# Ocean Literacy Guide

# Principle #2

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## 2 The ocean and life in the ocean shape the features of Earth.

**A** Many earth materials and biogeochemical cycles originate in the ocean. Many of the sedimentary rocks now exposed on land were formed in the ocean. Ocean life laid down the vast volume of siliceous and carbonate rocks.

**B** Sea level changes over time have expanded and contracted continental shelves, created and destroyed inland seas, and shaped the surface of land.

**C** Erosion—the wearing away of rock, soil, and other biotic and abiotic earth materials—occurs in coastal areas as wind, waves, and currents in rivers and the ocean, and the processes associated with plate tectonics move sediments. Most beach sand (tiny bits of animals, plants, rocks, and minerals) is eroded from land sources and carried to the coast by rivers; sand is also eroded from coastal sources by surf. Sand is redistributed seasonally by waves and coastal currents.

**D** The ocean is the largest reservoir of rapidly cycling carbon on Earth. Many organisms use carbon dissolved in the ocean to form shells, other skeletal parts, and coral reefs.

**E** Tectonic activity, sea level changes, and the force of waves influence the physical structure and landforms of the coast.

**WAVES CRASHING** on the shore of Big Sur. Photo: Steve Lonhart/NOAA Monterey Bay National Marine Sanctuary

# #2 – The ocean and life in the ocean shape the features of Earth

- **Rock Cycle and Plate Tectonics**
  All rocks end up in the sea
  Erosion and Deposition
  New Formation and Recycling

- **Biogeochemical cycles**
  Carbon cycle
  Nitrogen cycle
  Phosphorus cycle
  Silicon cycle

  …Salt cycle?
  … Sand cycle?

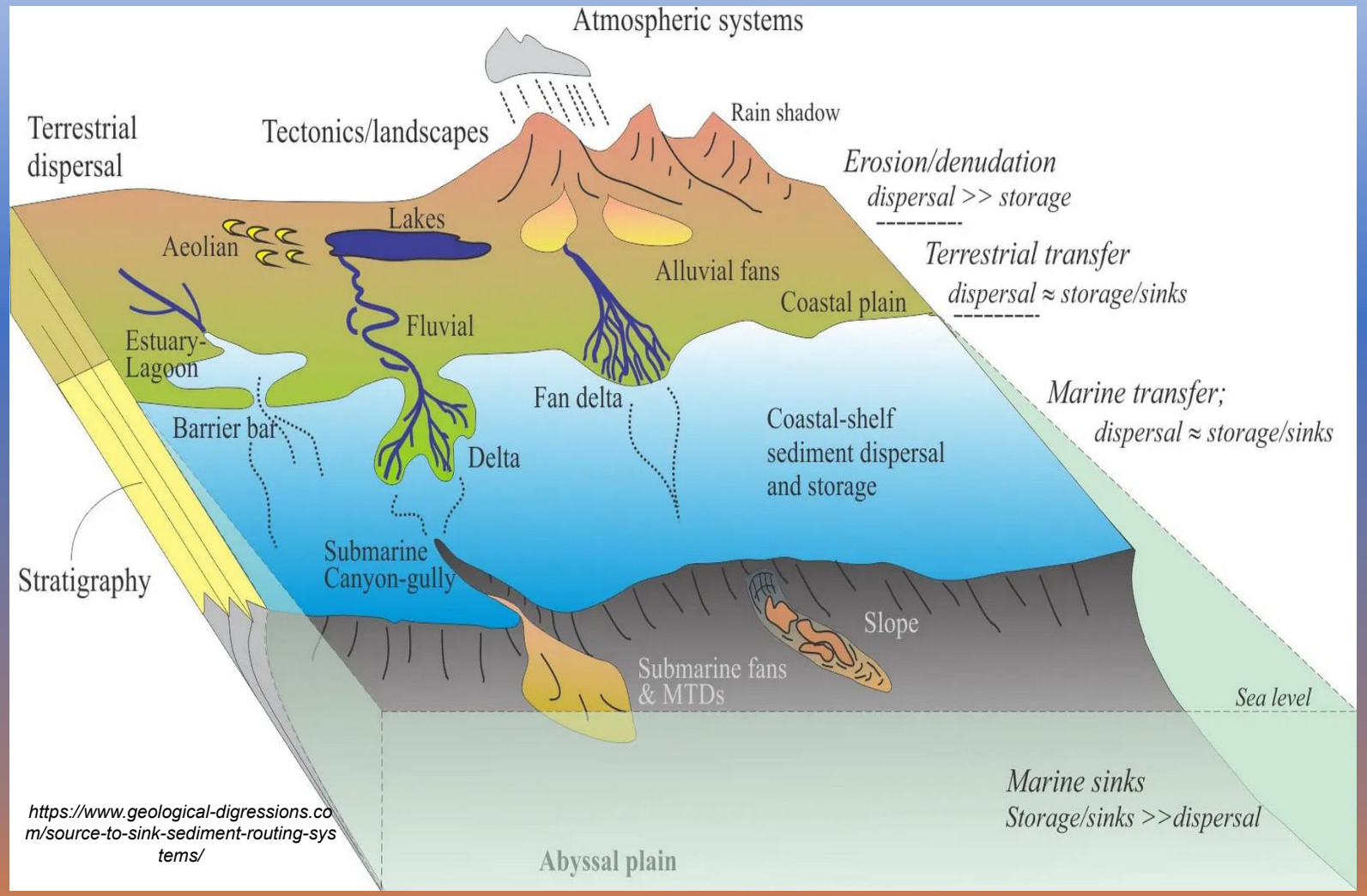
# #2 – Rock Cycle & Plate Tectonics

- Many earth materials and biogeochemical cycles originate in the ocean
- Many of the sedimentary rocks now exposed on land were formed in the ocean
- Ocean life laid down the vast volume of siliceous and carbonate rocks

## ROCK CYCLE

The ROCK CYCLE is the model that represents the genetic relationships of rocks to each other and to magma within the Earth's crust

Rocks are constantly being formed, transformed and recycled through physical, chemical and biological processes



