Introduction to Earth Science (ES1101)

Instructors: Dr. Subhronil Mondal
Dr. Gaurav Shukla

Book: 1) **Understanding Earth by Grotzinger & Jordan** (Textbook)

2) The Blue Planet: An Introduction to Earth System Science by Skinner & Murck

3) Earth: An introduction to Physical Geology by Tarbuck & Lutgens

4) Earth: Evolution of a Habitable World by Lunine

5) The Solid Earth: An introduction to global geophysics by Fowler

Syllabus: https://welearn.iiserkol.ac.in/teaching-plan/course/2023/Autumn/ES1101/

The Earth System and its components and interactions - introductory remarks

Origin of the Solar System; Nucleosynthesis - fusion reactions, neutron capture (Supernova explosion), evidence from meteorite; Formation and differentiation of the Earth

Earth's internal structure and identification - chemical (core, mantle, crust) and physical (lithosphere, asthenosphere, mesosphere, outer core, inner core); Seismic waves (P and S) and shadow zone; Geomagnetism; Geothermal gradient; Theory of Plate tectonics -concept and evolution (Continental Drift); Types of plates and plate boundaries

Earth's materials - rock forming minerals and rocks (igneous, metamorphic, sedimentary) and rock forming processes; Tectonic environments at plate boundaries -rock deformation and manifestation

Geological Time Scale; Basic concept of Stratigraphy; Major events in Earth's history - origin and early development of life and oxygen revolution, Cambrian Explosion, mass extinctions; Anthropocene Extinction

Earth Science and Society - Earth processes and economic mineralization, Earth processes and natural hazards

Course Evaluation Plan (Tentative):

- **Mid Semester Exam (30%)**
- **End Semester Exam (50%)**
- **Group Presentations/Class Tests/Attendance/Assignments (20%)**

Teaching Plan: **2 (theory)+ 1 (tutorial) + 1 (practical/demonstration)**

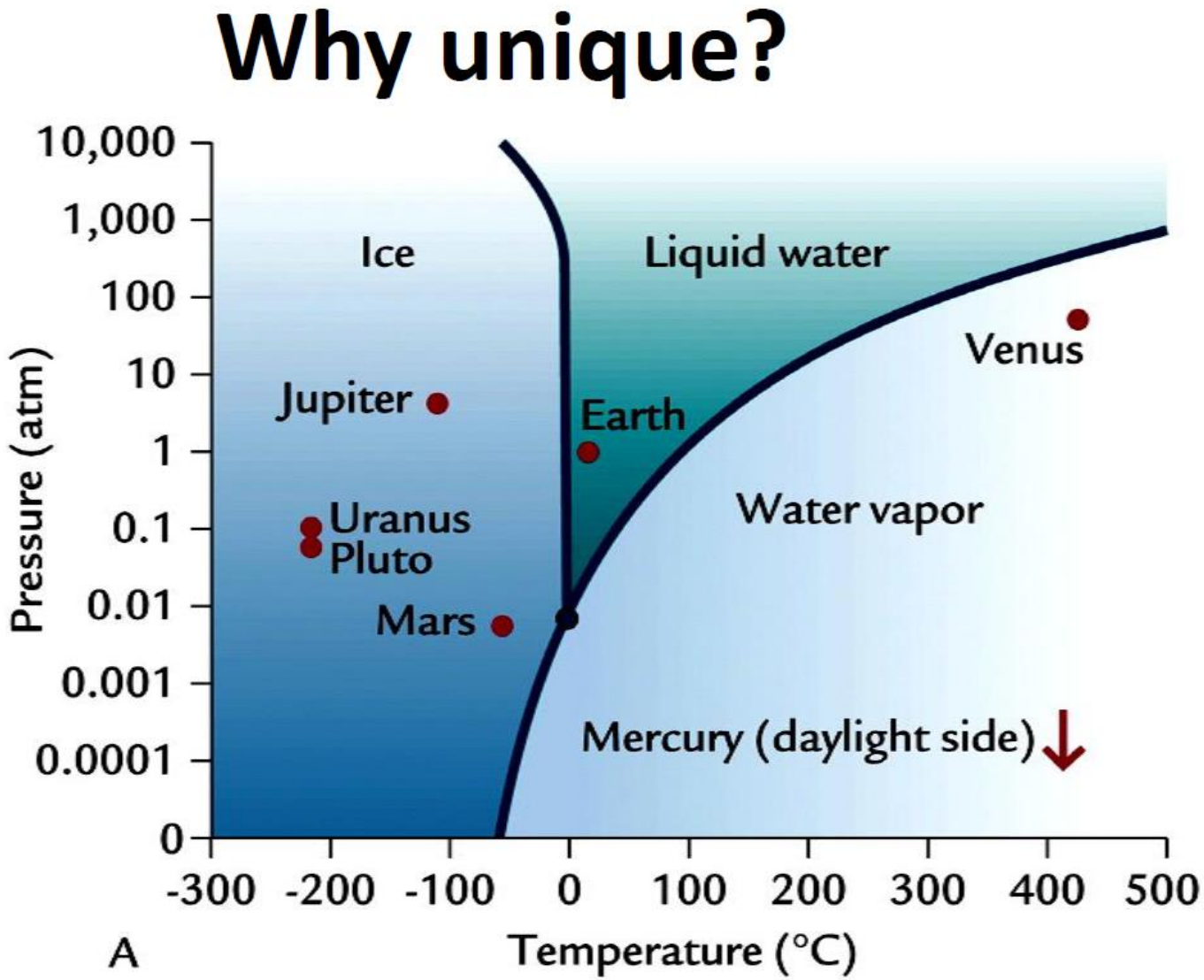
Timetable:

