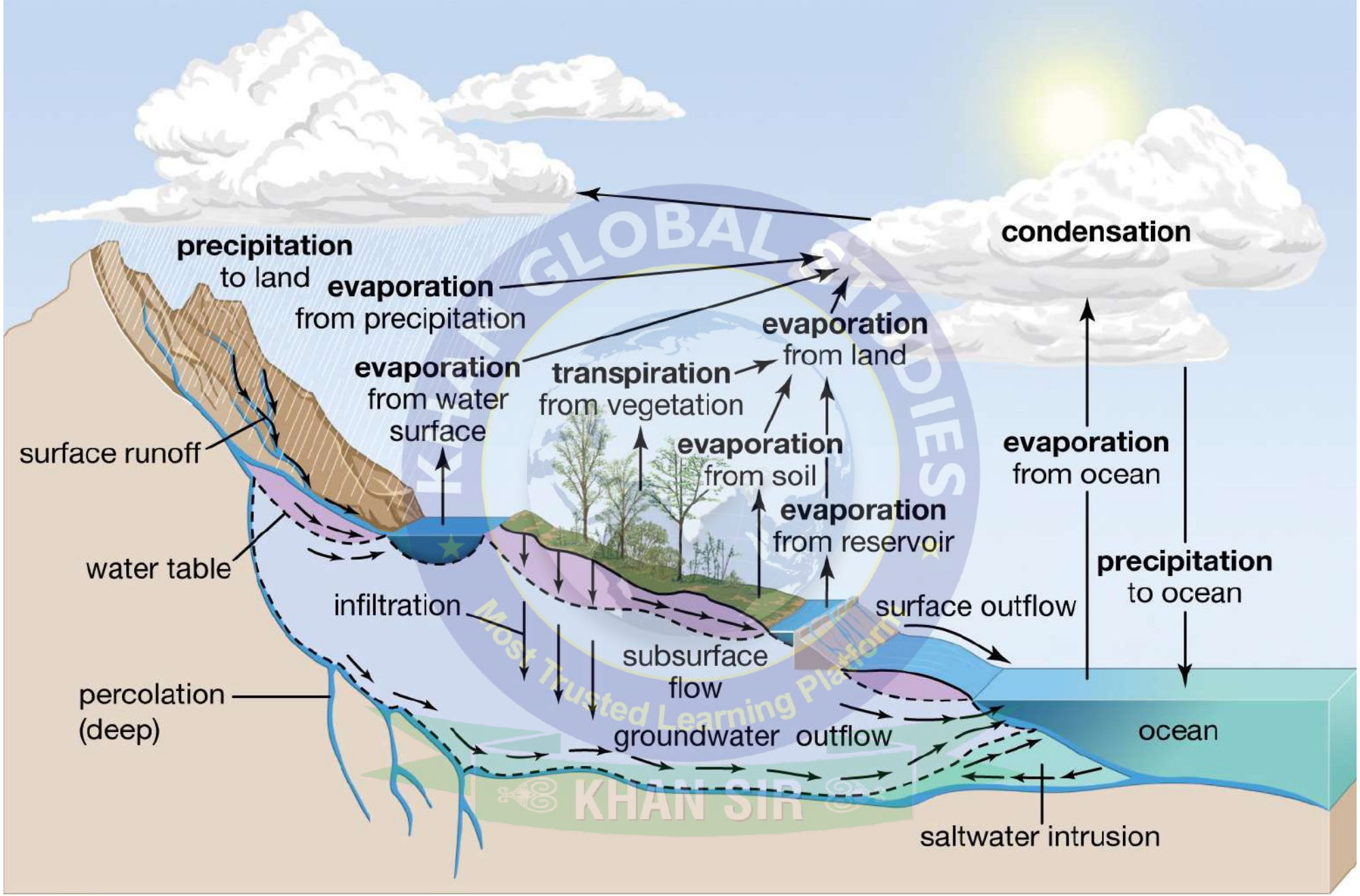
Biogeochemical Cycle
जैव भू-रासायनिक चक्र

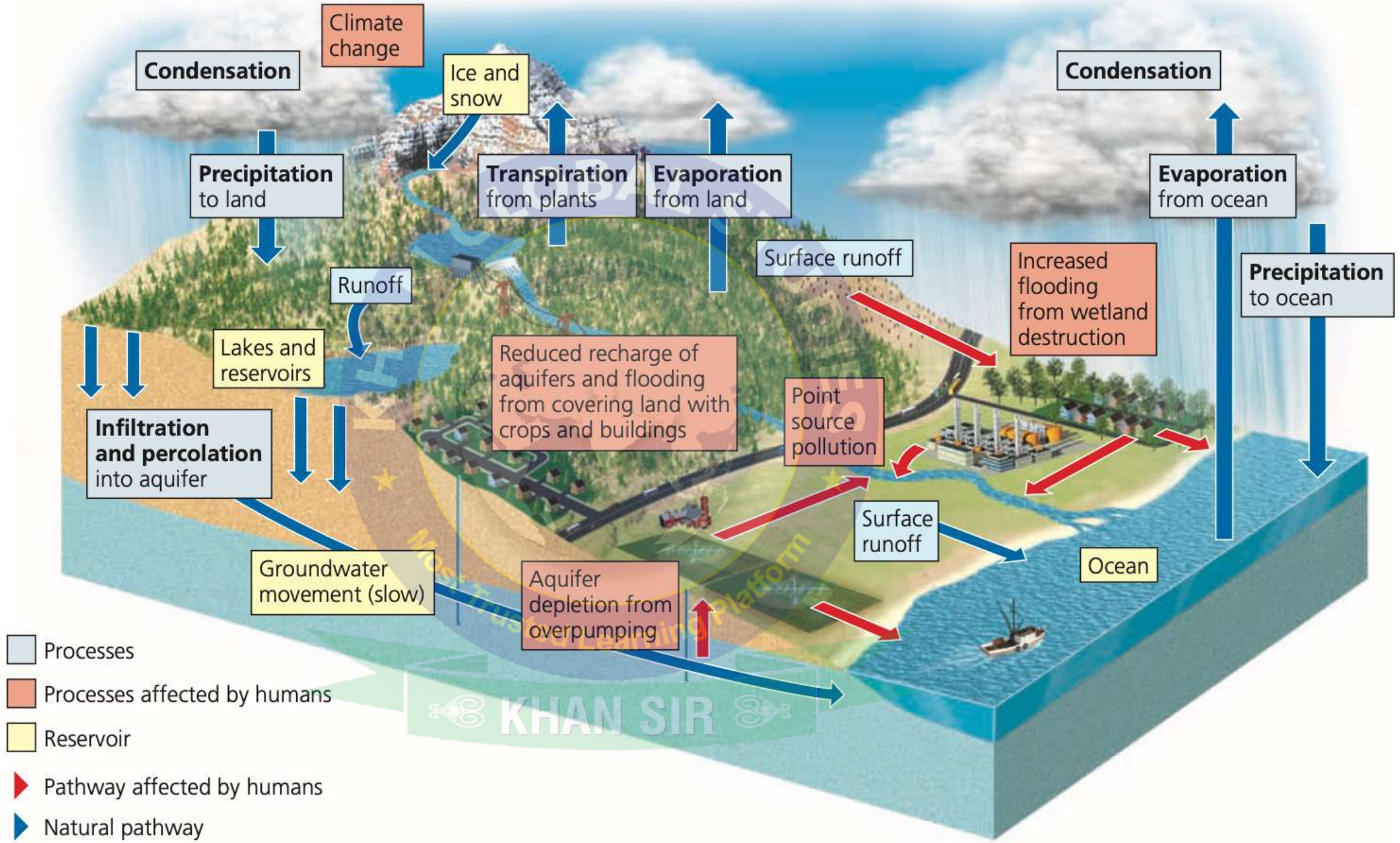
Basic Concepts

- What (जैव भू-रासायनिक चक्र क्या होते हैं?)
- Basic Terms (आधारभूत concepts)
- Major types (मुख्य प्रकार)
  - Nitrogen Cycle (नाइट्रोजन चक्र)
  - Carbon Cycle (कार्बन चक्र)
  - Phosphorus Cycle (फ़ॉस्फ़ोरस चक्र)
  - Sulphur Cycle (सल्फ़र चक्र)