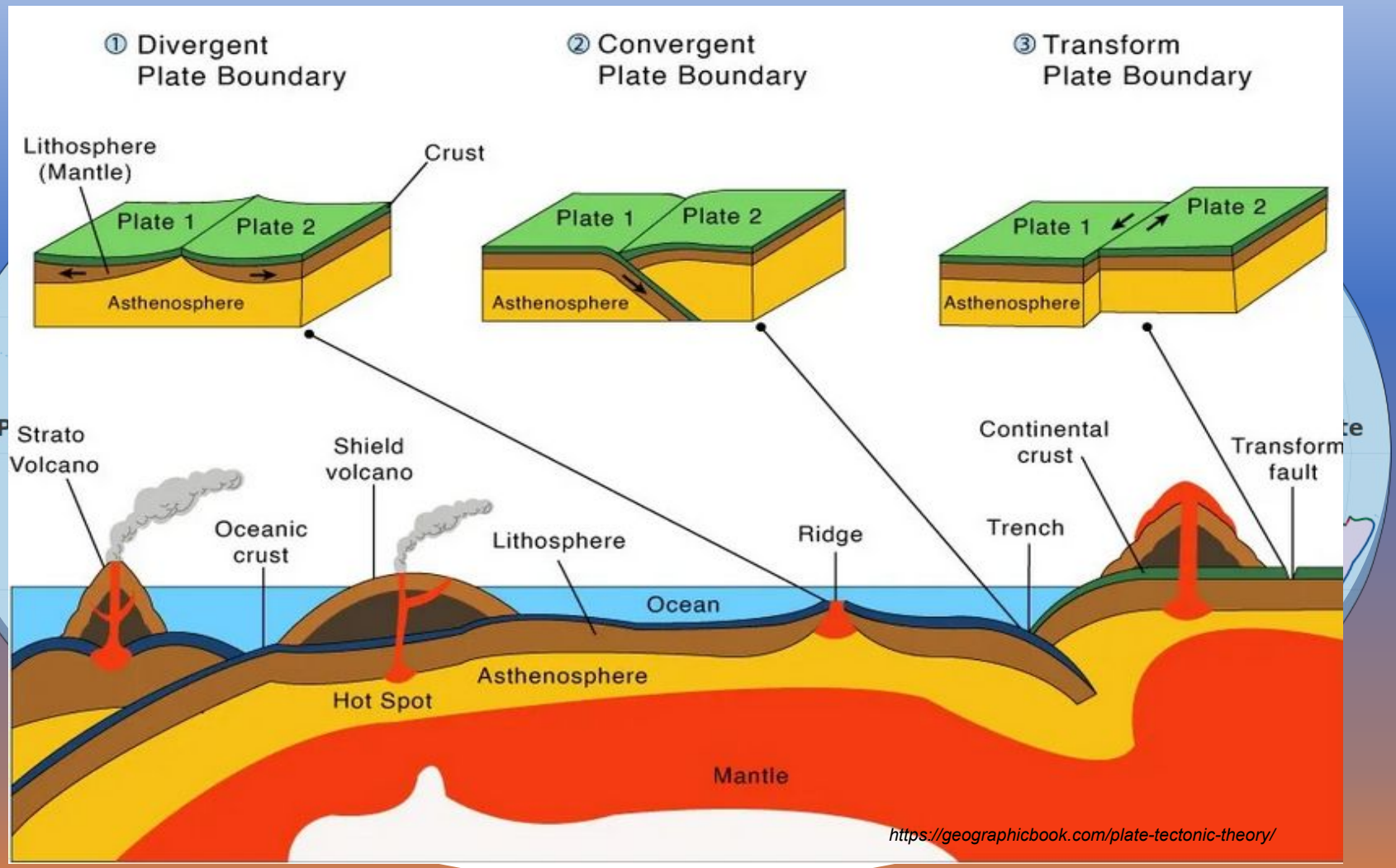
# #2 – Rock Cycle & Plate Tectonics

## PLATE TECTONICS

It is the model of the Earth's dynamics that most geologists agree on, according to which the lithosphere is divided into about 20 rigid portions (plates or clods)

The Earth's lithosphere is the rigid outer shell of the planet including the crust and upper mantle

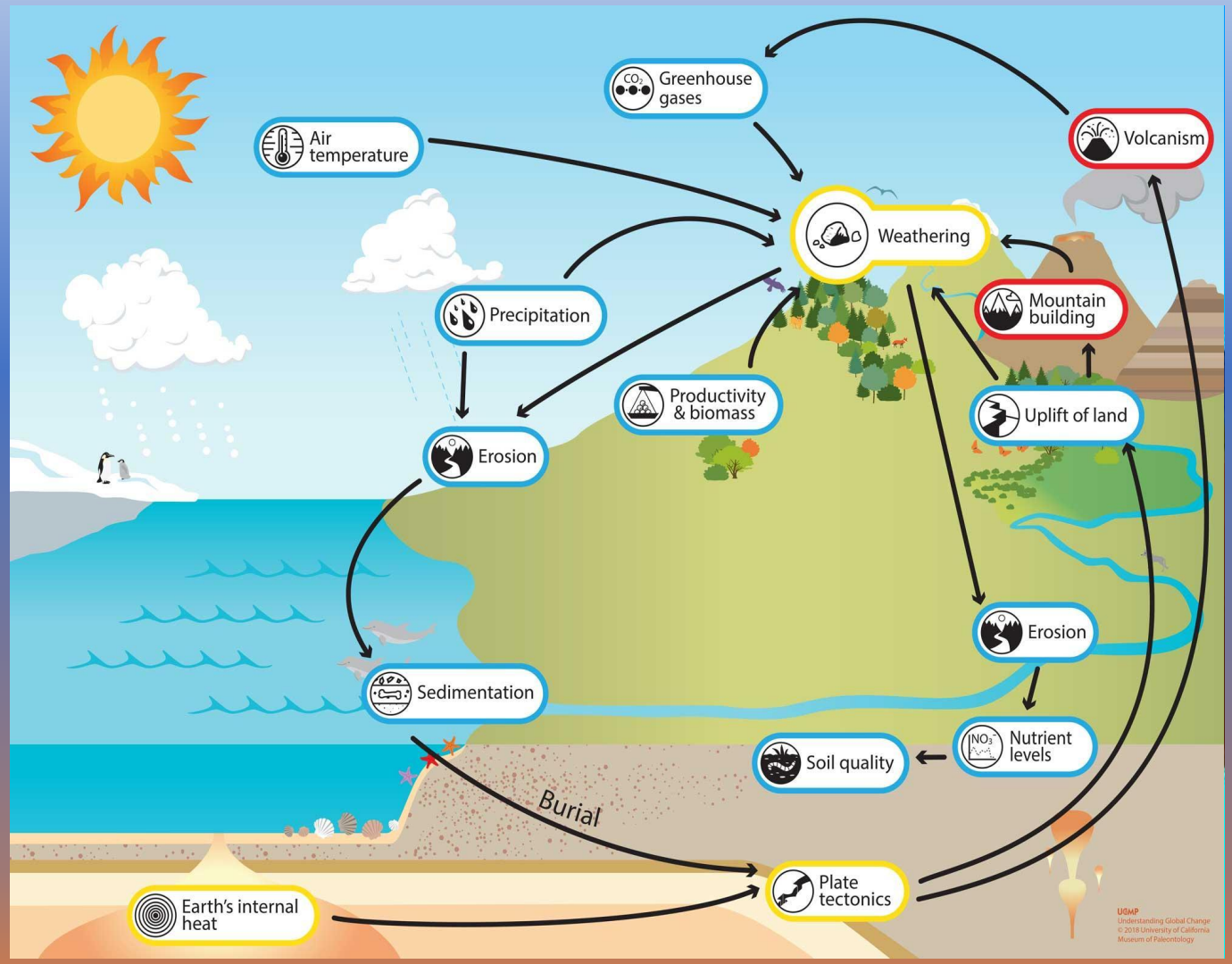
Tectonic plates can move over the asthenosphere and where the plates meet, their relative motion determines the type of plate boundary: convergent, divergent, or transform



# #2 – Rock Cycle & Plate Tectonics

## Inside & Outside

- Endogenous dynamics is determined by the action of the geosphere
- It originates in the Earth's interior
- It generates the characteristic structures of the seabed and continents




- Exogenous dynamics is determined by the action of the atmosphere, biosphere and hydrosphere
- It originates on the Earth's surface
- It shapes the forms produced by endogenous dynamics

# #2 – Rock Cycle & Plate Tectonics

## The 'land' that comes from the sea

- The oceanic crust represents more than 60 per cent of the earth's surface
- There are therefore magmatic and metamorphic rocks that now form the continents that are derived from the ocean

