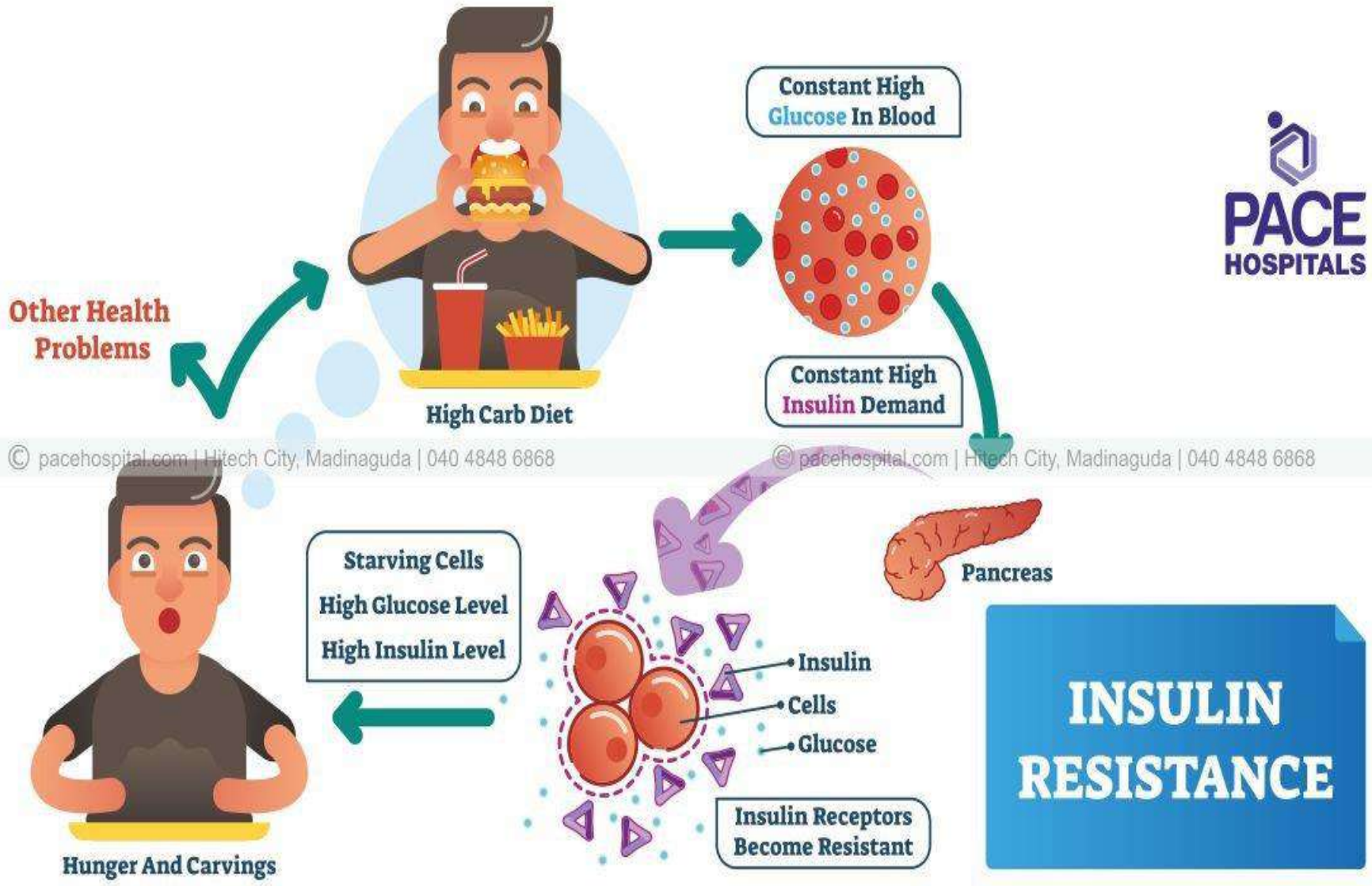
# The way energy is partitioned among the flows(1)

- The partitioning of energy among the parts of the energy budget can be described by a **series of efficiencies**.
- Many of these have been used by ecologists, but **THREE** are of primary importance:

1) *A/I = assimilation efficiency:* Describes how good a consumer is at extracting energy from its food.
2) *P/A = net growth efficiency:* Describes the partitioning between growth and respiration.
3) *P/I = gross growth efficiency:* a combination of the previous two efficiencies, which describes the overall efficiency with which food is converted to **consumer tissue.**

- All the three, are **highly variable**, commonly depending on at least four variables: *diet, temperature, metabolic type* (homeothermy vs. poikilothermy), and *physiological status*