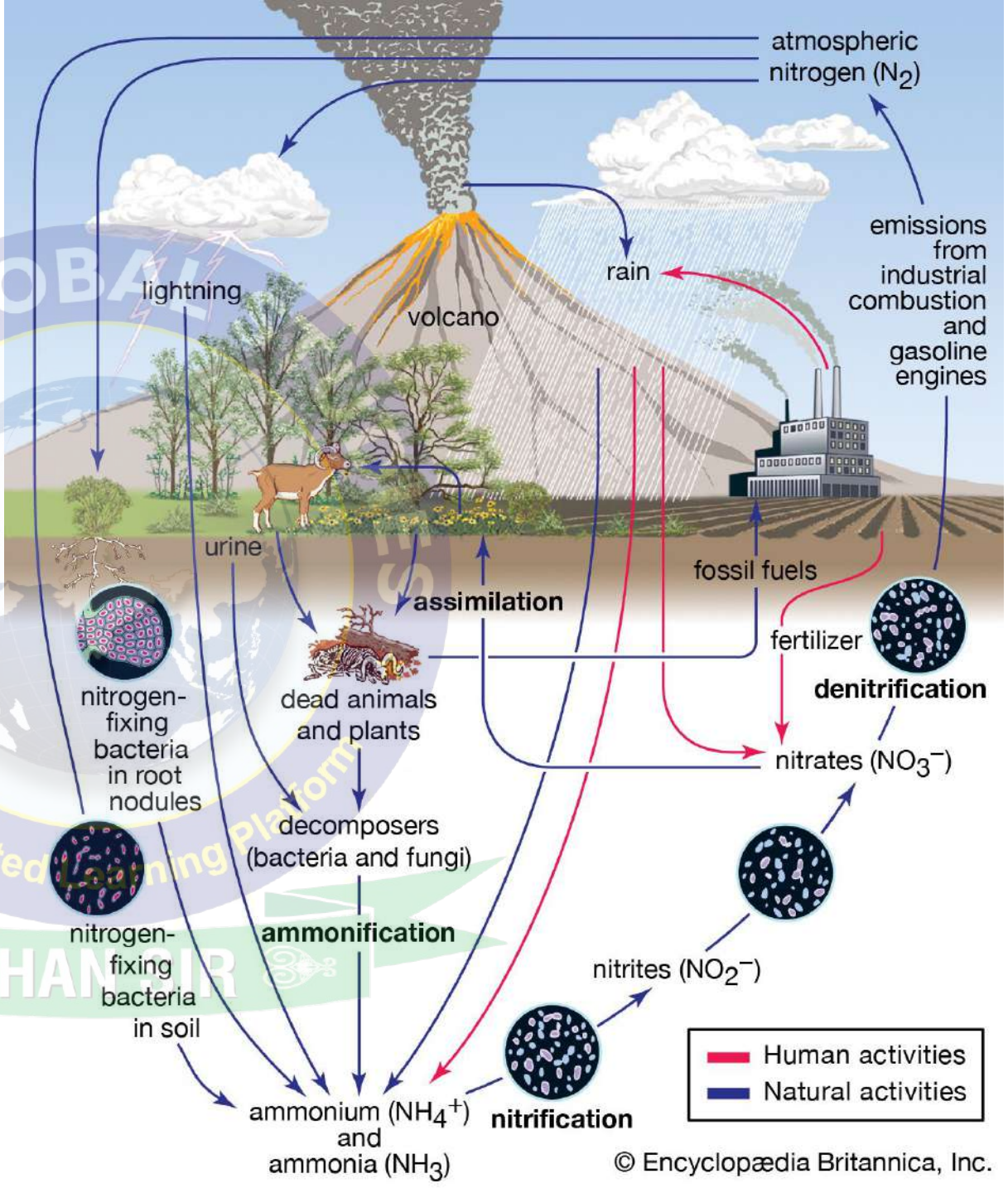
Water Cycle

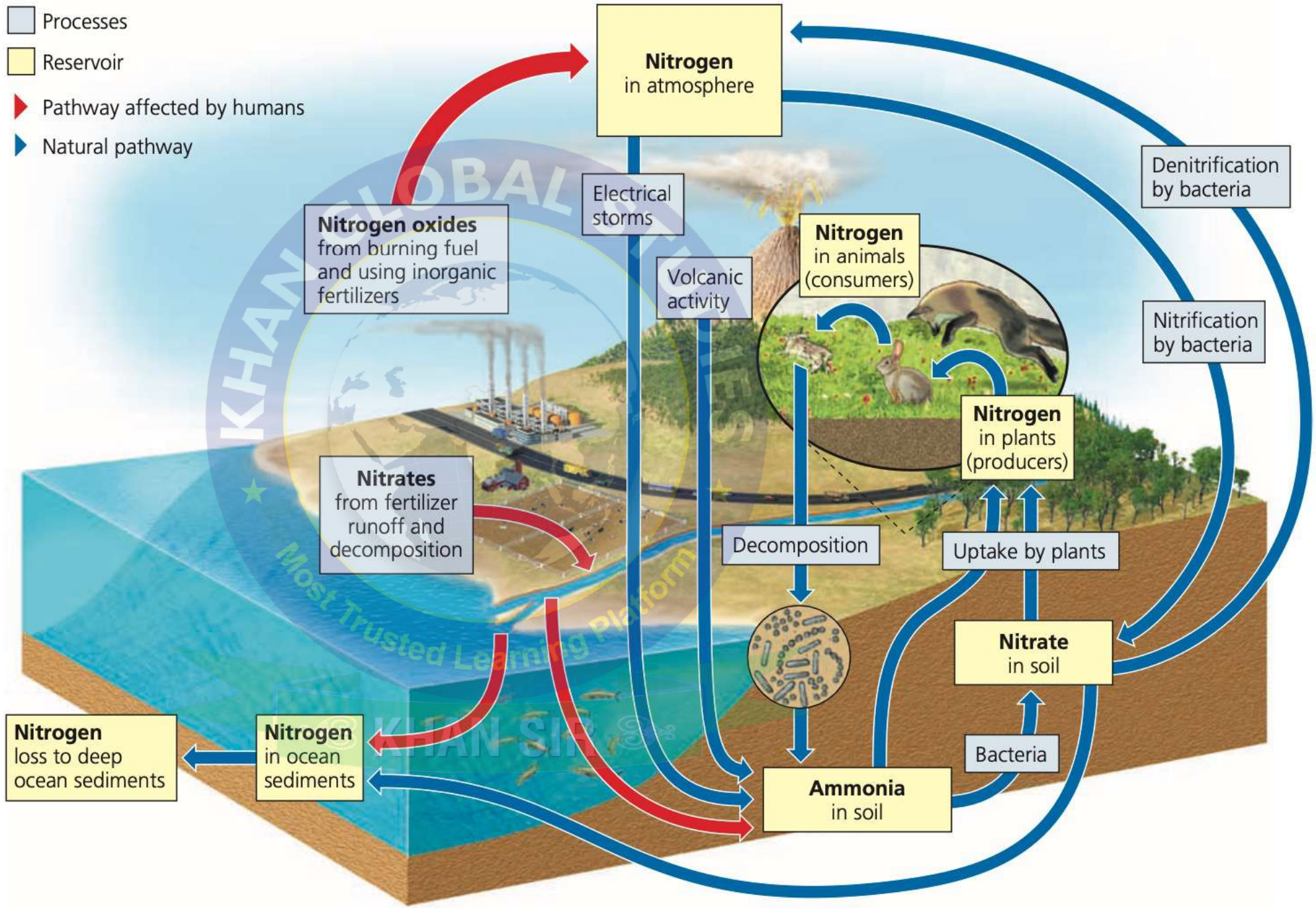

KHAN GLOBAL STUDIES
Most Trusted Learning Platform
KHAN SIR



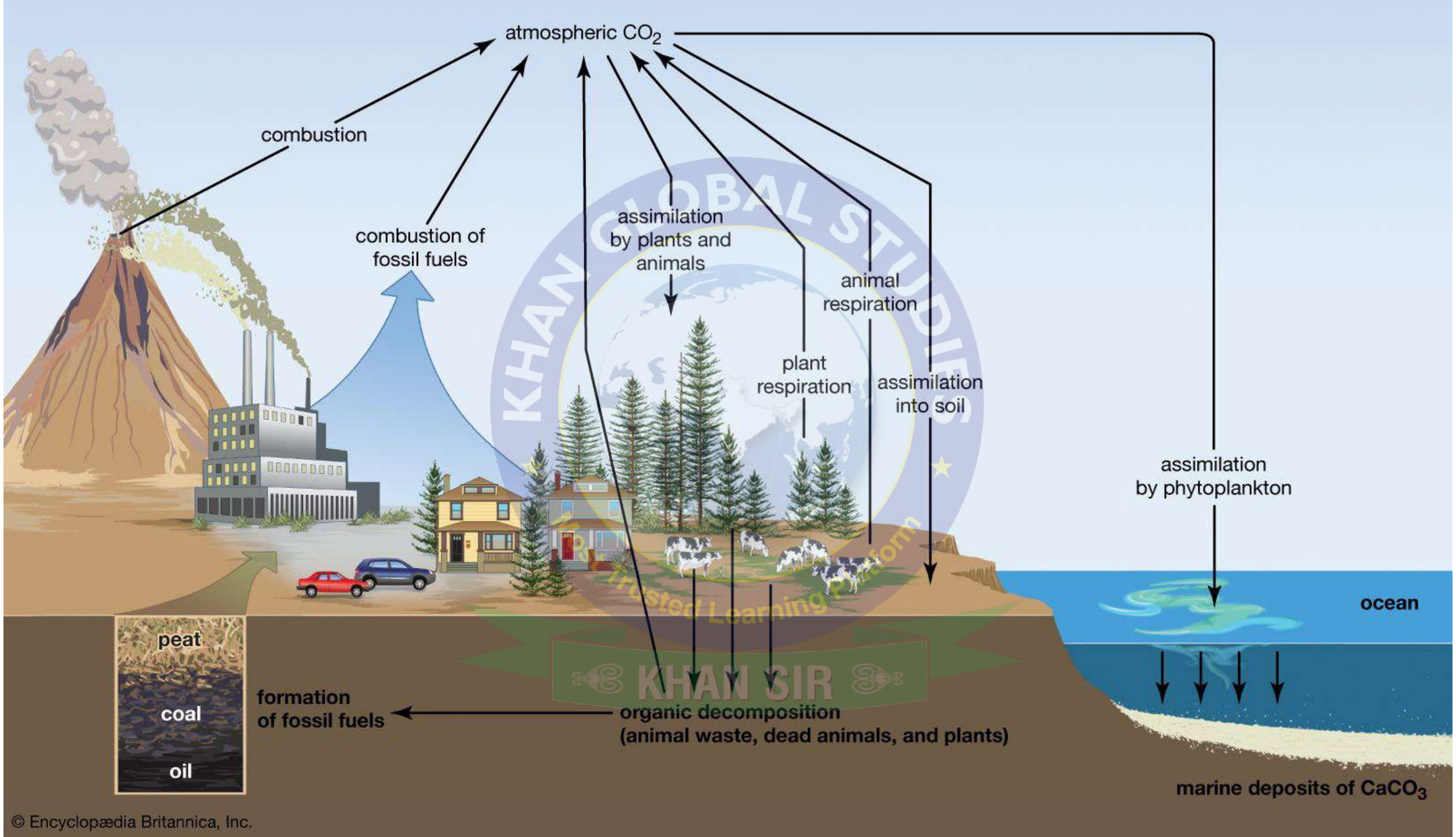

Climate change
Condensation
Ice and snow
Condensation
Precipitation to land
Transpiration from plants
Evaporation from land
Evaporation from ocean
Surface runoff
Increased flooding from wetland destruction
Runoff
Precipitation to ocean
Lakes and reservoirs
Reduced recharge of aquifers and flooding from covering land with crops and buildings
Point source pollution
Infiltration and percolation into aquifer
Surface runoff
Groundwater movement (slow)
Aquifer depletion from overpumping
Ocean
Processes
Processes affected by humans
Reservoir
Pathway affected by humans
Natural pathway