# #2 – Rock Cycle & Plate Tectonics

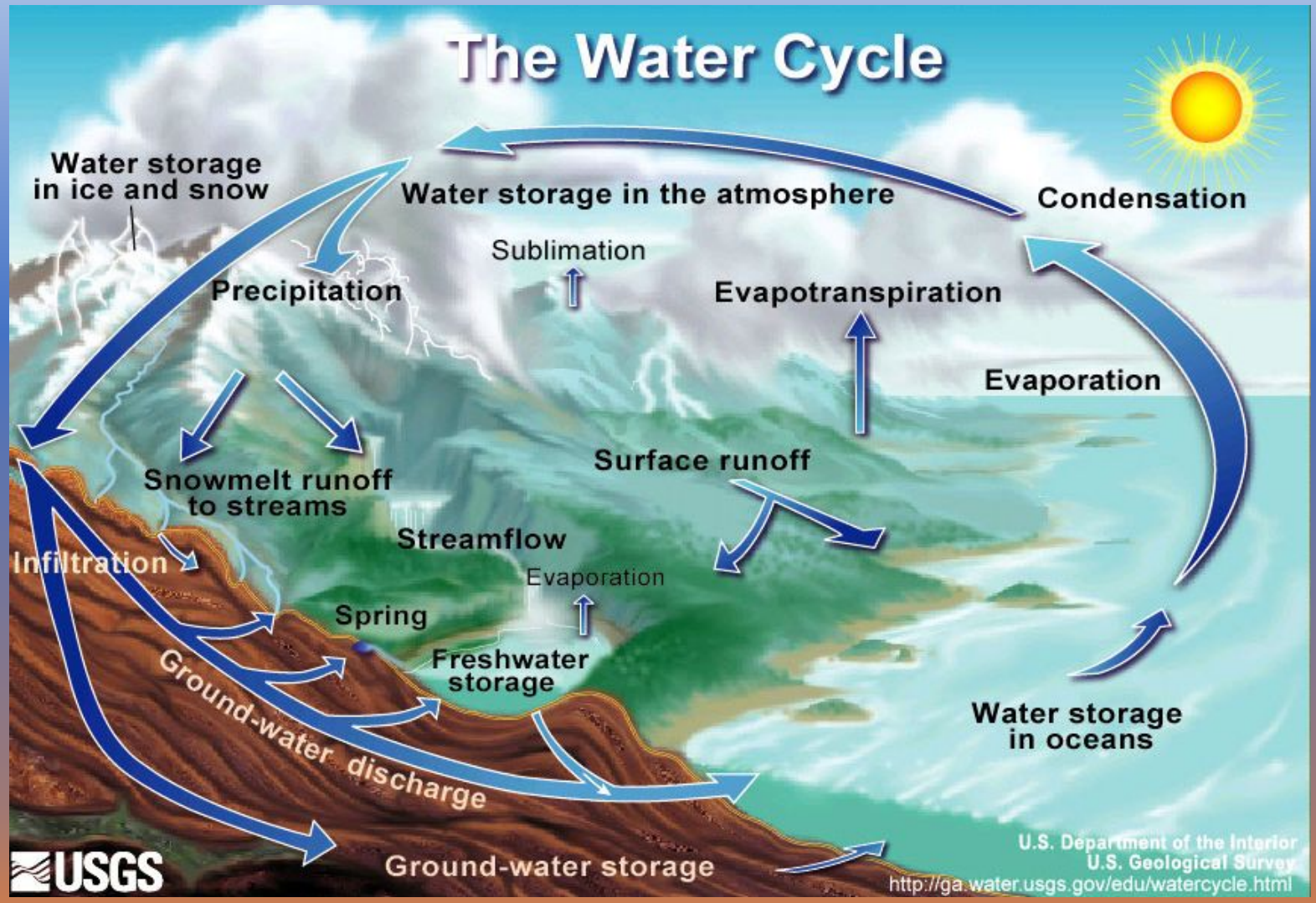
- The 'land' that comes from the sea

# #2 – Biogeochemical Cycles

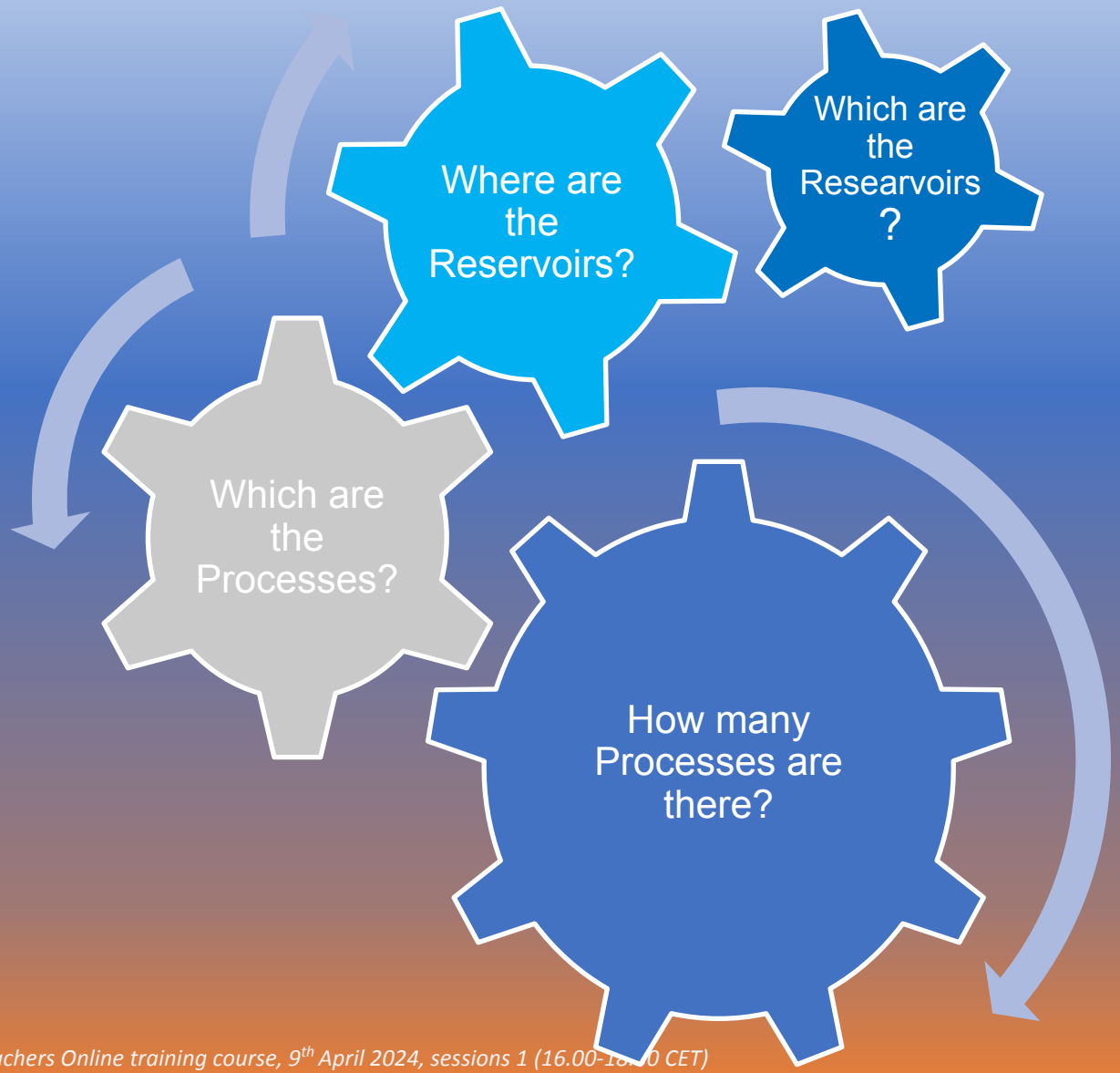
- WHY A CYCLE AND WHAT IS IT?