# Human health and High levels of Carb intake



# Human health and High levels of Carb intake

## Symptoms of Insulin Resistance


Cravings for sweets and salty foods

Darkening of skin in the groin, armpits, or behind the neck

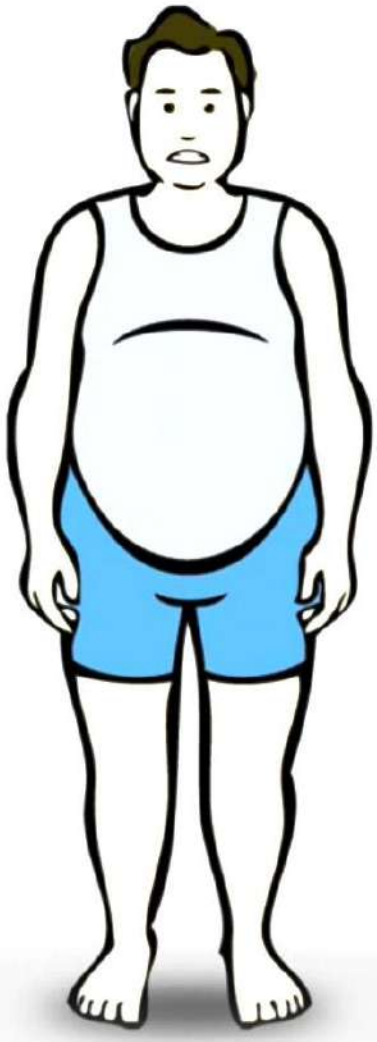

Fatigue

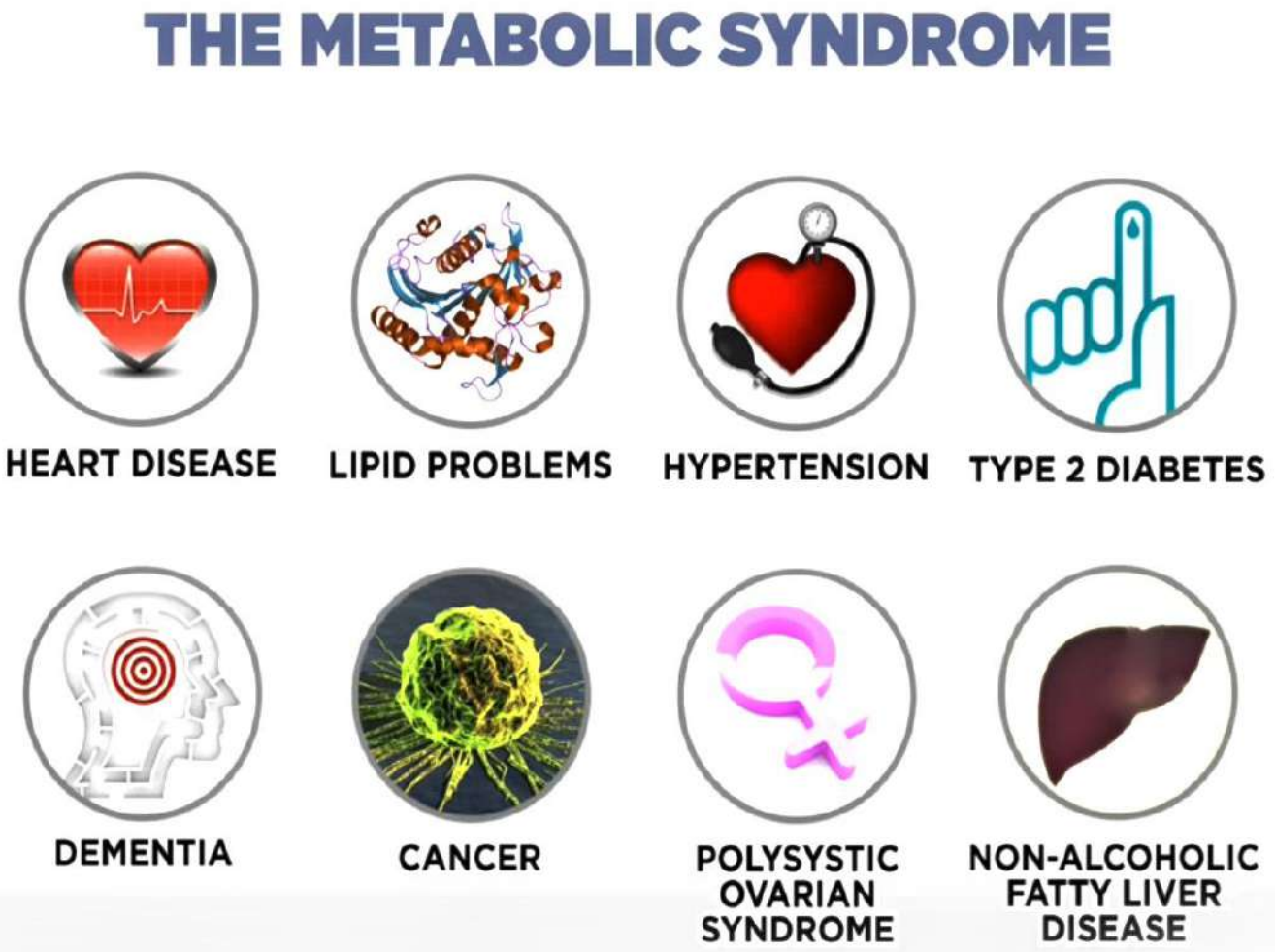
Frequent or increased urination

Increased hunger or thirst

Tingling sensations in hands or feet

# Human health and High levels of Carb intake

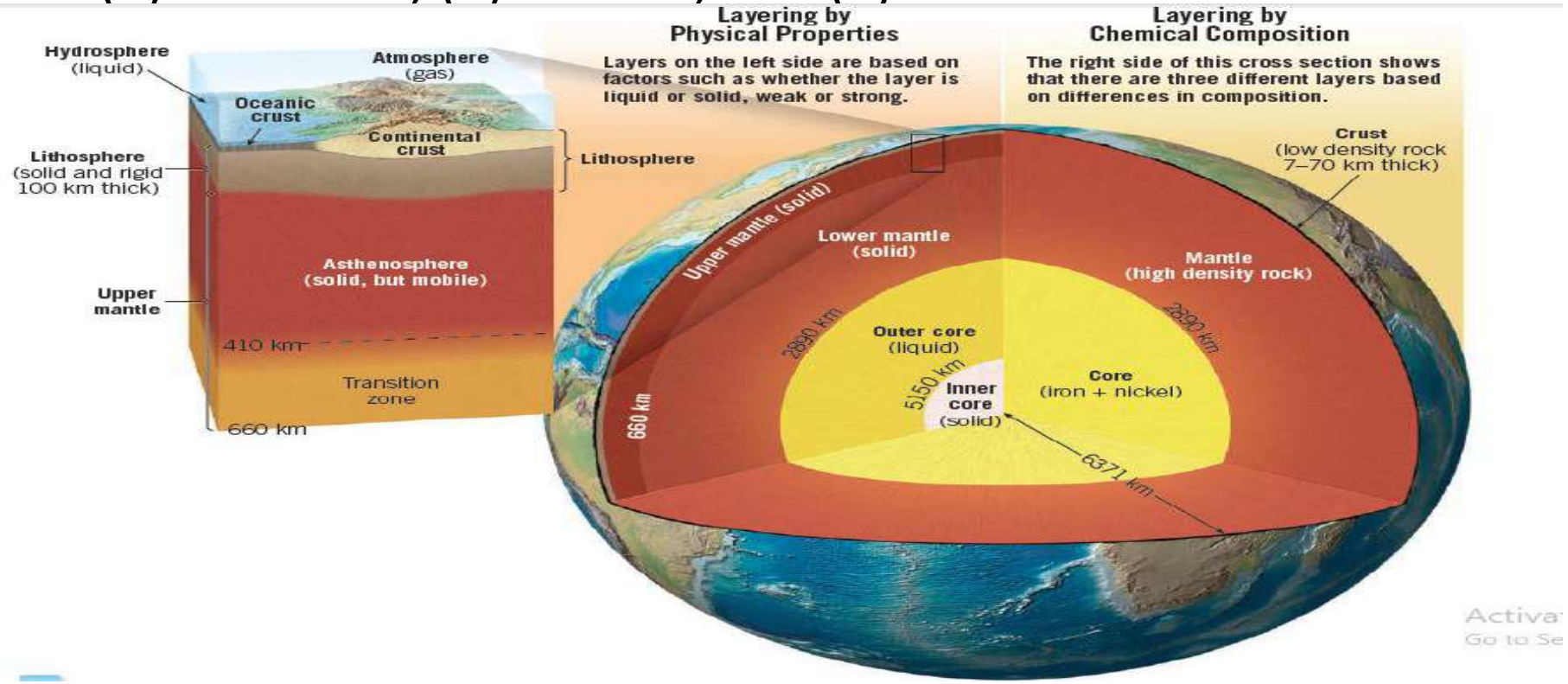




# TOPIC 1: INTRODUCTION TO EARTH SCIENCE

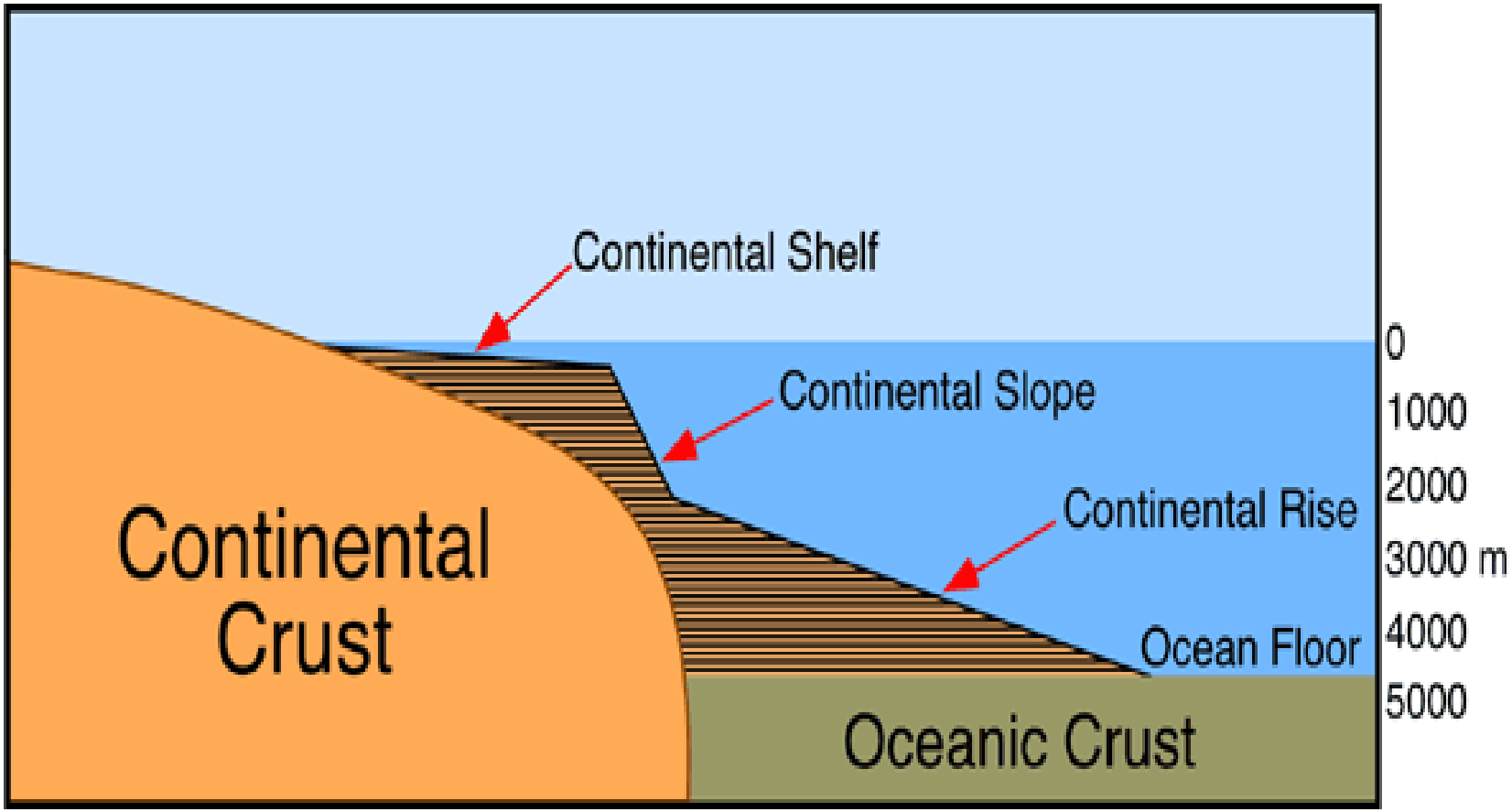
**b) The Geosphere:** It is beneath the atmosphere and the ocean extending from the surface to the center of the planet, a depth of 6400 kilometers [4000 miles], making it by far the largest of Earth's four spheres. It is composed of three layers

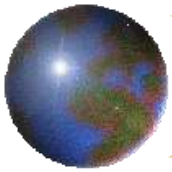
(1) The Crust, (2) Mantle, and (3) Core.



# TOPIC 1: INTRODUCTION TO EARTH SCIENCE

1. **Earth's Crust:** It has a relatively thin, rocky outer skin and it, is of two different types—*continental crust* and *oceanic crust*





# TOPIC 1: INTRODUCTION TO EARTH SCIENCE

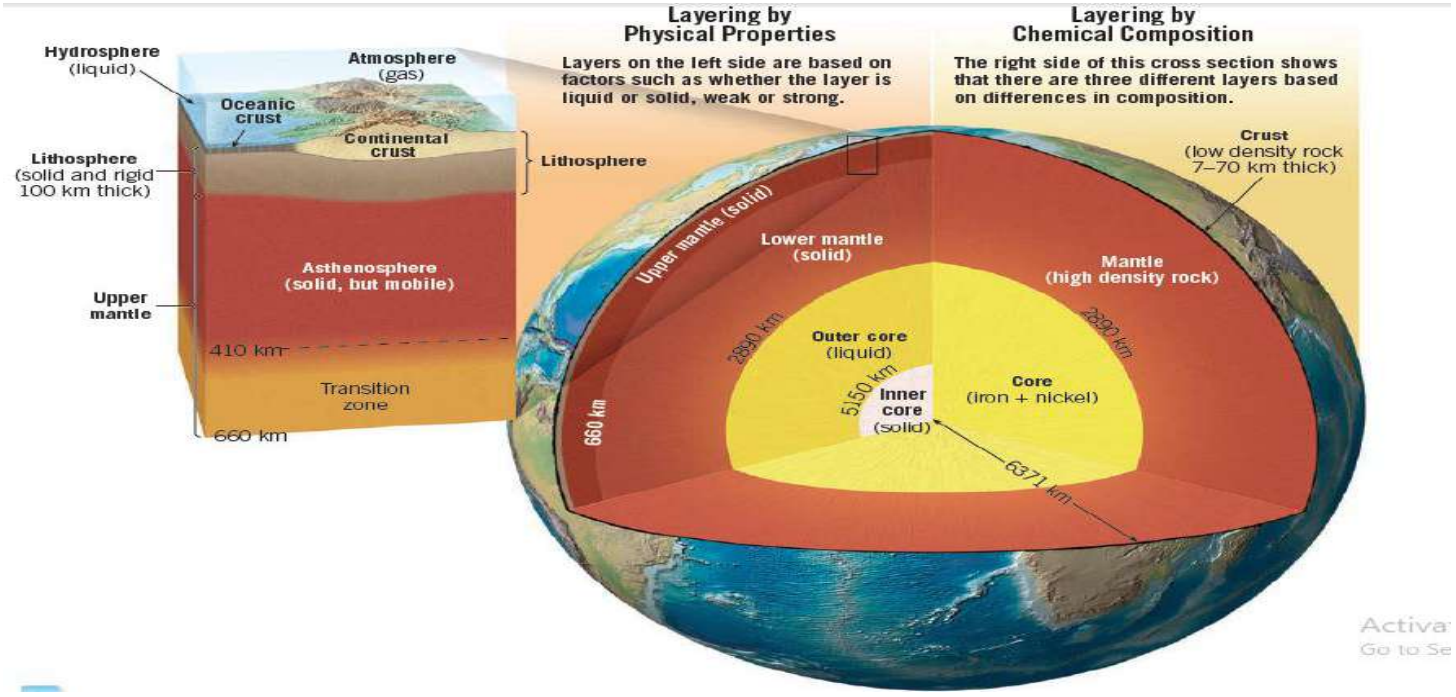
## ❑ Description of the Earth's Crust

- ✓ The oceanic crust is roughly 7 kilometers (5miles) **thick** and composed of the dark igneous rock *basalt*.
- ✓ By contrast, the continental crust averages about 35 kilometers (22 miles) **thick** but may exceed 70 kilometers (40 miles) in some mountainous regions, such as the Rockies and Himalayas.
- ✓ Unlike the oceanic crust, which has a relatively homogeneous chemical composition, *the continental crust consists of many rock types.*
- ✓ Continental rocks have an average density of about 2.7 g/cm3, and some are more than 4 billion years old. The rocks of the oceanic crust are younger (180 million years or less) and denser (about 3.0 g/cm3) than continental rocks.