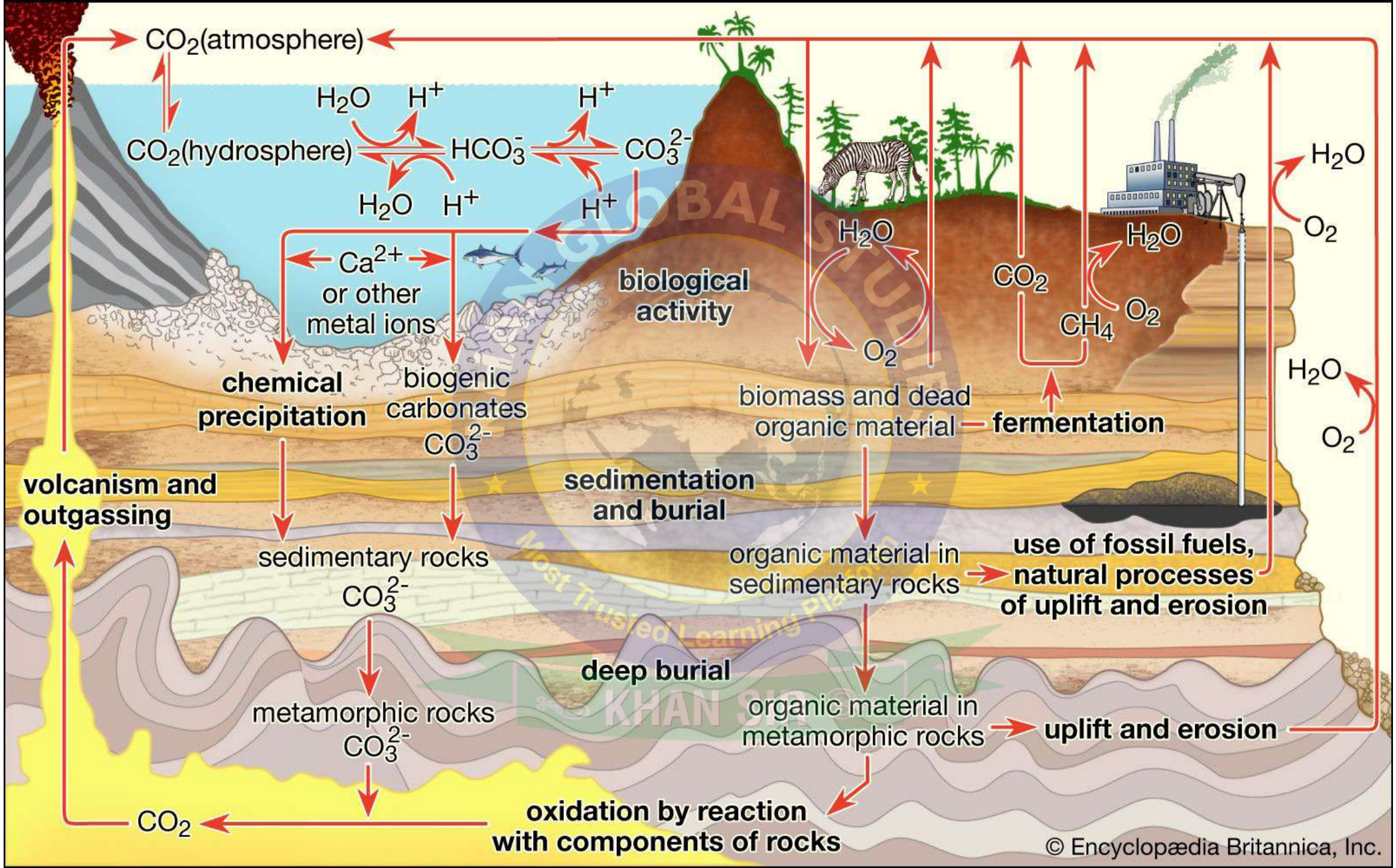
Nitrogen Cycle

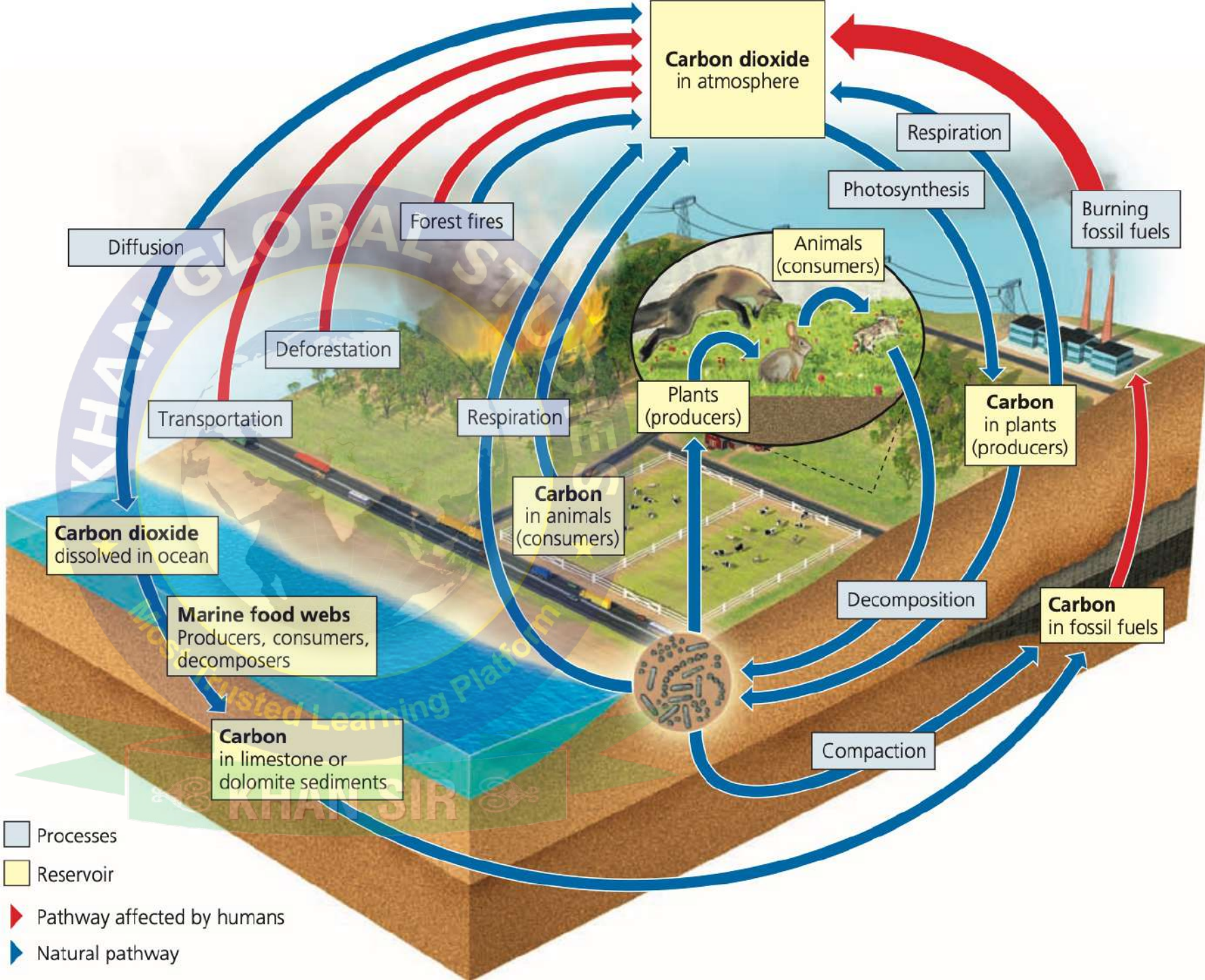

atmospheric nitrogen (N_2)
emissions from industrial combustion and gasoline engines
rain
lightning
volcano
urine
fossil fuels
assimilation
fertilizer
denitrification
nitrogen-fixing bacteria in root nodules
dead animals and plants
nitrates (NO_3^-)
decomposers (bacteria and fungi)
ammonification
nitrogen-fixing bacteria in soil
nitrites (NO_2^-)
ammonium (NH_4^+) and ammonia (NH_3)
nitrification
Human activities
Natural activities
© Encyclopædia Britannica, Inc.