In a cycle, there is no beginning or end!

Molecules or elements move continuously between different RESERVOIRS by physical, chemical or biological PROCESSES



# #2 – Biogeochemical Cycles




- RESERVOIRS & PROCESSES

A RESERVOIR is the PLACE where that element is contained in one of the different PHASES OF THE CYCLE

A PROCESS is the WAY in which that element is TRANSFERRED from one reservoir to another

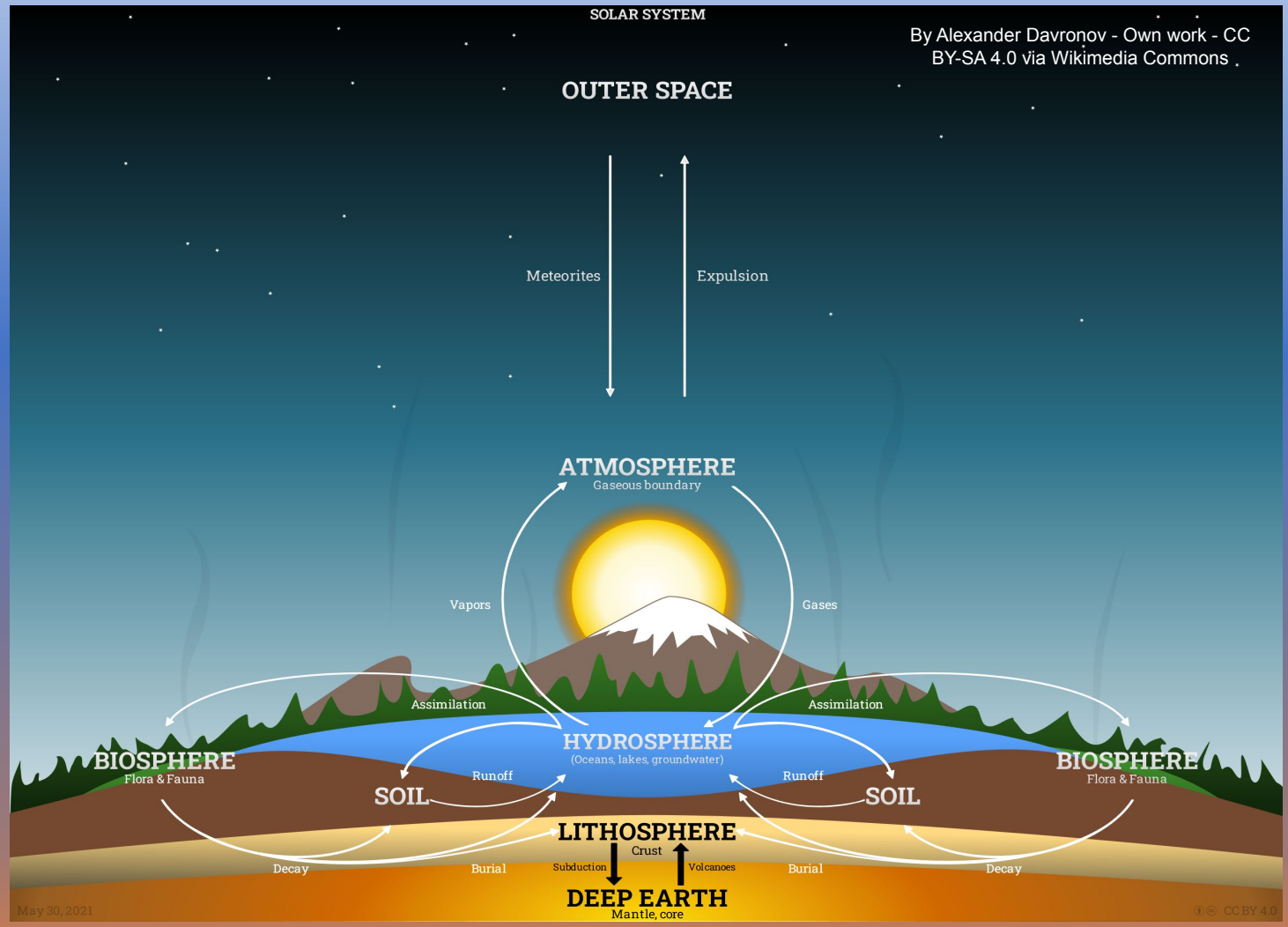
# #2 – BIOGEOCHEMICAL CYCLES

- Nutrient cycles
  - Carbon cycle
  - Nitrogen cycle
  - Phosphorus cycle
  - Silicon cycle

The complex interplay of dynamic balances through which the circulation of chemical elements from organisms to the environment and vice versa takes place

They are cycles of matter and energy where movement and transformation of chemical elements and compounds occur between living organisms, the atmosphere, the hydrosphere and the Earth's crust

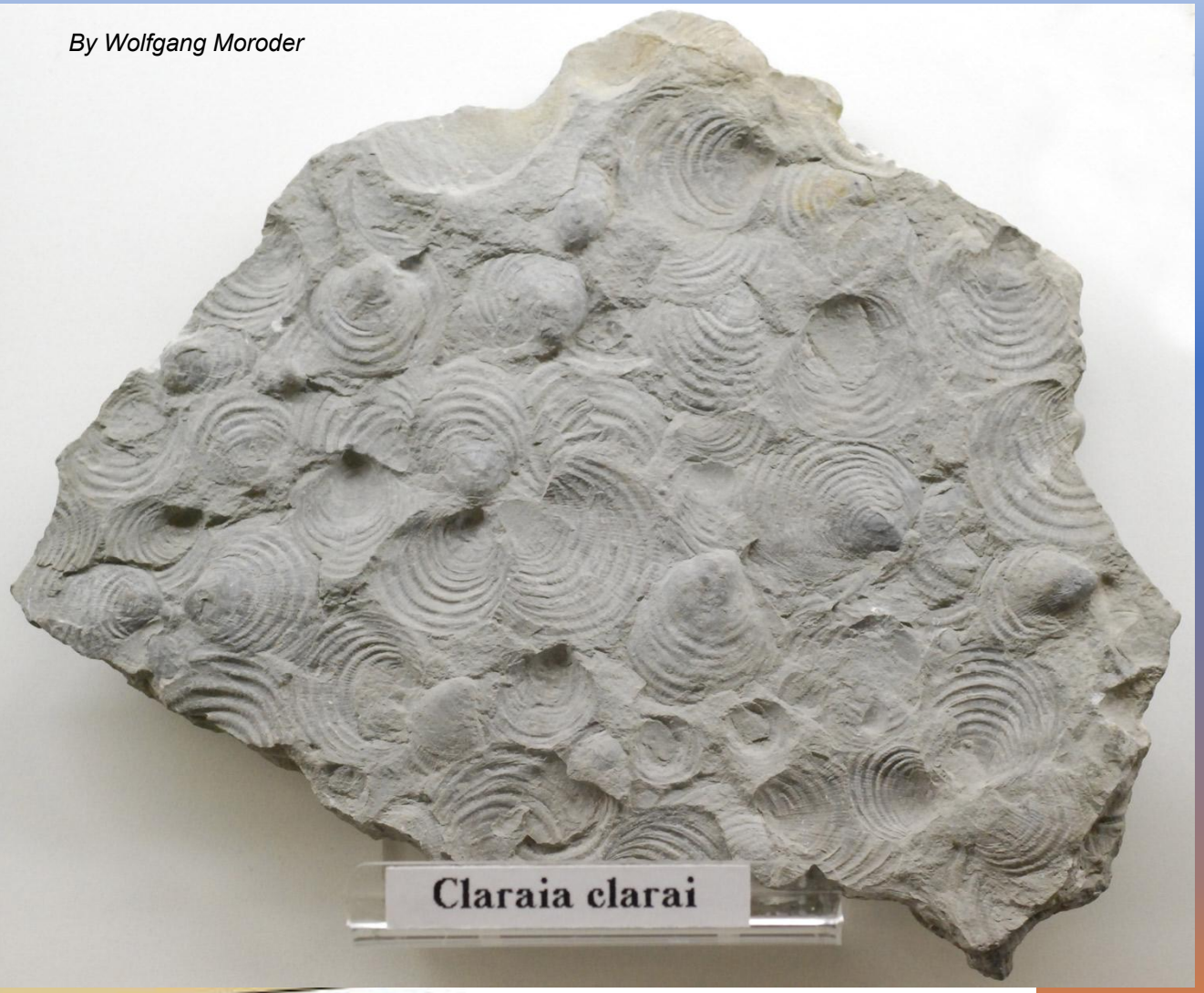
The chemical element or molecule are transformed and cycled by living organisms and through various geological forms and reservoirs