# TOPIC 1: INTRODUCTION TO EARTH SCIENCE

**2. Earth's Mantle:** It is a solid, rocky shell that extends to a depth of nearly 2,900 kilometers

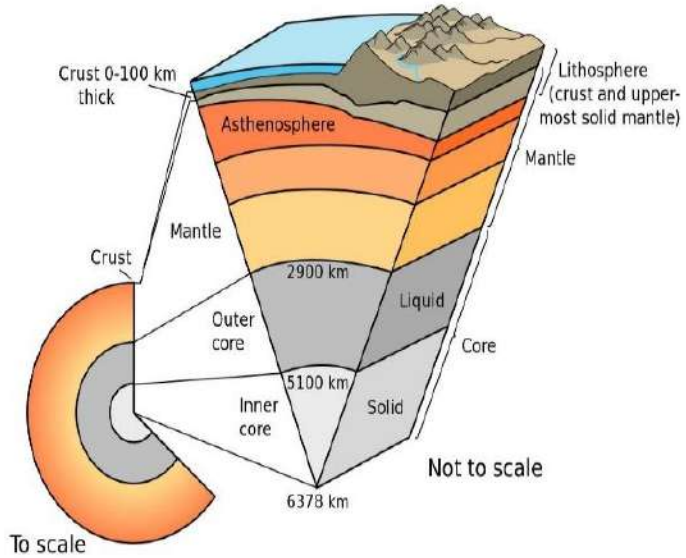
- ✓ The upper mantle extends from the crust–mantle boundary to a depth of about 660 kilometers (410 miles).
- ✓ The upper mantle can be **divided into two different parts**. The top portion of the upper mantle is part of the *stiff lithosphere*, and beneath that is the *weaker asthenosphere*.



# TOPIC 1: INTRODUCTION TO EARTH SCIENCE

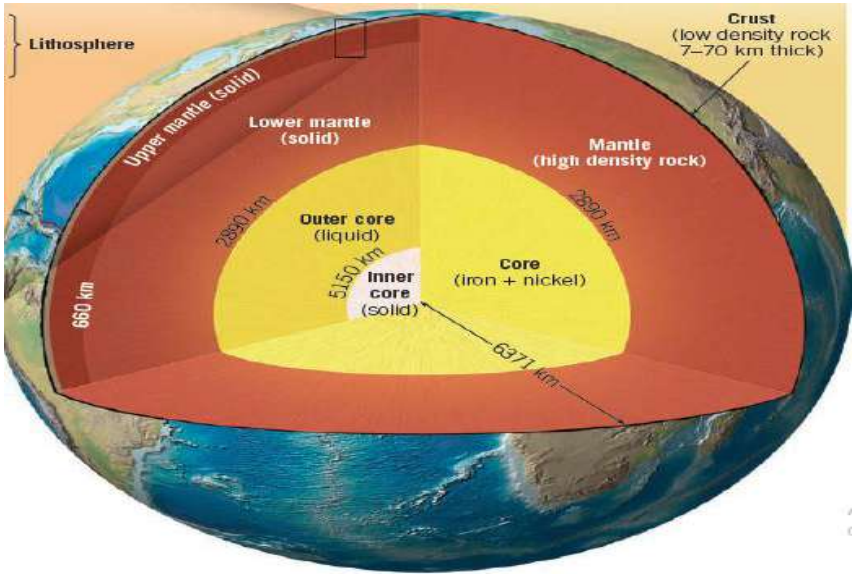
## ❑ Description of the Earth's Mantle

- ✓ The lithosphere ***("sphere of rock")*** consists of the entire crust and uppermost mantle and forms Earth's relatively ***cool, rigid outer shell***.
- ✓ Beneath this stiff layer (lithosphere) to a depth of about 350 kilometers (220 miles) lies a soft, comparatively weak layer known as the **asthenosphere *("weak sphere").*** The top portion of the asthenosphere **has a temperature/ pressure regime** that results in a small ***amount of melting***. Within this very weak zone, the **lithosphere is mechanically detached** from the layer below. The result is that the lithosphere is able to move independently of the asthenosphere.



# TOPIC 1: INTRODUCTION TO EARTH SCIENCE

3. **Earth's Core:** The core is divided into two regions that exhibit very different mechanical strengths.
   1. The outer core is **A LIQUID LAYER** of about 2,260 kilometers (about 1400 miles) **thick.** It is the movement of metallic iron within this zone that generates **Earth's magnetic field**.
   2. The inner core is a sphere that has a radius of 1216 kilometers (754 miles). Despite its higher temperature, the iron in the inner core is ***SOLID*** due to the ***IMMENSE PRESSURES*** that exist in the center of the planet.



# TOPIC 1: INTRODUCTION TO EARTH SCIENCE

- **The Mobile Geosphere:** Athough the earth is made of solid "rock" it is capable of moving on the lithosphere. Two concepts can explain this:

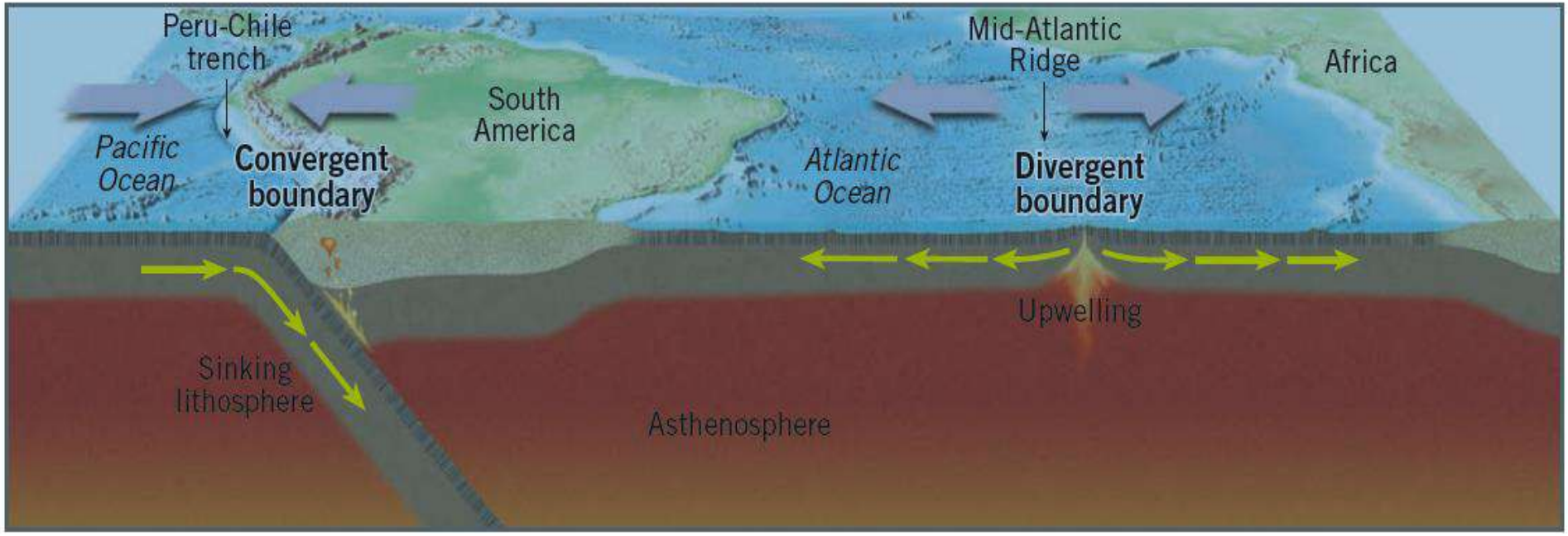
    1. **Continental Drift:** *C*ontinents move on the face of the planet. This theory however contradicted the established view that the continents and ocean basins are permanent and stationary features on the face of Earth. For that reason, the notion of drifting continents was received with great skepticism.
    2. **Plate Tectonics:** Earth's rigid outer shell (the lithosphere) is broken into numerous slabs called **lithospheric plates**, which are in continual motion.

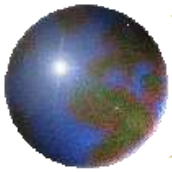
- **Plate Motion**: Driven by the ***unequal distribution of heat*** within our planet, lithospheric plates move relative to each other at a very slow but continuous rate that averages about ***5 centimeters (2 inches) per year.***

# TOPIC 1: INTRODUCTION TO EARTH SCIENCE

- Because plates move as coherent units, they interact along their margins leading to **two Boundaries:**

1. **Convergent boundary:** Occurs when two plates move towards each other and later one of the plates plunges beneath the other and descends into the mantle.
2. **Divergent boundary**: Located where plates pull apart and fractures created are filled with molten rock that wells up from the mantle.