Processes
Reservoir
Pathway affected by humans
Natural pathway
Nitrogen in atmosphere
Nitrogen oxides from burning fuel and using inorganic fertilizers
Electrical storms
Volcanic activity
Nitrogen in animals (consumers)
Denitrification by bacteria
Nitrification by bacteria
Nitrogen in plants (producers)
Nitrates from fertilizer runoff and decomposition
Decomposition
Uptake by plants
Nitrate in soil
Bacteria
Ammonia in soil
Nitrogen in ocean sediments
Nitrogen loss to deep ocean sediments

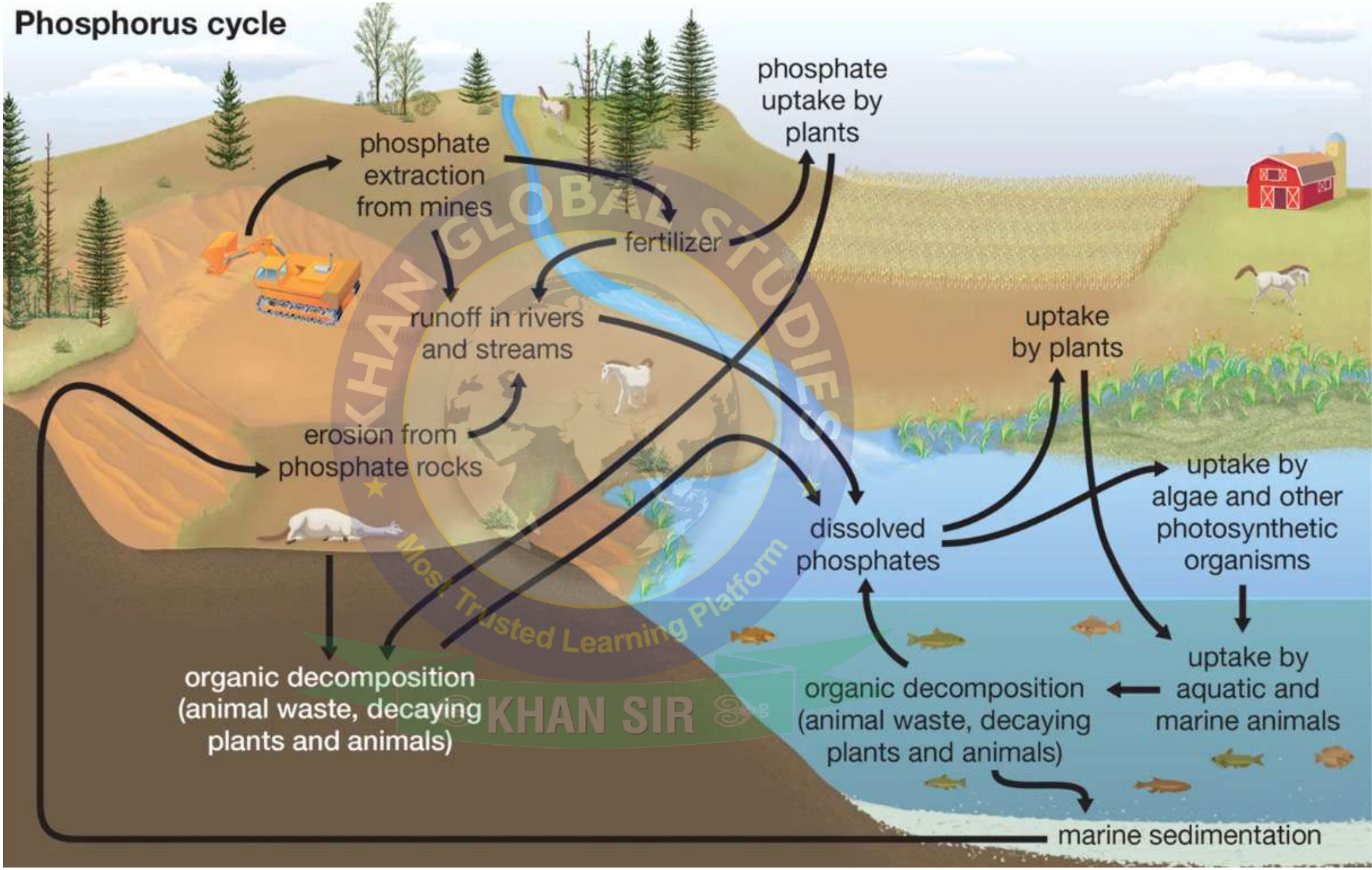
Carbon Cycle

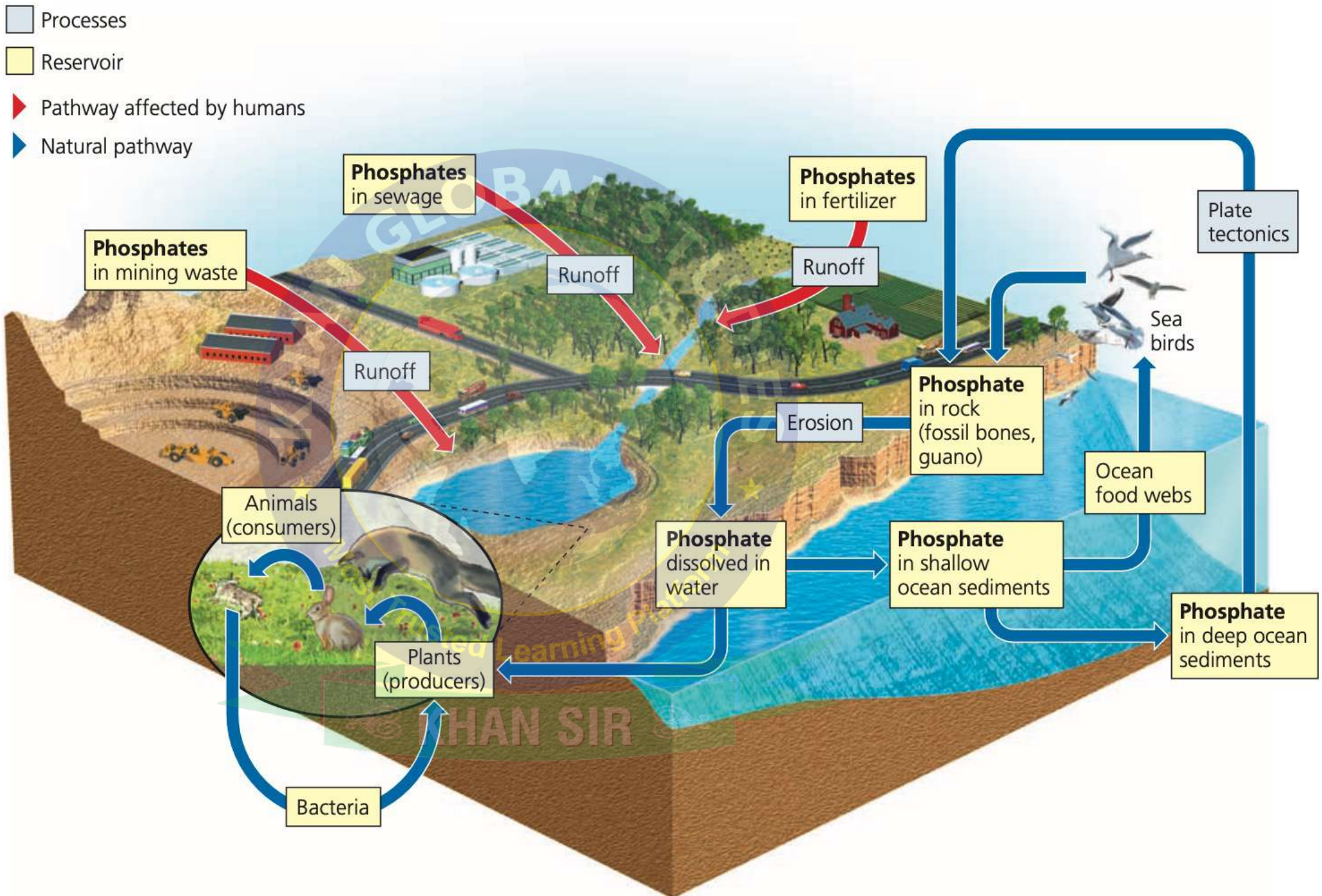

atmospheric CO_2
combustion
combustion of fossil fuels
assimilation by plants and animals
animal respiration
plant respiration
assimilation into soil
assimilation by phytoplankton
ocean
peat
coal
oil
formation of fossil fuels
organic decomposition (animal waste, dead animals, and plants)
marine deposits of $CaCO_3$
© Encyclopædia Britannica, Inc.