https://youtu.be/Bn41IXKyVWQ

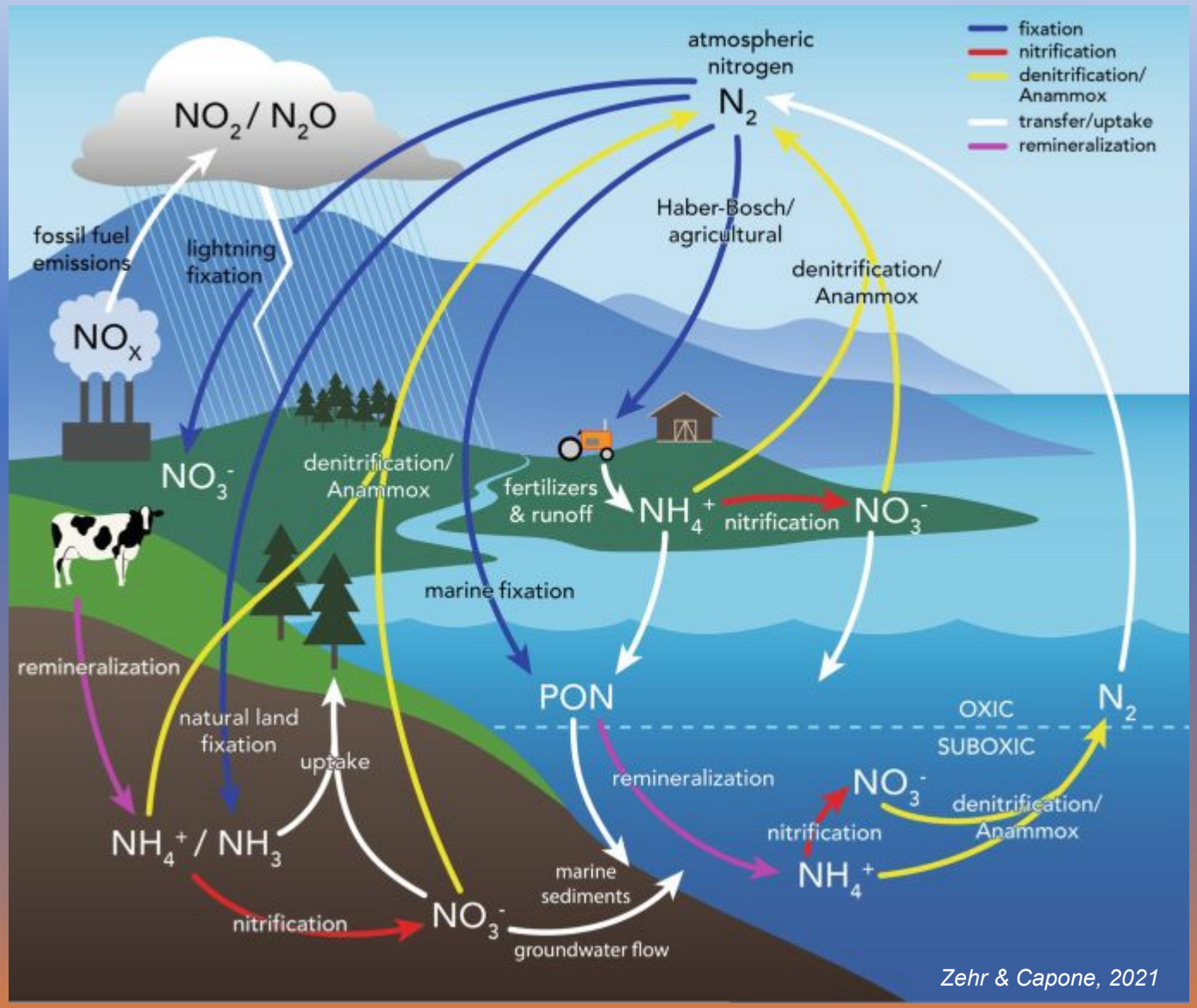
# #2 – BIOGEOCHEMICAL CYCLES

Wikimedia Foundation




By Wolfgang Moroder

# #2 – BIOGEOCHEMICAL CYCLES




## Nitrogen Cycle

The reservoir of this chemical element is the atmosphere where nitrogen occupies about 78% of the total volume

Living organisms must assimilate nitrogen for the formation of vital organic compounds such as proteins and nucleic acids

Except for particular bacteria (nitrogen fixers), atmospheric nitrogen cannot be directly absorbed by organisms and this is often a limiting factor

Just a few types microbes convert the nitrogen into a much more useable form known as ammonium (NH4+)

The chemical processes involved in their formation can be divided into 4 types: nitrogen fixation, ammonification, nitrification and denitrification