# TOPIC 1: INTRODUCTION TO EARTH SCIENCE

## c) The Atmosphere:

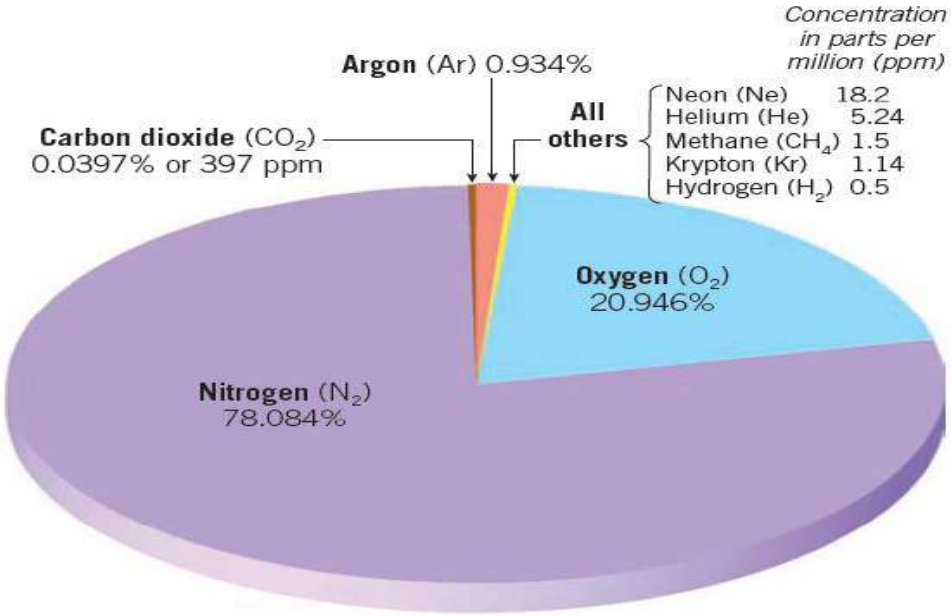
- Earth is surrounded by a life-giving gaseous envelope called the **atmosphere.**
- When compared to the thickness (radius) of the solid Earth (about 6400 kilometers [4000 miles]), the atmosphere is a *very shallow layer*.
- It not only provides the air that we breathe but also protects us from the Sun's dangerous ultraviolet radiation. (Ozone layer)
- The energy exchanges that continually occur between the atmosphere and Earth's surface and between the atmosphere and space produce the effects we call weather and climate.
- Able to absorb heat in atmosphere from energy radiated from earth's surface, helps keep the atmosphere warm.

# TOPIC 1: INTRODUCTION TO EARTH SCIENCE

- **Composition of the Atmosphere:**

✓ Sometimes the term *air* is used as if it were a specific gas, but it is not.

✓ Rather, **air** is a *mixture* of many discrete gases, each with its own physical properties, in which varying quantities of tiny solid and liquid particles are suspended.



# TOPIC 1: INTRODUCTION TO EARTH SCIENCE

## ❑ Composition of the Atmosphere:

### 1. Carbon Dioxide ($CO_2$)

- It is a green house gas and without it, the earth would have been very cold to -18 degrees Celsius.
- However increased carbon dioxide concentrations have contributed to a warming of Earth's atmosphere over the past several decades.

### 2. Water Vapor

- Water vapor is the source of all clouds and precipitation
- Like ($CO_2$), water vapor is a green house gas

### 3. Aerosols: these are tiny, often invisible particles

- act as surfaces on which water vapor can condense, an important function in the formation of clouds and fog.
- can absorb, reflect, and scatter incoming solar radiation.
- contribute to an optical phenomenon we have all observed—the **varied hues of red** and orange at sunrise and sunset

## 4. Ozone

- It is a form of oxygen that combines three oxygen atoms into each molecule ($O_3$).
- Ozone is not the same as oxygen we breathe, which has two atoms per molecule ($O_2$).
- There is very little ozone in the atmosphere, and its distribution is not uniform. It is concentrated between 10 and 50 kilometers above the surface, in a layer called the *stratosphere*.
- Ozone **absorbs much of the potentially harmful ultraviolet** (UV) radiation from the Sun. Without $O_3$ our planet would be uninhabitable for most life.
- Chlorofluorocarbons (CFCs for short) used in as coolants for air-conditioning and refrigeration equipment, cleaning solvents for electronic components, and propellants for aerosol sprays are detrimental to ozone.

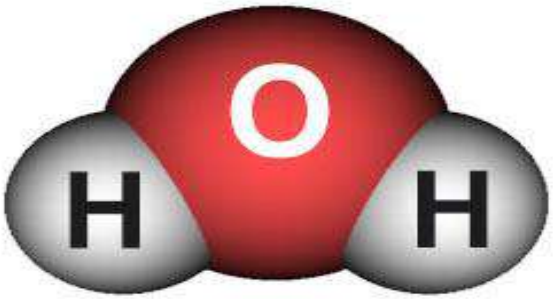
## How does ozone do this?

- High energy ultraviolet light, traveling through the ozone layer, **breaks apart the ozone molecule**, $O_3$ into one oxygen molecule ($O_2$) and one oxygen atom (O).
- This process absorbs the Sun's most harmful UV rays.
- Ozone is also reformed in the ozone layer: oxygen atoms bond with $O_2$ molecules to make $O_3$.
- Under natural circumstances, the same amount of ozone is continually being **created and destroyed** and so the amount of ozone in the ozone layer remains the same.

***QN. Briefly describe the working mechanism of Ozone creation and destruction***

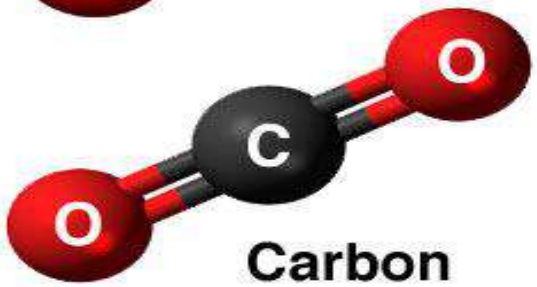
## ❑ Climate change and the Green House gasses

Human activities like burning of fossil fuels, power generation, agriculture, deforestation etc. are changing the natural greenhouse. Green house gases cause the green house effect

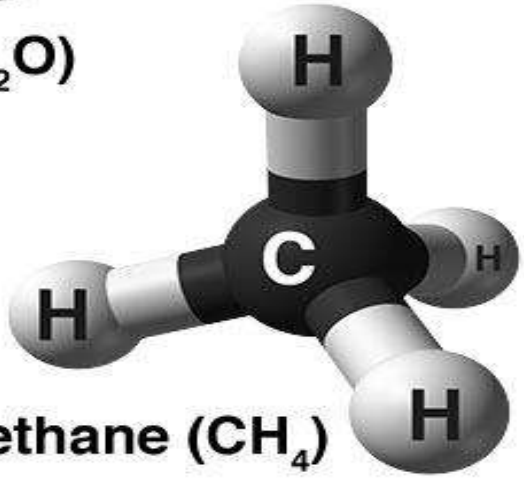



Water vapor ($H_2O$)

Nitrous oxide ($N_2O$)


Carbon dioxide ($CO_2$)




Methane ($CH_4$)

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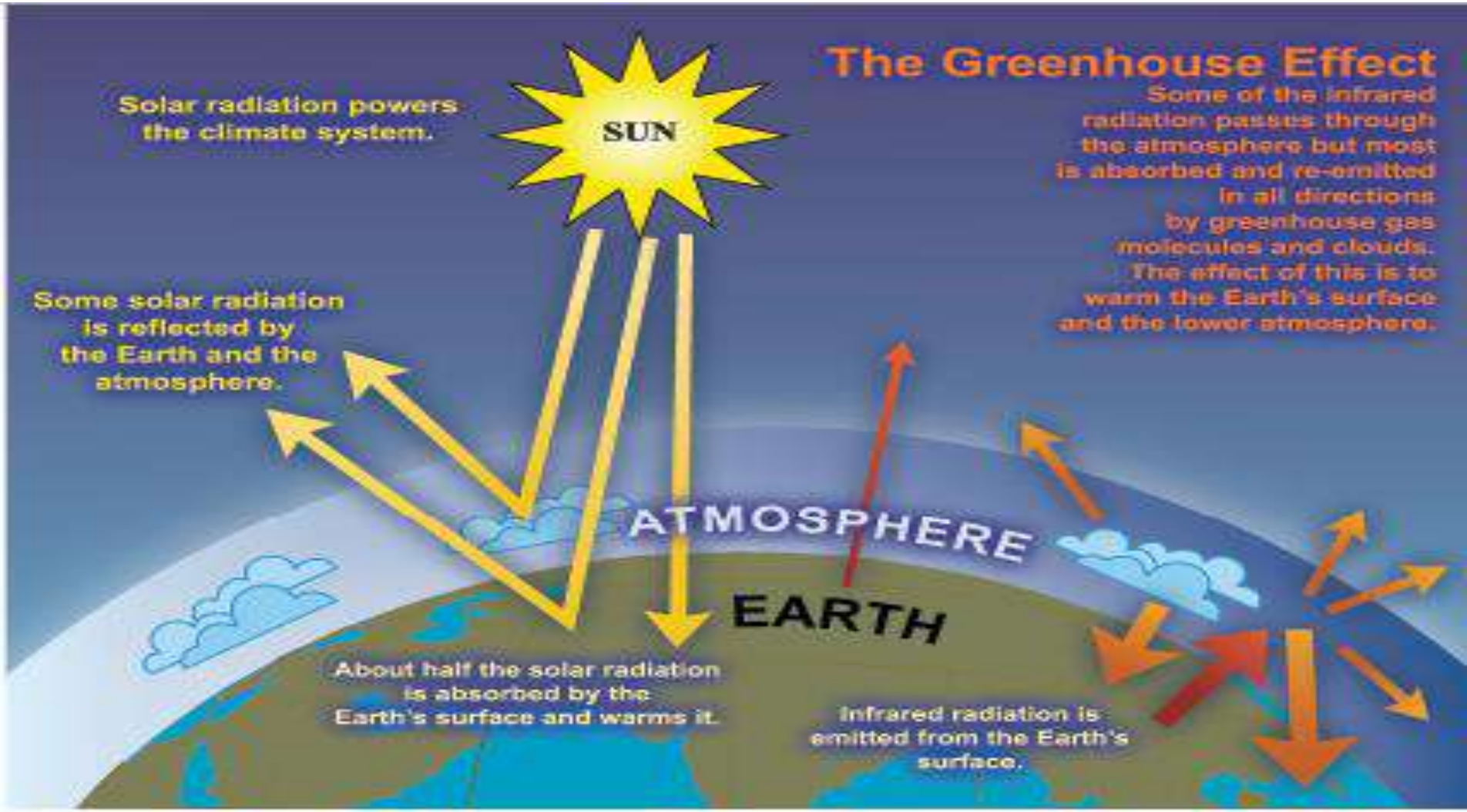
## The Green House Effect

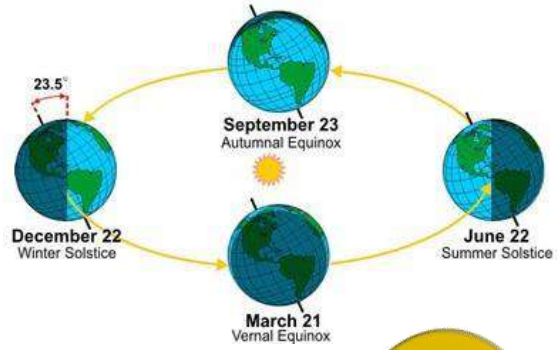


# ❑ Causes of Climate Change

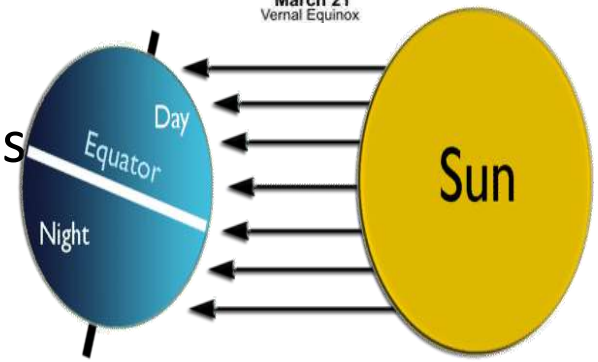
## A) Natural Causes

❑**The Milankovitch Theory:** Explains long term climate change based on the changes in:

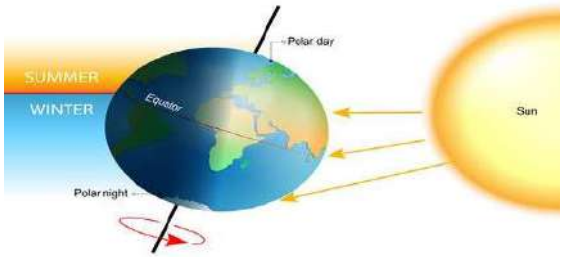
1.Earth's orbital shape: when the Earth is closest to the sun, it gets more solar radiation.