CO_2(atmosphere)
CO_2(hydrosphere)
H_2O
H^+
HCO_3^-
CO_3^{2-}
Ca^{2+} or other metal ions
biological activity
chemical precipitation
biogenic carbonates CO_3^{2-}
biomass and dead organic material
fermentation
CO_2
CH_4
O_2
volcanism and outgassing
sedimentation and burial
sedimentary rocks CO_3^{2-}
organic material in sedimentary rocks
use of fossil fuels, natural processes of uplift and erosion
deep burial
metamorphic rocks CO_3^{2-}
organic material in metamorphic rocks
uplift and erosion
oxidation by reaction with components of rocks
© Encyclopædia Britannica, Inc.

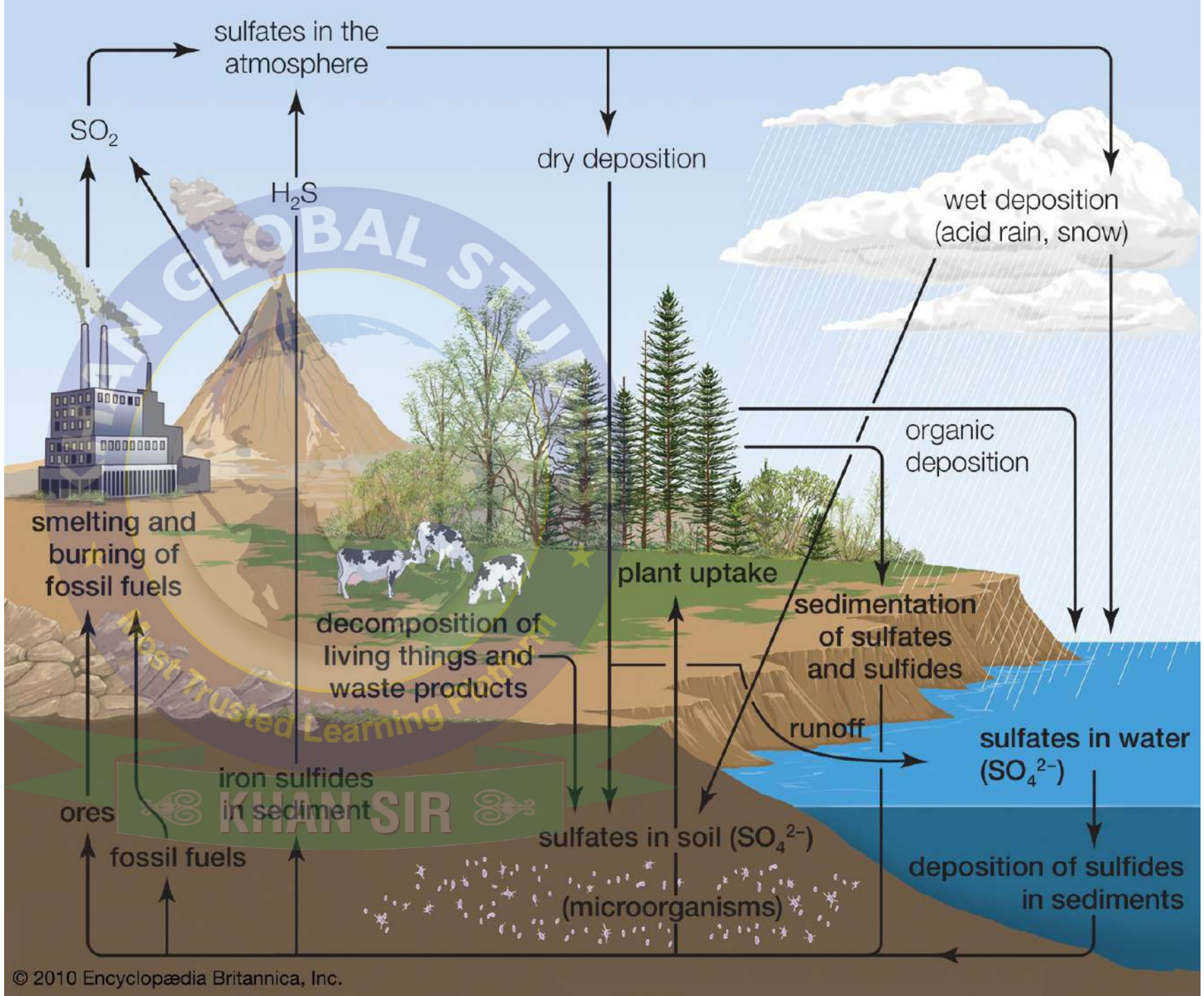

Carbon dioxide
in atmosphere
Respiration
Photosynthesis
Burning
fossil fuels
Forest fires
Diffusion
Animals
(consumers)
Deforestation
Plants
(producers)
Carbon
in plants
(producers)
Transportation
Respiration
Carbon
in animals
(consumers)
Carbon dioxide
dissolved in ocean
Decomposition
Carbon
in fossil fuels
Marine food webs
Producers, consumers,
decomposers
Compaction
Carbon
in limestone or
dolomite sediments
Processes
Reservoir
Pathway affected by humans
Natural pathway