# #2 – BIOGEOCHEMICAL CYCLES

- Phosphorus Cycle

By Miguel Yupanqui, CC BY-SA 3.0 , via Wikimedia Commons

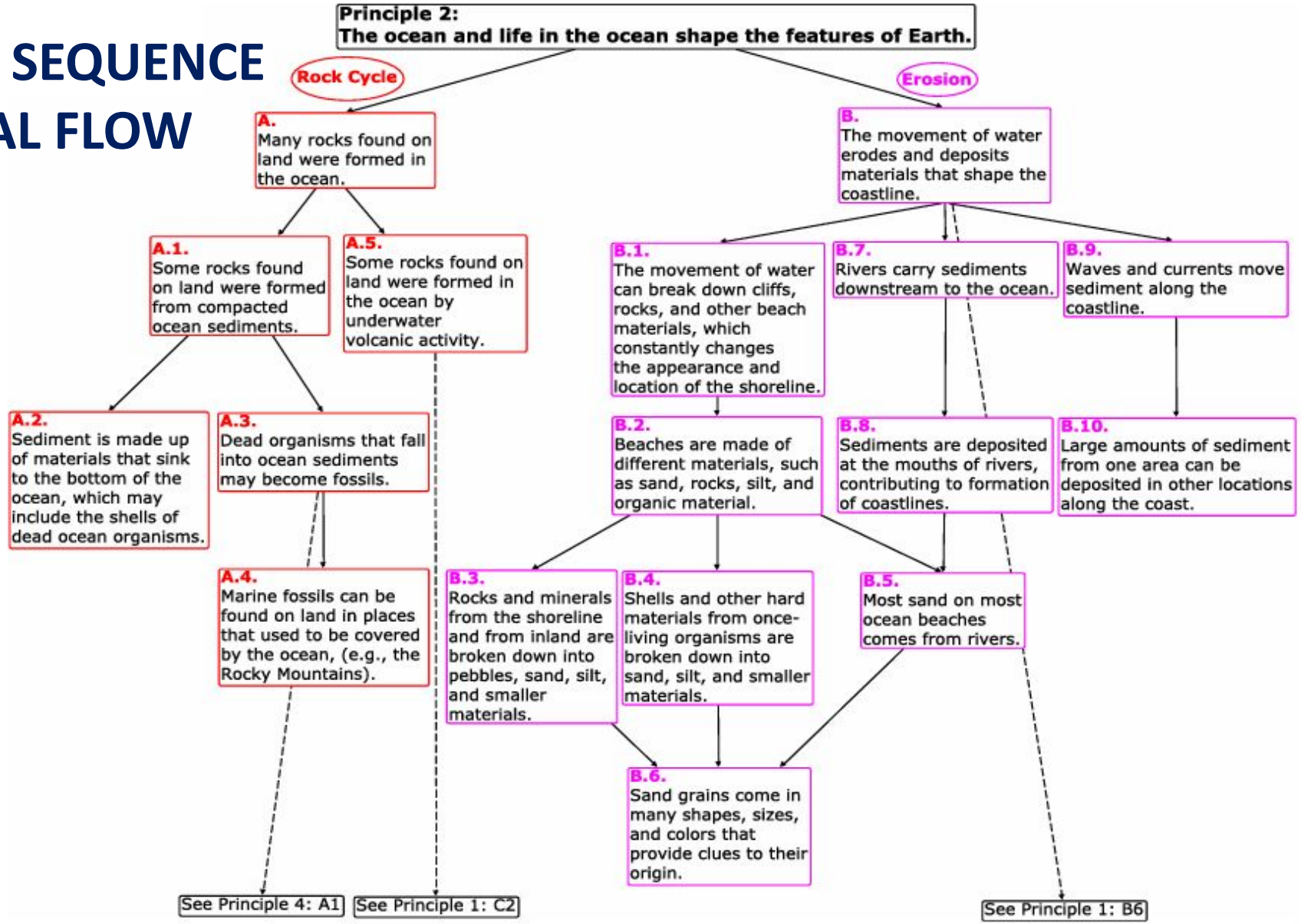
noticias/the-importance-of-seabird-guano-in-pre-inca-agriculture/

Fluxes: 10^12gP/yr

# #2 – BIOGEOCHEMICAL CYCLES




# SCOPE AND SEQUENCE CONCEPTUAL FLOW DIAGRAM




https://www.marine-ed.org/ocean-literacy/scope-and-sequence

# SCOPE AND SEQUENCE CONCEPTUAL TABLE

## Principle 2

GRADES 6 THROUGH 8

### Principle 2: The ocean and life in the ocean shape the features of Earth.

#### Geologic Change — A

Many changes in geologic features occur where the ocean meets the land.

**A1** — Many landforms are the result of a combination of constructive and destructive forces where the ocean meets the land.

**A2** — Weathering is the breaking down of rocks, soils, and minerals through physical, chemical, and biological processes.

- **A3** — Biological weathering is caused by living organisms (e.g., when sea urchins grind holes in rocks).
- **A6** — Chemical weathering breaks down and alters the chemical composition of rocks and minerals through hydrolysis, oxidation, and acidification.
- **A7** — Physical weathering of rocks can be caused by freeze-thaw cycles, salt crystallization, hydraulic action, pressure release, wind abrasion, and/or thermal expansion.
  - **A4** — Organisms can release organic acids that can increase chemical weathering.
  - **A5** — Cracks in rock become sites where further weathering is more likely to occur.
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**A8** — Erosion and deposition of rocks, sediments, and other particles by wind, rain, waves, ice, gravity, or living organisms can alter coastlines.

- **A9** — Powerful storms can cause drastic short- and long-term changes to coastlines.
- **A10** — Beach profiles change seasonally due to different wave action and water flow.
  - **A11** — Powerful winter wave action removes sediment from shorelines. Gentle summer wave action rebuilds beaches.
  - **A12** — Sediment deposits from rivers replace sand removed by waves and currents.

**A13** — The surface of the land is shaped by sea level changes.

**A14** — Sea level is affected by changes in climate and tectonic activity.

- **A15** — Variations in global climate affect the volume of water in the ocean by changing the size of polar ice caps and glaciers, resulting in relative sea-level changes.
  - **A16** — Changes in sea level can create, destroy, expose, and cover landforms, such as continental shelves, islands, marine terraces, beaches, and inland seas.
  - **A17** — Fossilized marine organisms, ancient coral reefs, and beaches can be found on land, far from current coastlines.
- **A18** — Tectonic activity causes uplift and subduction, which results in relative sea level changes.
  - **A16** — Changes in sea level can create, destroy, expose, and cover landforms, such as continental shelves, islands, marine terraces, beaches, and inland seas.
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**Plate Tectonics — A19** — Tectonic activity between oceanic and continental plates can result in volcanoes, earthquakes, and mountain formation near the coast.

- **A18** — Tectonic activity causes uplift and subduction, which results in relative sea level changes.
  - **A16** — Changes in sea level can create, destroy, expose, and cover landforms, such as continental shelves, islands, marine terraces, beaches, and inland seas.
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#### Rock Cycle — B

Many of the rocks exposed on land were formed in the ocean.

**B1** — Some igneous rocks are formed in the ocean in volcanoes, at hot spots, and at mid-ocean ridges.

**B2** — Some metamorphic rocks are formed in the ocean (e.g., at subduction zones).

**B3** — Many sedimentary rocks are formed in the ocean from organic sediments.

**B4** — Many marine organisms form carbonate and silicate skeletal structures, which contribute to the formation of sedimentary rocks, reefs, and stromatolites.