2.Axial tilt: More tilt means- warmer surfaces; less tilt means- cold surfaces.




3.Axial rotation: Changes in the axis location changes distance from sun



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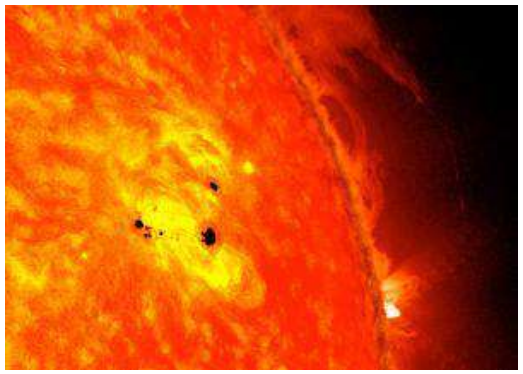
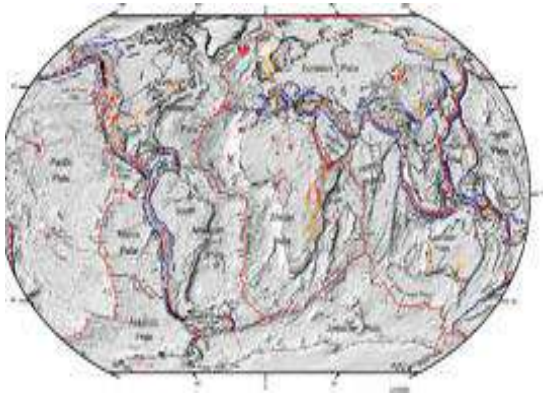
- **Volcanic Eruptions:** discharge carbon dioxide, sulfur dioxide, emit aerosols, volcanic ash or dust. Violent eruption of Indonesia's Mount Tambora caused global cooling in 1816.

- **Variation in Solar Radiation:** a decrease in solar activity is thought to have triggered the Little Ice Age



- **Movement of Crustal Plates:** As tectonic plates move over geological timescales, landmasses are carried along to different positions and latitudes.

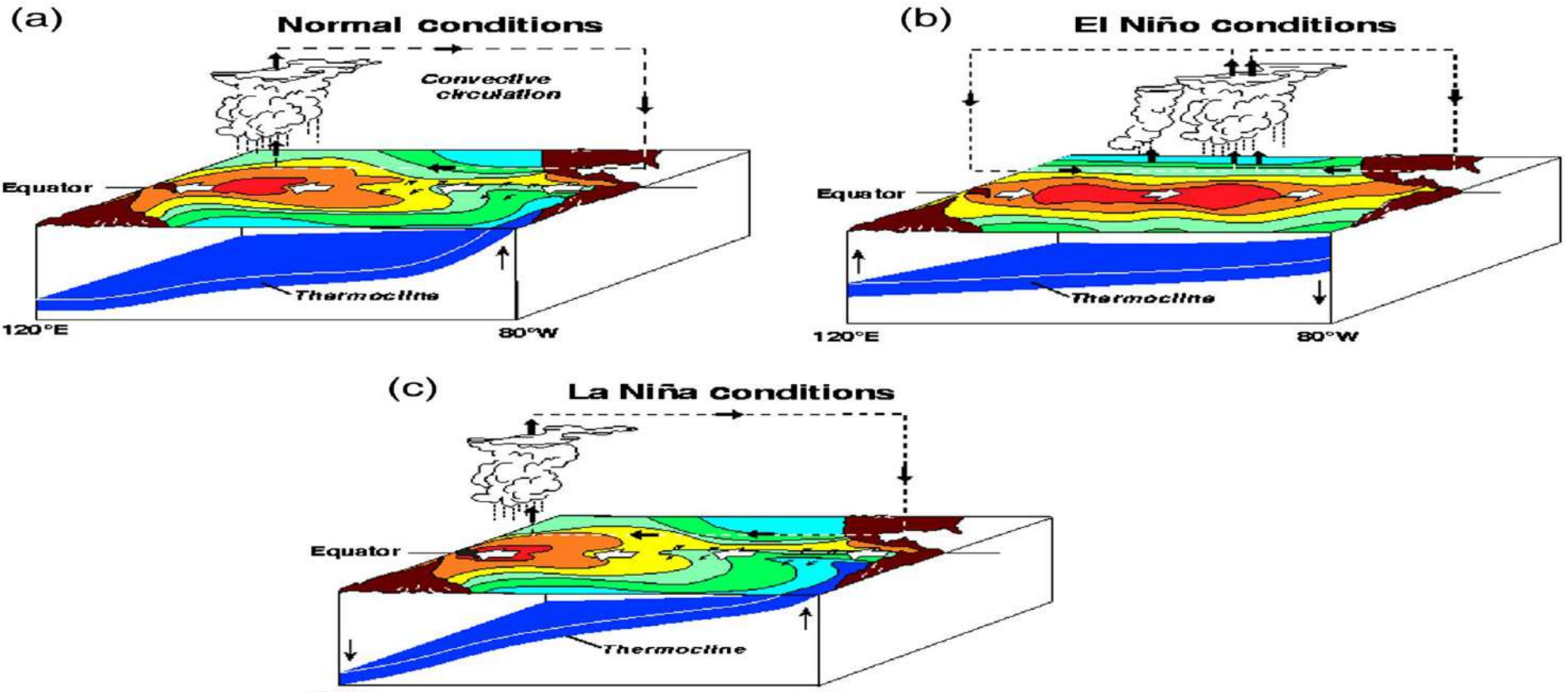


# TOPIC 1: INTRODUCTION TO EARTH SCIENCE

- **ElNiño-South Oscillation (ENSO)-**large-scale climatic phenomenon that originates in the tropical Pacific but affects global climate patterns
  1. **El Niño-Warm phase: C**auses the water temperature off South America to be warmer, thus creating a **low pressure zone.**
  2. **La Niña-Cold phase: Cold water** cause **high pressure zones**
- In a normal year, when ENSO is inactive, the equatorial Pacific trade winds blow from *east to west*.
- The winds push the **warmer surface water towards the west**, and colder water rises up from deeper in the ocean to replace it.
- This creates an east–west difference in sea-surface temperature (SST) and hence an east–west difference in *sea level air pressure* that maintains the trade winds and so drives ***a positive feedback loop***

# TOPIC 1: INTRODUCTION TO EARTH SCIENCE

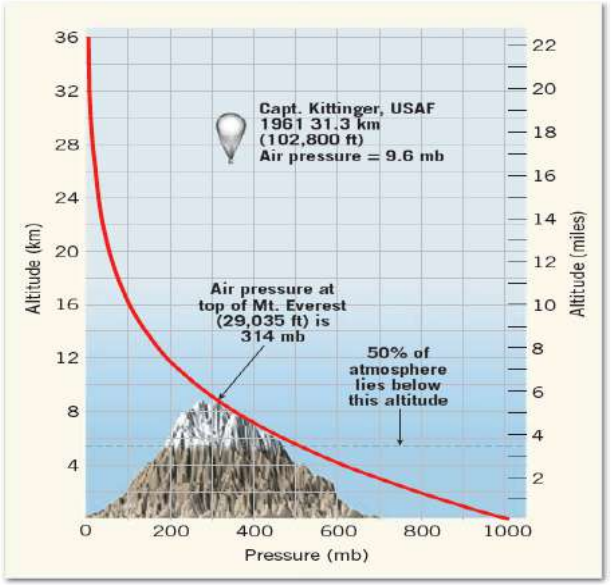
- During an El Niño year, 1) *the east–west SST difference weakens*, 2) *the air pressure difference weakens*, and *3) the trade winds and their effects on the ocean weaken*, so the eastern Pacific warms (Fig. b).
- During a La Niña year, the opposite happens: 1) *the east–west difference in temperature strengthens*, *2) the pressure difference strengthens*, and 3) *the trade winds and their effects on the ocean strengthen,* so the east Pacific cools



## ❑ Vertical Structure of the Atmosphere

**i) Pressure Changes:** To understand the vertical extent of the atmosphere, lets look at the changes in atmospheric pressure with height. *Atmospheric pressure is simply the weight of the air above.*