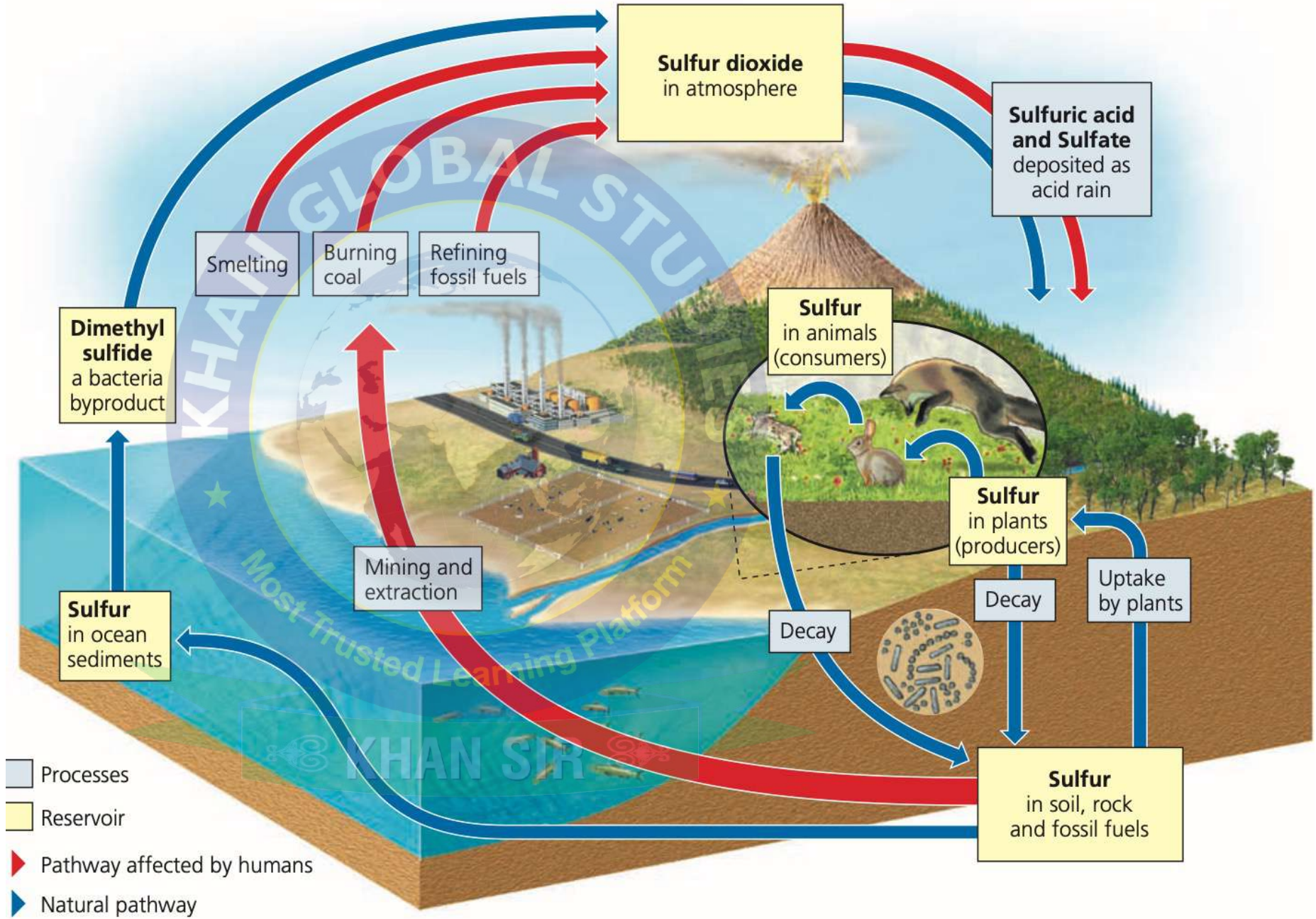
Phosphorus Cycle

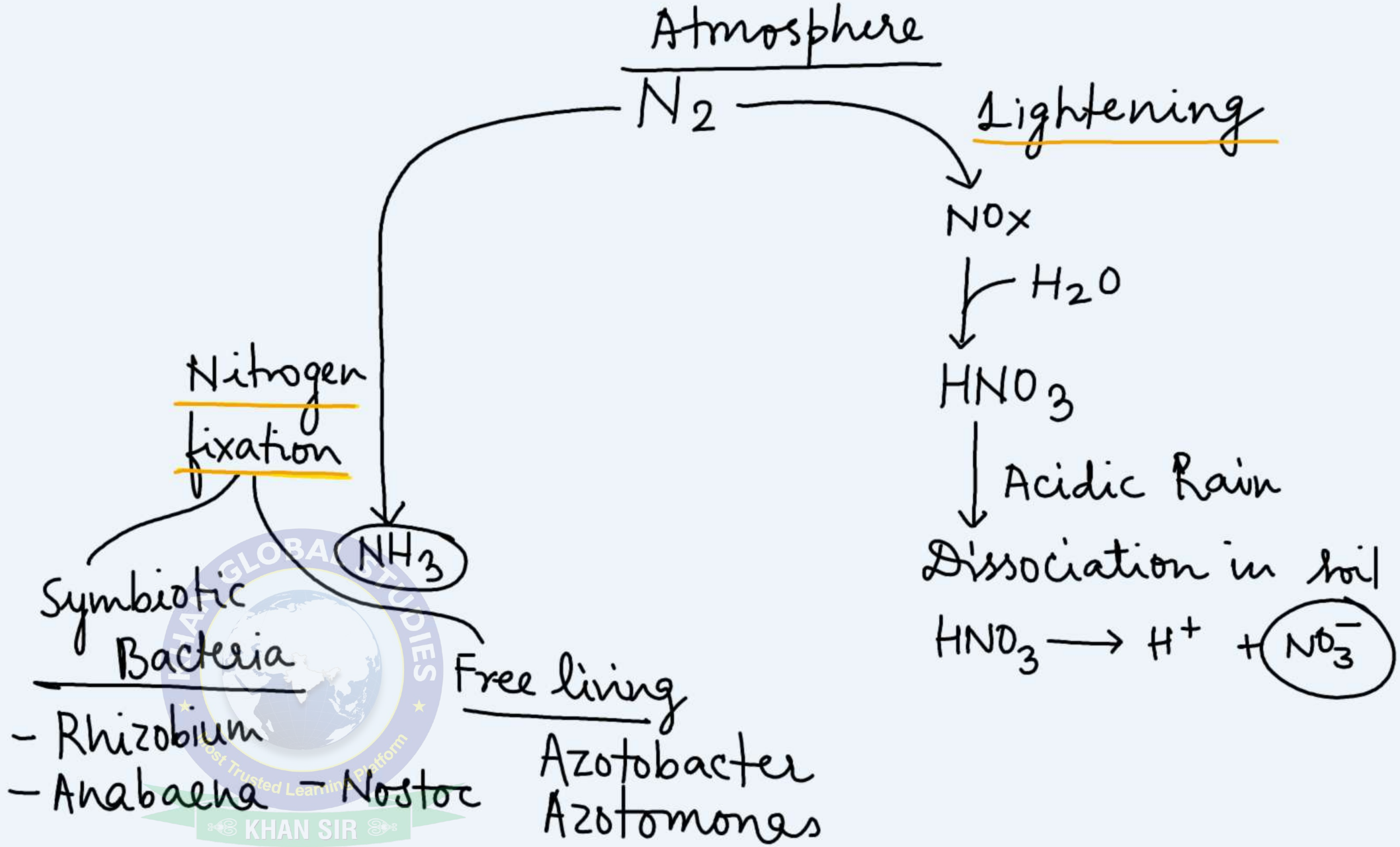

Phosphorus cycle
phosphate extraction from mines
phosphate uptake by plants
fertilizer
runoff in rivers and streams
uptake by plants
erosion from phosphate rocks
dissolved phosphates
uptake by algae and other photosynthetic organisms
organic decomposition (animal waste, decaying plants and animals)
uptake by aquatic and marine animals
organic decomposition (animal waste, decaying plants and animals)
marine sedimentation
KHAN GLOBAL STUDIES
Most Trusted Learning Platform
KHAN SIR


Processes
Reservoir
Pathway affected by humans
Natural pathway
Phosphates in sewage
Phosphates in fertilizer
Phosphates in mining waste
Runoff
Runoff
Runoff
Plate tectonics
Sea birds
Phosphate in rock (fossil bones, guano)
Erosion
Ocean food webs
Animals (consumers)
Phosphate dissolved in water
Phosphate in shallow ocean sediments
Phosphate in deep ocean sediments
Plants (producers)
Bacteria

Sulphur Cycle


sulfates in the atmosphere
SO_2
H_2S
dry deposition
wet deposition (acid rain, snow)
organic deposition
smelting and burning of fossil fuels
decomposition of living things and waste products
plant uptake
sedimentation of sulfates and sulfides
runoff
sulfates in water (SO_4^{2-})
iron sulfides in sediment
ores
fossil fuels
sulfates in soil (SO_4^{2-})
(microorganisms)
deposition of sulfides in sediments
© 2010 Encyclopædia Britannica, Inc.