- **B5** — Some organisms, such as cyanobacteria, coralline algae, and corals construct complex structures (e.g., stromatolites and reefs).
  - **B6** — Lime-secreting cyanobacteria trap sediments and form large mounds called stromatolites.
  - **B7** — Stromatolites are a major component of the fossil record for the first 3.5 billion years of life on Earth.
  - **B8** — Coral reefs are produced by living organisms that secrete an exoskeleton of calcium carbonate.
- **B9** — The skeletal structures formed by some organisms (e.g., mollusk shells, foraminifera, coccoliths, radiolaria, and diatom cell walls) sink and are deposited on the ocean floor, eventually forming sedimentary rocks.

https://www.marine-ed.org/ocean-literacy/scope-and-sequence

| Grade Band | Coastal Erosion | Plate Tectonics | Rock Cycle | Biogeochemical Cycles |
|---|---|---|---|---|
| K-2 | a. Deposition of Earth materials<br>b. Erosion of Earth materials | | | |

# SCOPE AND SEQUENCE CHART

*https://oceanliteracy.wp2.coexploration.org/?page_id=1641#ep2topics*

**Topics and Subtopics of Principle 2**

The charts list the major topics and subtopics in the conceptual flow diagrams of the Scope and Sequence

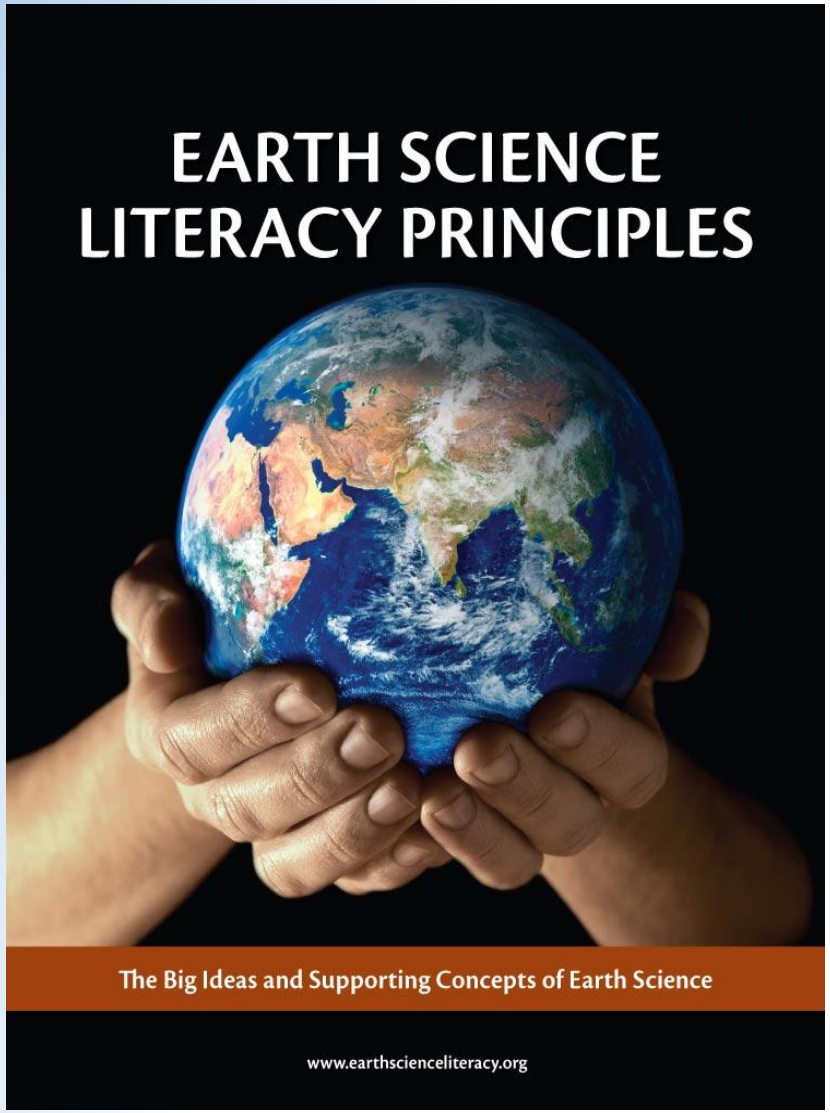
There is one chart for each principle

For each chart, the major branches of topics on the conceptual flow diagrams for that principle run horizontally across the top

The grade bands run vertically along the left column

| | | | | |
|---|---|---|---|---|
| 9-12 | | a. Continental plates<br>b. Erosion<br>c. Geologic features from subduction<br>d. Oceanic plates<br>e. Residence Times<br>f. Subduction<br>g. Tectonic activity<br>h. Weathering | a. Accretion<br>b. Igneous processes<br>c. Sedimentation<br>d. Volcanism | a. Carbon cycle<br>b. Elements in ocean water<br>c. Nitrogen cycle<br>d. Phosphorus cycle<br>e. Silica cycle |

# WHY DOES EARTH SCIENCE LITERACY MATTER?




**Why is Earth Science Literacy Important?**

Earth is our home and we rely upon it for our existence in many different ways

Its resources feed us and provide the materials of our way of life

Even modest changes to Earth's systems have had profound influences on human societies and the course of civilization. Understanding these systems and how they interact with us is vital for our survival

Earth Science Literacy is especially important at this time in history. There are many challenges facing humanity—dwindling energy and mineral resources, changing climates, water shortages—directly relating to the Earth sciences

There are many difficult decisions that governments, local and national, will have to make concerning these issues, and how well humans survive the twenty-first century will depend upon the success of these decisions

We need governments that are Earth science literate

It will take a deep and subtle understanding of Earth's systems for future generations to be able to feed, clothe, house, and provide a meaningful existence for all humans

We need citizens and businesses that are Earth science literate

http://www.earthscienceliteracy.org/es_literacy_6may10_.pdf

# EARTH SCIENCE LITERACY PRINCIPLES

BIG IDEA 1. Earth scientists use repeatable observations and testable ideas to understand and explain our planet.

BIG IDEA 2. Earth is 4.6 billion years old.

BIG IDEA 3. Earth is a complex system of interacting rock, water, air, and life.

BIG IDEA 4. Earth is continuously changing.

BIG IDEA 5. Earth is the water planet.