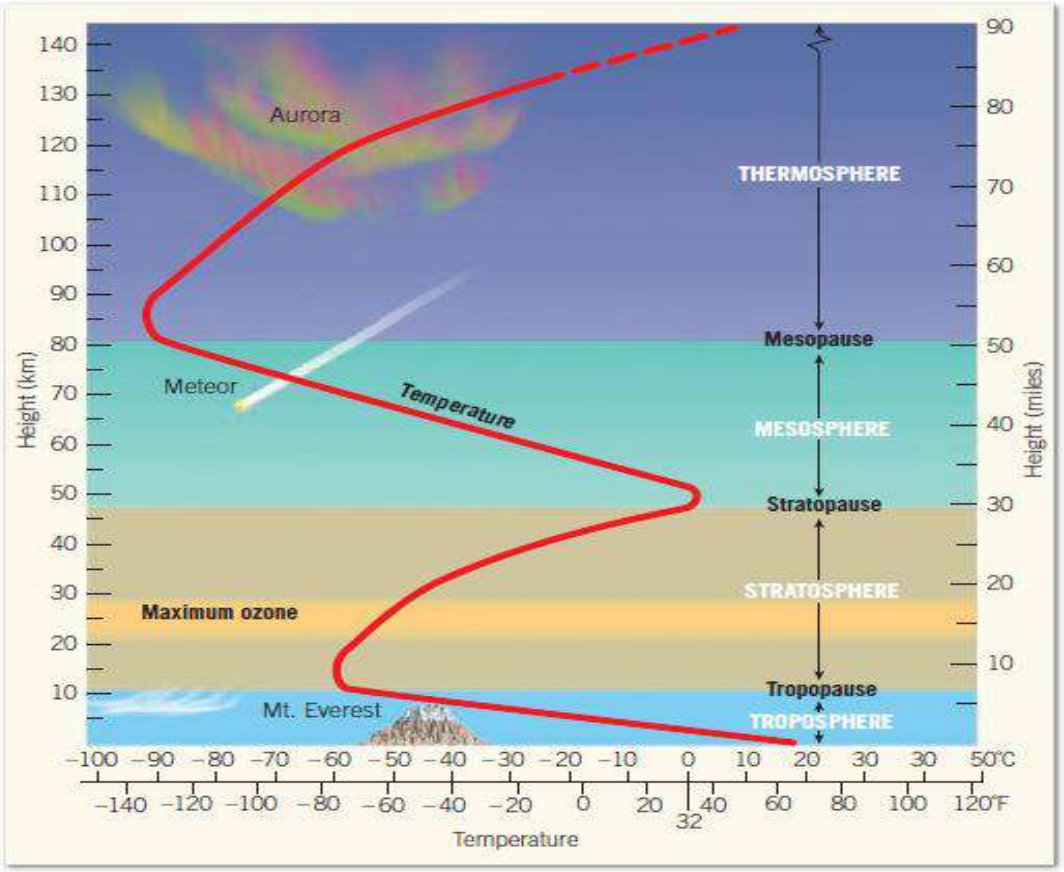
- At sea level, the average pressure is slightly more than 1000 millibars (mb)
- The pressure at higher altitudes is less
- Pressure decreases rapidly near Earth's surface and more gradually at greater heights.



## ❑ Vertical Structure of the Atmosphere

### ii) Temperature Changes

We divide the atmosphere vertically into four layers, on the basis of temperature



# TOPIC 1: INTRODUCTION TO EA


## ❑ Vertical Structure of the Atmosphere

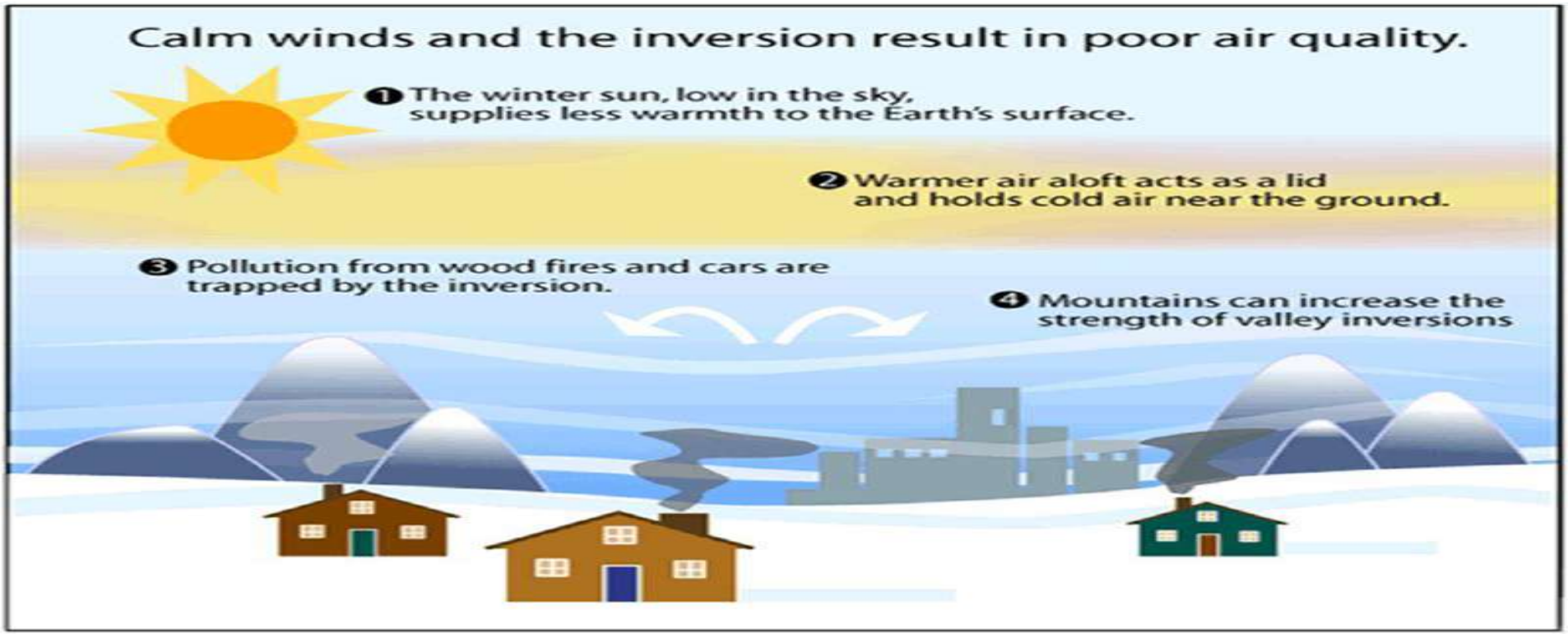
### a) Troposphere (1)

- ✓ Occurs between **6 to 10 km** from the earth's surface
- ✓ Temperature decrease with increase in altitude at a rate **of 6.5°C per** kilometer (3.5°F per 1000 feet),
- ✓ Temperature decrease in the troposphere is called the **environmental lapse rate.**
- ✓ **A radiosonde**, a lightweight package of instruments that is carried aloft by a small weather balloon is used to measure or transmit data on vertical changes in temperature, pressure, and humidity in the troposphere
- ✓ The thickness of troposphere varies with latitude and season.

# TOPIC 1: INTRODUCTION TO EARTH SCIENCE

## a) Troposphere (2)

- ✓ When there a **temperature inversion**, air temperature in the troposphere **increases with altitude and warm air sits over cold air.** Inversions commonly form over land at night or in winter.
- ✓ The Great Smog, which blanketed the British capital for five days in December **1952**, is estimated by some experts to have **killed** more than 12,000 **people** and hospitalized 150,000. Thousands of animals also **died**



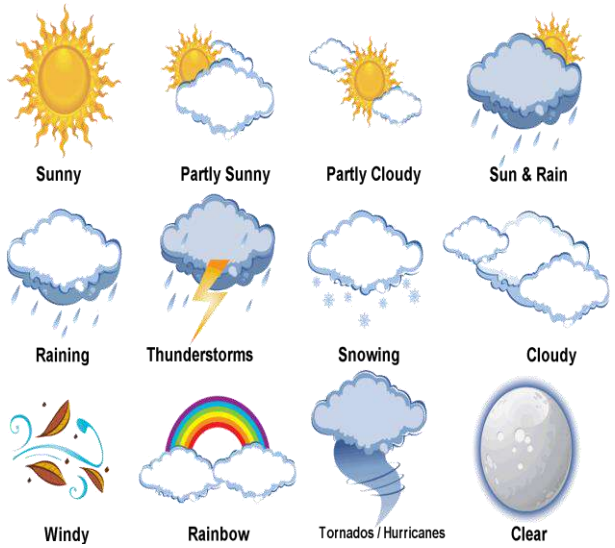
# TOPIC 1: INTRODUCTION TO EARTH SCIENCE

**a) Troposphere (3):** all important **weather and climate phenomena** occur

## 1. Weather:

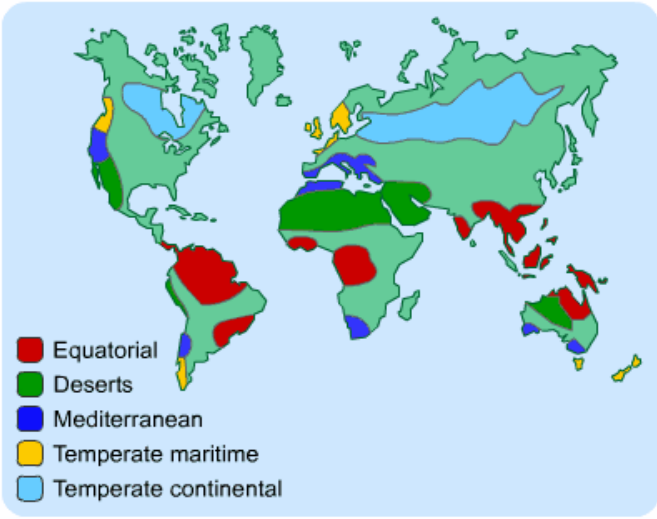
The day-to-day **atmospheric conditions** of a particular place. (elements: *temperature, precipitation, wind, humidity, sunshine, cloud cover, visibility, pressure*).

Note: These parameters are related and hence weather is the sum total of all its elements




## 2. Climate:

- The **average weather conditions** of a particular place/location/country/region recorded over a **long period of time**, usually 30 years.



## ❑ Vertical Structure of the Atmosphere

### b) Stratosphere (1)

- ✓ It is above the troposphere
- ✓ The temperature **remains constant** to a height of about 20 kilometers and then begins a gradual increase that continues until the *stratopause*, at a height of nearly **50 kilometers** above Earth's surface.
- ✓ Temperature and humidity **are not readily transferred** by large-scale turbulence and mixing as the case in the Troposphere.
- ✓ Temperatures increase in the stratosphere because it is in this layer that the **atmosphere's ozone is concentrated**.
- ✓ It should be remember that ozone absorbs **ultraviolet radiation** from the Sun. As a consequence, the stratosphere is **heated**.

- **Vertical Structure of the Atmosphere**

## C) Mesosphere

- ✓ Third layer of the atmosphere.
- ✓ Temperature decrease with height until at the mesopause approx. 80km above surface
- ✓ Temperature approaches -90 °C
- ✓ The coldest temperature anywhere in the atmosphere occurs at the mesopause
- ✓ The **temperature** decreases in the **mesosphere** since there is no ozone and the amount of air and gas molecules is **decreasing**.