Sulfur dioxide
in atmosphere
Sulfuric acid
and Sulfate
deposited as
acid rain
Smelting
Burning
coal
Refining
fossil fuels
Dimethyl
sulfide
a bacteria
byproduct
Sulfur
in animals
(consumers)
Sulfur
in plants
(producers)
Mining and
extraction
Decay
Uptake
by plants
Decay
Sulfur
in ocean
sediments
Sulfur
in soil, rock
and fossil fuels
Processes
Reservoir
Pathway affected by humans
Natural pathway


Atmosphere
N_2
Lightening
NOx
H_2O
HNO_3
Acidic Rain
Dissociation in soil
$HNO_3 \longrightarrow H^+ + NO_3^-$
Nitrogen fixation
NH_3
Symbiotic Bacteria
- Rhizobium
- Anabaena - Nostoc
Free living
Azotobacter
Azotomonas

Forms of (N) in soil

NH_3

- Nitrogen Fixation
- Ammonification
- Application of fertilizers

Organic Compounds Containing N

- Proteins & Amino Acids in dead & waste biological matter
  ↓
  ammonification

NO_2^- & NO_3^-

Process :

NITRIFICATION

NH_3
↓
NO_2^-
↓
NO_3^-

3

Organic (N) compounds → Ammonification

What happens to (N) Compounds in soil

1. NH_3
   - * Taken up by fungi and bacteria
   - absorbed by plants

2. NO_3^-
   - * Taken up by plants → Part of plant biomass
   - Denitrification: $NO_3^- \longrightarrow N_2\uparrow$

What is N_2-fixation

Background:

Dinitrogen is very stable
not easily reactive.

Dinitrogen

N_2

$N \equiv N$ ✓ Triple bonded

✓ very stable

Definition

Conversion of N_2 into a stable Nitrogenous Compound.

3 types of N_2-fixing processes

1. **Atmospheric Fixation**
   - Lightening
   - $N_2 \longrightarrow NOx$
2. **Biological Fixation**
   - $N_2 \longrightarrow NH_3$
3. **Industrial Fixation**
   - Haber-Bosch Process
   - $N_2 \longrightarrow NH_3$

2 types of Compounds

- NOx
- NH_3

Biological Fixation

Reaction

$N_2 + 8H^+$

High Energy (16 ATP) → Dinitrogenase Complex

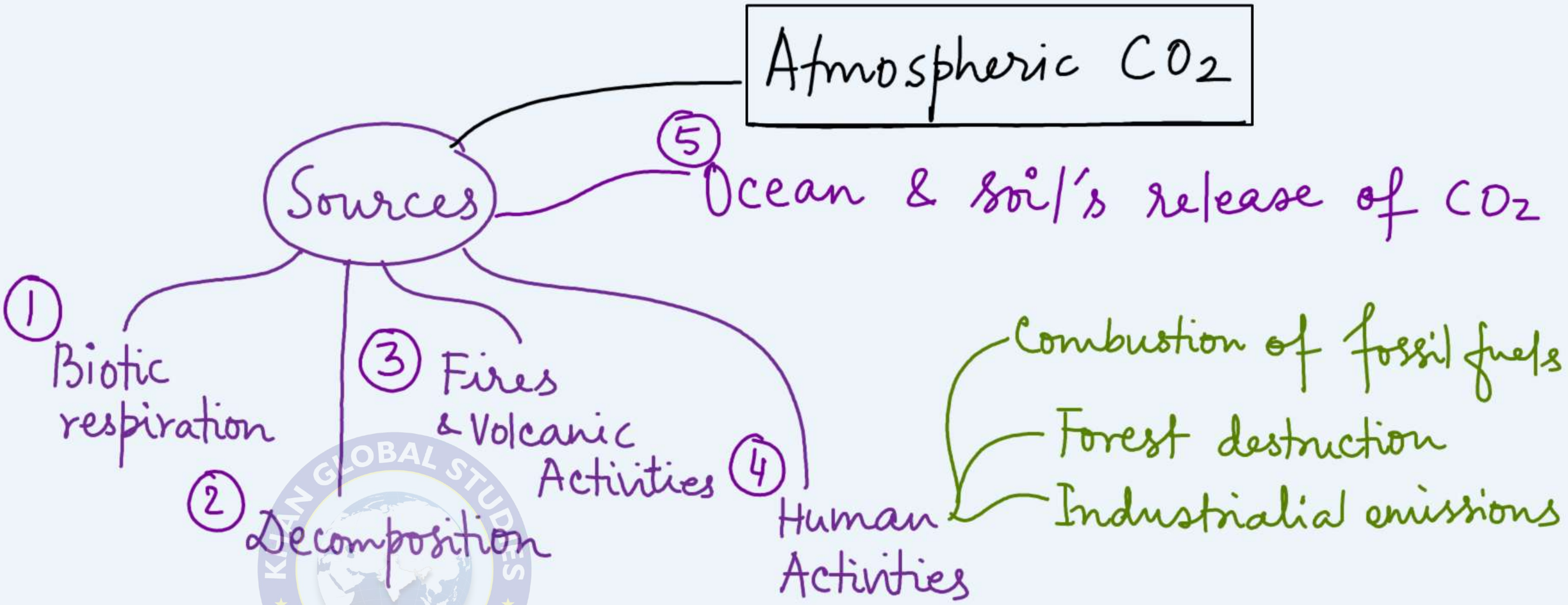
$2NH_3 + H_2\uparrow$

→ carried out only by some bacteria — also known as DIAZOTROPHS

- Diazotrophs → Two → Nitrogen → Dinitrogen Eaters (N_2)
- Diazotrophs → Eater

bacteria:

- Free living
- Symbiotic → only with plants & some algae



Atmospheric CO_2

Lost to

1. Absorption by colder parts of Hydrosphere

2. Photosynthesis by

- Plants
- Algae

Biospheric Carbon

Forms

- Organic Molecules of biomass

Source

- **Entry** → Photosynthesis

$$6CO_2 + 6H_2O \xrightarrow{\text{Radiant Energy}} C_6H_{12}O_6 + 6O_2$$

- **Circulation** → Trophic Chain

Loss

- Methanogenesis
  - CH_4 formation by some bacteria
- Combustion of Biomass → CO_2
- Respiration → CO_2
- Decomposition → CO_2

Lithosphere

Forms

- ✓ Organic Matter (Humus) in soil
- ✓ Carbonate rocks
  - $CaCO_3$ — Calcium Carbonate
  - $CaMg(CO_3)_2$ — Dolomite

Sources

- Dead & waste biomass
- Carbonate ions

$$CO_2 + H_2O \rightarrow H_2CO_3$$

$$H_2CO_3 \xrightarrow{\text{Dissociate}} HCO_3^- + H^+$$

$$HCO_3^- \longleftarrow H^+ + CO_3^{--}$$

Release

- CO_2 — Decomposition
- Carbonate rock mining

KHAN GLOBAL STUDIES
Most Trusted Learning Platform
KHAN SIR