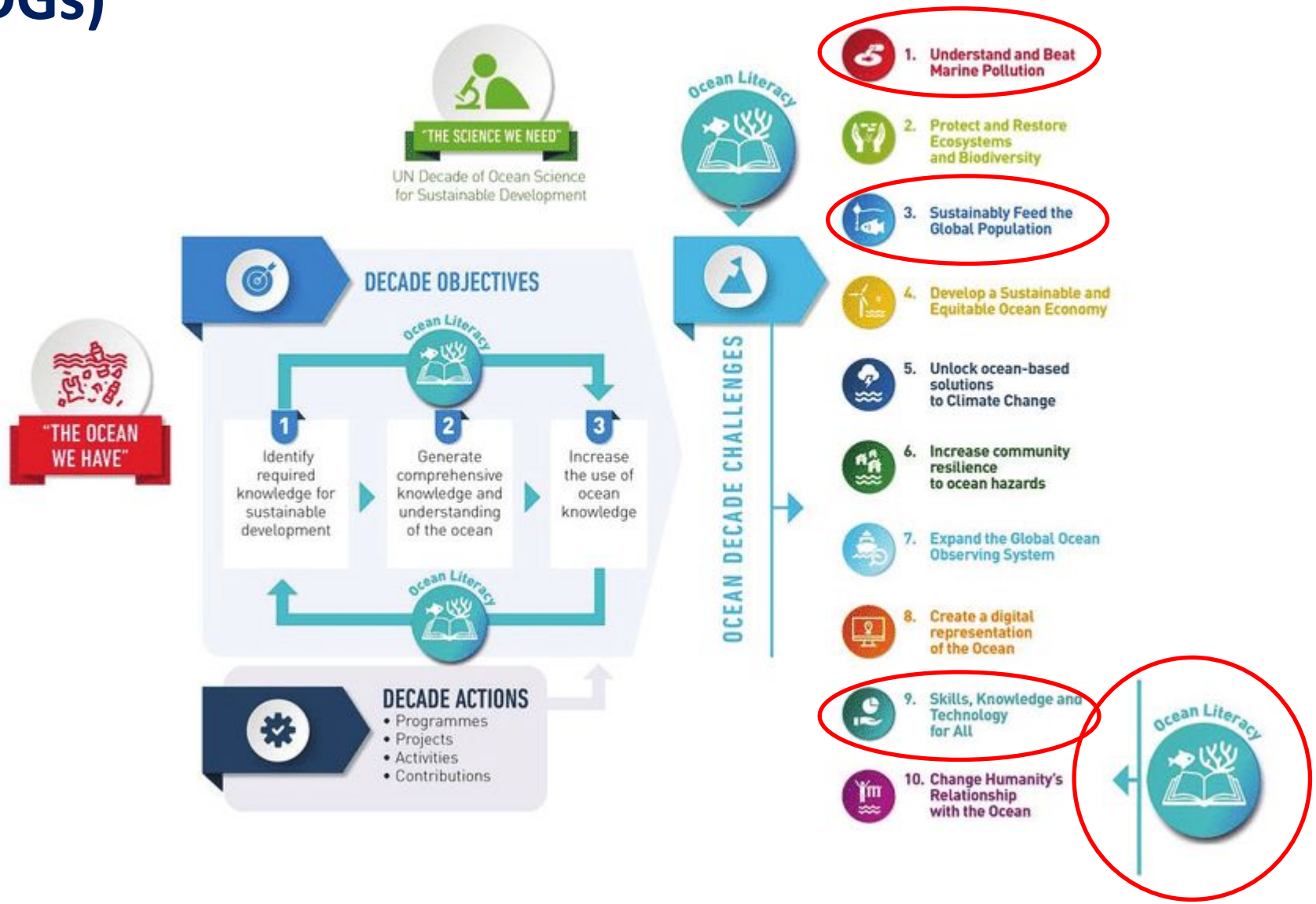
BIG IDEA 6. Life evolves on a dynamic Earth and continuously modifies Earth.

BIG IDEA 7. Humans depend on Earth for resources.

BIG IDEA 8. Natural hazards pose risks to humans.

BIG IDEA 9. Humans significantly alter the Earth.

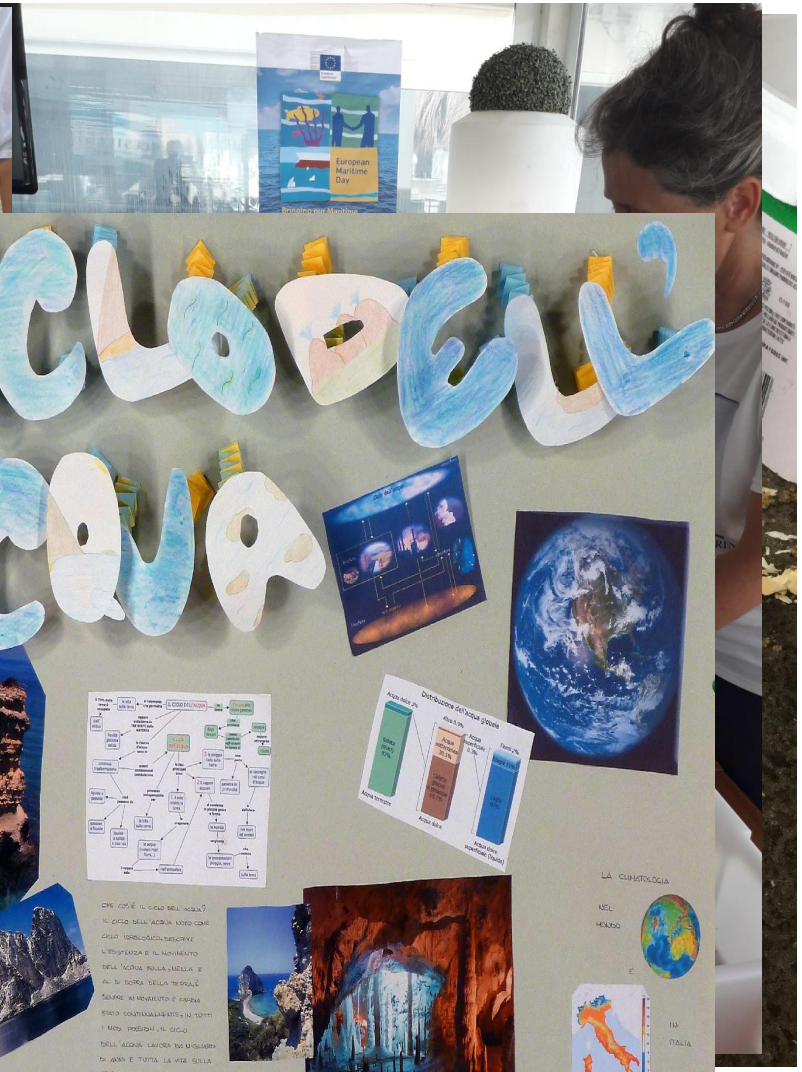
# The OCEAN flows through all 17 UN Sustainable Development Goals (SDGs)

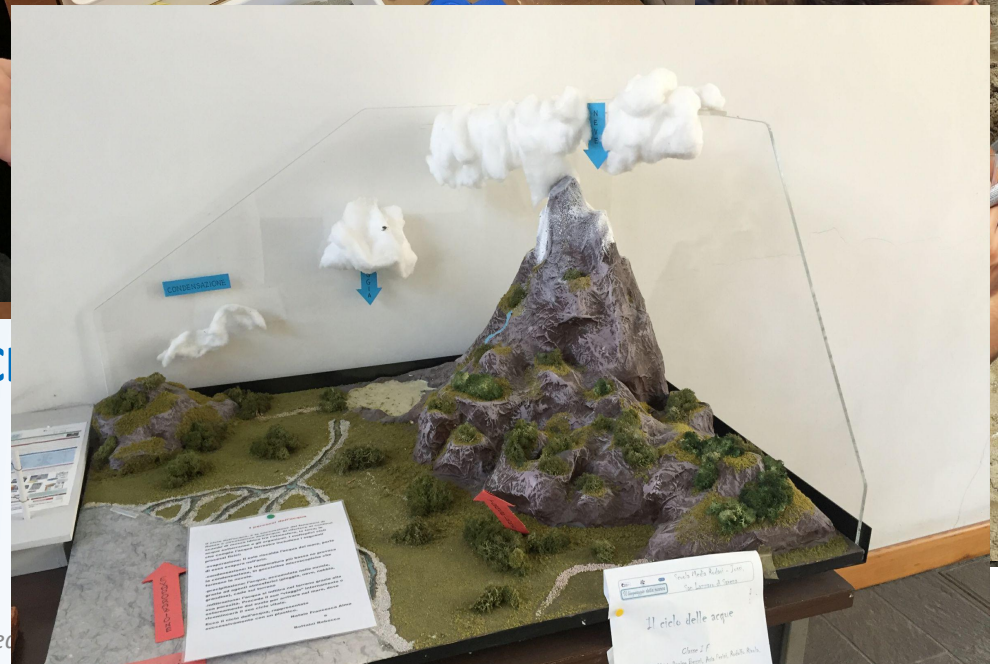



https://sdgs.un.org/goals

# Young geologists at work! Let’s discover the different pathways around us!









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