- **Vertical Structure of the Atmosphere**

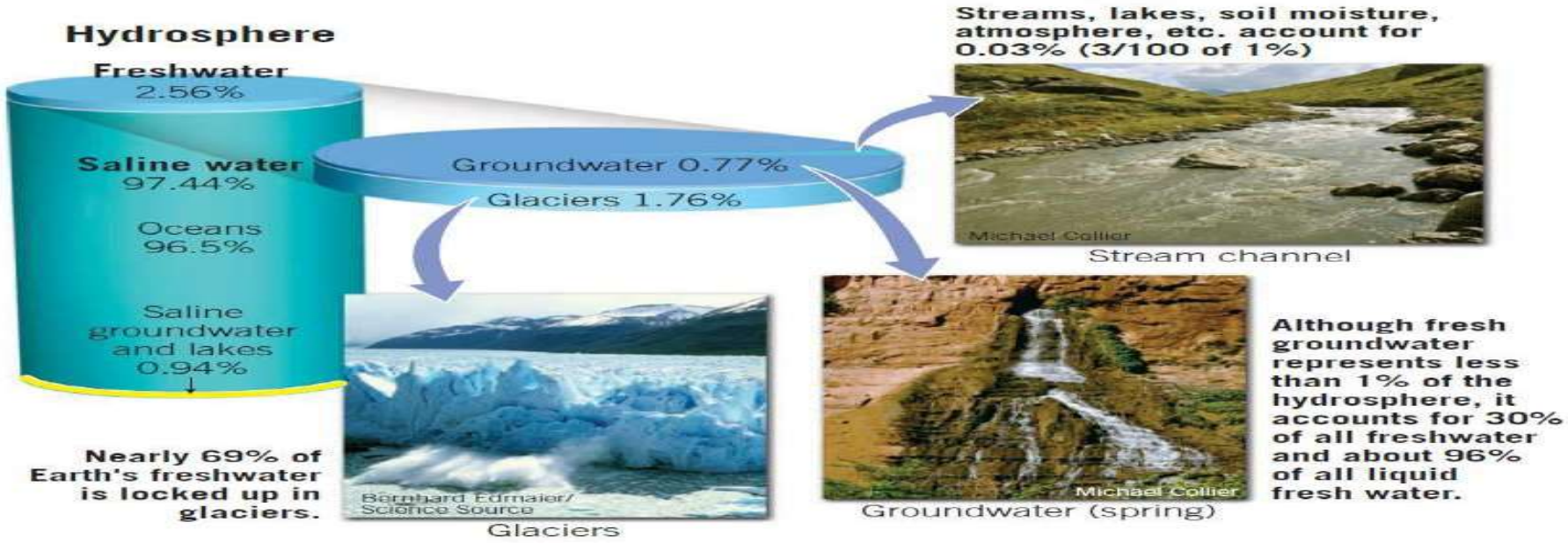
## d) Thermosphere

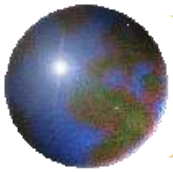
- ✓ The **fourth layer** extends outward from the mesopause and has no well-defined upper limit.
- ✓ It contains only a tiny fraction of the atmosphere's mass
- ✓ Temperatures again increase, due to the absorption of very **short-wave**, high-energy solar radiation by **atoms of oxygen and nitrogen**

# TOPIC 1: INTRODUCTION TO EARTH SCIENCE

## d) The Hydrosphere

- It is a dynamic **mass of water that is continually on the move**, evaporating from the oceans to the atmosphere, precipitating to the land, and running back to the ocean again.
- Streams, glaciers, and groundwater are responsible for sculpturing and creating many of our planet's varied landforms
- Water and air uniquely combine on the earth's surface and make it habitable for life forms..



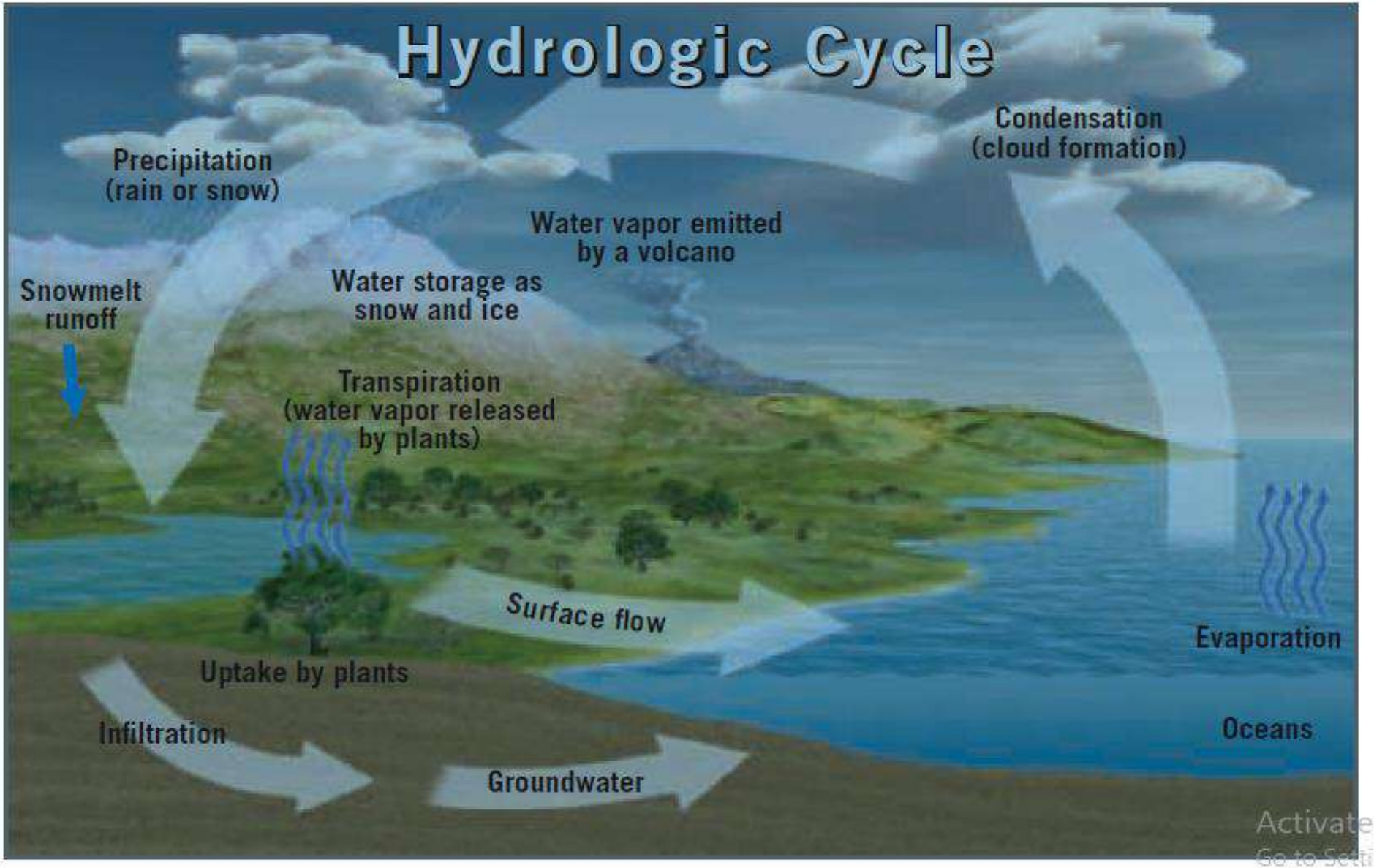


# TOPIC 1: INTRODUCTION TO EARTH SCIENCE

## ❑ Earth as a System

- ✓ A **system** is a group of interacting, or interdependent, parts that form a complex whole
- ✓ The Earth system has a nearly endless array of subsystems in which matter is recycled over and over. One familiar loop, or subsystem, is the ***hydrologic cycle.***
- ✓ It represents the unending circulation of Earth's water among the hydrosphere, atmosphere, biosphere, and geosphere.
- ✓ Water enters the **atmosphere through evaporation** from Earth's surface and transpiration from plants.
- ✓ Water vapor condenses in the atmosphere to form clouds, which in turn produce precipitation that falls back to Earth's surface
- ✓ Some of the rain that falls onto the land sinks in and then is taken up by plants or becomes groundwater, and some flows across the surface toward the ocean

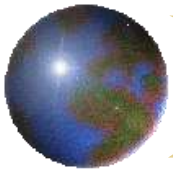
# TOPIC 1: INTRODUCTION TO EARTH SCIENCE



## ❑ Energy for the Earth System

- The Earth system is powered by energy from two sources:

1. The **Sun drives external processes** that occur in the atmosphere, in the hydrosphere, and at Earth's surface. Weather and climate, ocean circulation and erosional processes are driven by energy from the Sun.
2. **Earth's interior is the second source of energy**. Heat remaining from when our planet formed and heat that is continuously generated by radioactive decay power the internal processes that produce volcanoes, earthquakes, and mountains.

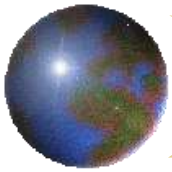


# TOPIC 1: INTRODUCTION TO EARTH SCIENCE

## ❑ The Nature of Scientific Inquiry

- ❑ Science is a process of producing knowledge.
  - ✓ The overall goal of science is to discover the underlying patterns in nature and then to use this knowledge to make predictions about what should or should not be expected, given certain facts or circumstances.
  - ✓ The development of new scientific knowledge involves some basic logical processes that are universally accepted.
- ❑ The nature of scientific inquiry involves

1. **Hypothesis:** a ***tentative explanation*** for an observation, phenomenon, or scientific problem that can be tested by further investigation. E.g. increased diarrhea in this community might be liked to sewerage leaks.
2. **Theory:** set of statements or principles devised to explain a group of facts or phenomena and can be used to make predictions about natural phenomena
3. **Scientific method**: involves the observation of phenomena, the formulation of a hypothesis concerning the phenomena, experimentation to demonstrate the truth or falseness of the hypothesis, and a conclusion that validates or modifies the hypothesis



# TOPIC 1: INTRODUCTION TO EARTH SCIENCE

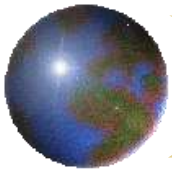
## Philosophical Assumptions in scientific inquiry

### ❖What is Philosophy?

- ✓ It means the use of abstract ideas and beliefs that inform our research
- ✓ It can also be defined as the study of the fundamental nature of *knowledge, reality, and existence*,

# Why Philosophy Is Important

1) It helps us to understand how reality is created
2) It shapes how we formulate our research problem, objectives and research questions to study
3) It helps us to know how we can seek information to answer the questions.



# TOPIC 1: INTRODUCTION TO EARTH SCIENCE

## Philosophical Assumptions 1: Ontology

❖It's a philosophical study of the **nature of being**, **becoming, existence, or reality.** *[the world in the mind and outside the mind].*

❖It deals with questions about *what things exist or can be said to exist,* and how such *entities can be grouped according to similarities and differences*. **E.g. classification of life i.e. from kingdom to species.**

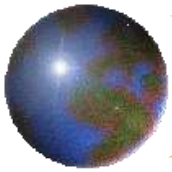
❖There are two ontological stances:

1. **Positivist ontology:** **Reality** is *INDEPENDENT OF HUMAN PERCEPTION*; the world is external; Thus, there is an objective reality to **ANY RESEARCH** phenomenon regardless to one's beliefs, culture or perspective.

   ✓ For example, we all agree that there is a **moon in the sky** and it visible at night. Then, if you go to another country, people will say the same thing. *Objective Reality is out there*.

2. **Social constructed ontology:** Reality is ***SOCIALLY CONSTRUCTED*** rather than objectively determined. **Subjective reality.** **E.g**

   ✓ What is beautiful for one person **MIGHT BE** ugly to another.
   ✓ A white girl or man might be perceived as **a ghost in the Amazon** tribes.
   ✓ A moon is perceived as god to some tribes etc.



# TOPIC 1: INTRODUCTION TO EARTH SCIENCE

## ❖ Philosophical Assumptions 2: Epistemology

The study of *knowing how to gain knowledge from the world*. In other words, the *relationship between reality (Objective or Subjective) and research.*

❖ There are two **Epistemological stance:**

1. **Positivistic/objectivistic epistemology:** There is *an objective reality*. **HOW DO WE GAIN KNOWLEDGE?:** By scientifically *measuring objective knowledge*, which is out there, outside our personal beliefs.
   - ✓ *For example, to study the moon, you can use a telescope to measure its diameter and radius and make conclusions, without your own beliefs Or subjective mind.*
2. **Interpretivism/ subjectivist epistemology**: there is *no objective reality*, there are multiple realities. **HOW DO WE GAIN KNOWLEDGE?:** Research focuses on the specific contexts, does not seek to generalize, seeks to explain, interpret; the world is how we interpret it.
   - ✓ *E.g. In some Indonesian tribes, people with black teeth are beautiful. This is how the knowledge of beauty is socially constructed for them.*
   - ✓ *Knowledge is co-created between the researcher and the researched. People and their narrative are important.*

# TOPIC 1: INTRODUCTION TO EARTH SCIENCE

## ❖ Philosophical Assumptions 2: Epistemology

Under subjectivity, **white teeth** are not always beautiful.

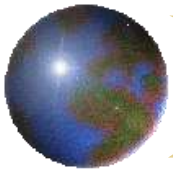
- ❖ Some Indonesian *tribes chew beetle nuts* to make their teeth black and beautiful.
- ❖ Thus, the **symbolic meaning** is more important **than the objective reality.**
- ❖ Therefore, subjective evidence is assembled based on individual view.
- ❖ This is how knowledge is known through the *subjective experiences of people*

# TOPIC 1: INTRODUCTION TO EARTH SCIENCE

- **Philosophical Assumptions 2: Epistemology**
  In objective reality, beauty can be measured with *experiments and surveys*.
- We can have the following hypothesis which states that "***a beautiful person has symmetrical features***"**[balanced proportions]**. i.e. Symmetry in one's face makes that person attractive or beautiful *[there is a cause and effect relationship]*.

***Face is not symmetrical***

***Symmetrical face***

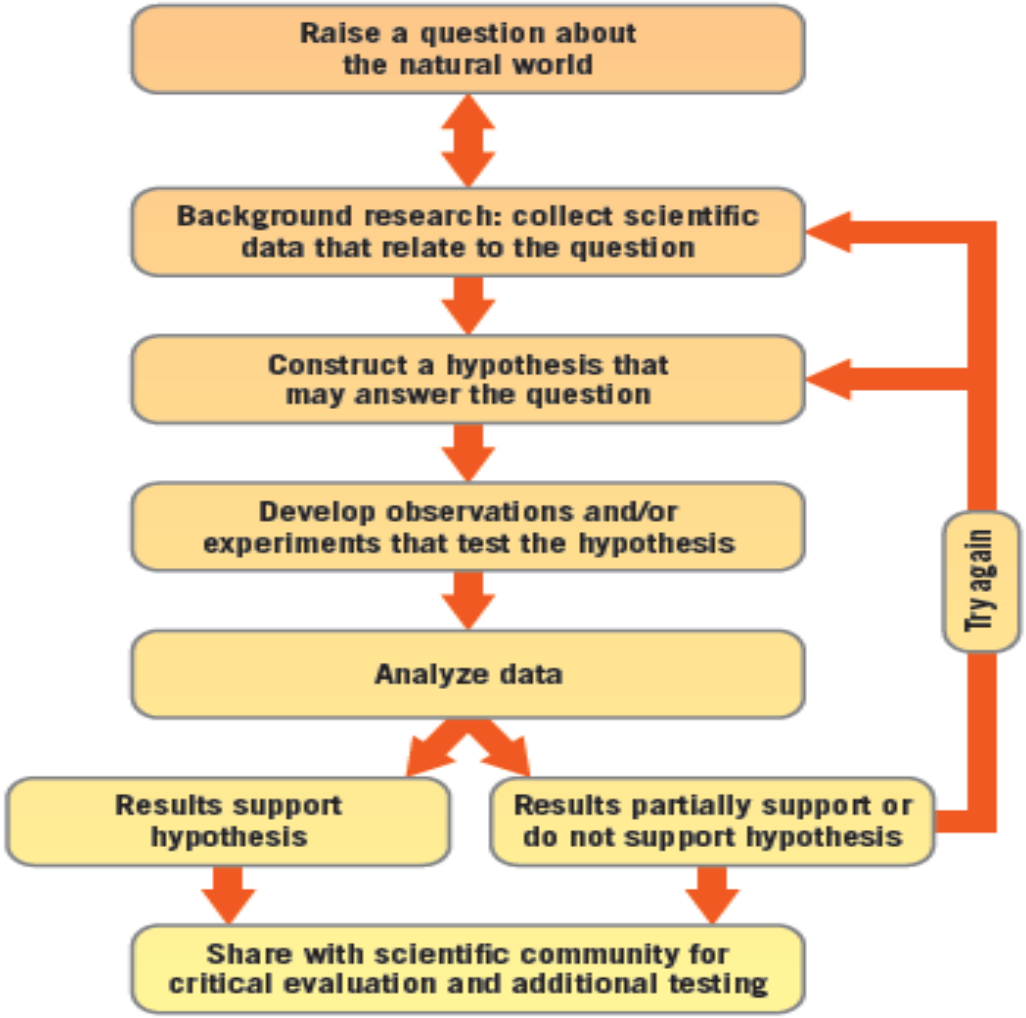


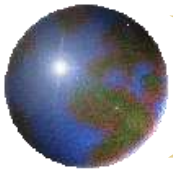
# TOPIC 1: INTRODUCTION TO EARTH SCIENCE

- **Another simplified example of Subjectivity and Objectivity**
- Take for example *if a tree falls* in the forest does it make **SOUND?**
  - *In reality, it does, **but without the human perception of sound** in our minds, there IS NO SOUND.*
- What is sound? Sound is *PERCEPTION* and perception is among our five senses*[ i.e. **Sight, hearing, touch, smell, and taste]***
  - *Then, our cognition is to process these signals (i.e. sound) in our minds to conclude that something is falling.*
- Subjectivist says ***without our own perception and cognition*** **SOUND IS NOT SOUND.**
- Objectivist says ***no sound or sound, it*** does not matter.
  - *What matters, is an objective reality independent of us or outside our minds.*
- But, by looking into the ontological lenses and the epistemological positions,
  - in any scientific inquiry, it is better to adopt both **Subjectivity and Objectivity** perspectives because **REALITY** is not only based on ***SUBJECTIVE*** experience but also ***OBJECTIVE*** experience

# TOPIC 1: INTRODUCTION TO EARTH SCIENCE

- Steps involved in the scientific investigation

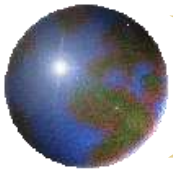




# TOPIC 1: INTRODUCTION TO EARTH SCIENCE

## ❑ Concept checks (1)

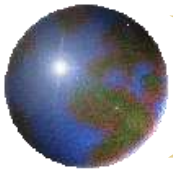
1. List and briefly define the four “spheres” that constitute our environment.
2. Compare the height of the atmosphere to the thickness of the geosphere.
3. How much of Earth’s surface do oceans cover?
4. How much of the planet’s total water supply do oceans represent?
5. Briefly summarize Earth’s layered structure.
6. To which sphere does soil belong?
7. List and briefly describe Earth’s compositional layers.
8. Contrast the lithosphere and the asthenosphere.
9. What are lithospheric plates? List the two types of boundaries that separate plates.
10. Is *air* a specific gas? Explain.



# TOPIC 1: INTRODUCTION TO EARTH SCIENCE

## ❑ Concept checks (2)

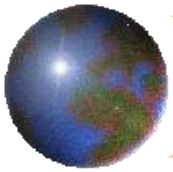
1. What are the two major components of clean, dry air? What proportion does each represent?
2. Why are water vapor and aerosols important constituents of Earth's atmosphere?
3. What is ozone? Why is ozone important to life on Earth?
4. What are CFCs, and what is their connection to the ozone problem?
5. List the major gases composing Earth's atmosphere and identify the components that are most important to understanding weather and climate.
6. Does air pressure increase or decrease with an increase in altitude? Is the rate of change constant or variable? Explain.
7. Is the outer edge of the atmosphere clearly defined? Explain.
8. The atmosphere is divided vertically into four layers, on the basis of temperature. List and describe these layers in order, from lowest to highest. In which layer does practically all our weather occur?



# TOPIC 1: INTRODUCTION TO EARTH SCIENCE

## ❑ Concept checks (3)

1. What is the environmental lapse rate, and how is it determined?
2. Why do temperatures increase in the stratosphere?
3. Why are temperatures in the thermosphere not strictly comparable to those experienced near Earth's surface?
4. Describe the process of ozone creation and loss in the ozone layer.
5. What is a system? List three examples of systems.
6. What are the two sources of energy for the Earth system?
7. What primary production. Explain the factors influencing primary production



# TOPIC 1: INTRODUCTION TO EARTH SCIENCE

## ❑ Concept checks (4)

1. Using illustrations, describe the concepts of perihelion and aphelion
2. Distinguish between primary production and secondary production
3. Using relevant examples, distinguish between NEP positive and NEP Negative
4. Describe the components of primary productivity
5. What is consumer energetics?
6. Discuss the nature of scientific inquiry and distinguish between a hypothesis and a theory
7. Explain the philosophical Assumptions that can be used in any scientific inquiry