Monday: 9:00 AM to 10:00 AM

Wednesday: 4:00 PM to 5:00 PM, 5PM-6PM

Thursday: 5:00 PM to 6:00 PM.

- **Earth is a unique planet: home to millions of organisms**



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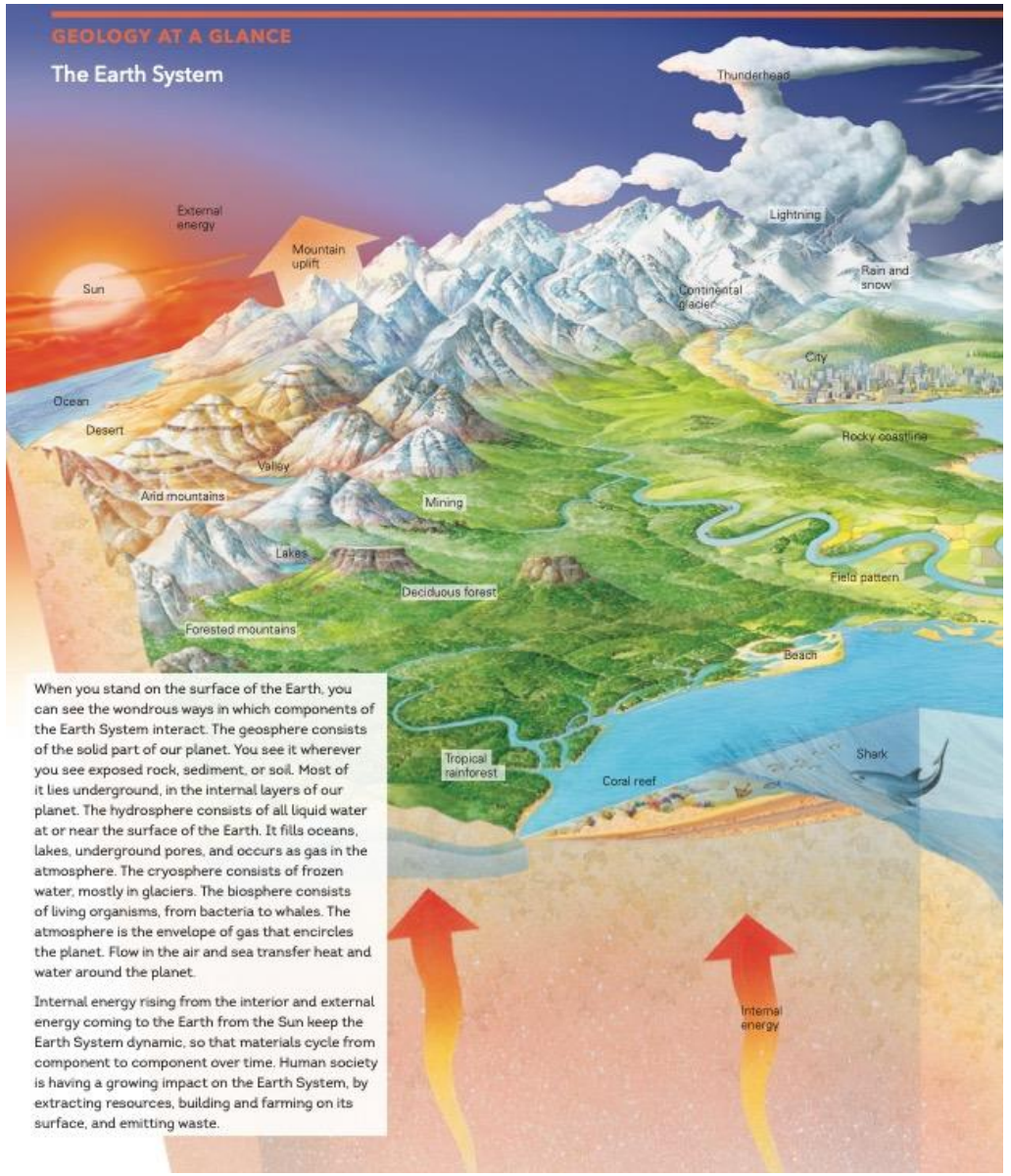

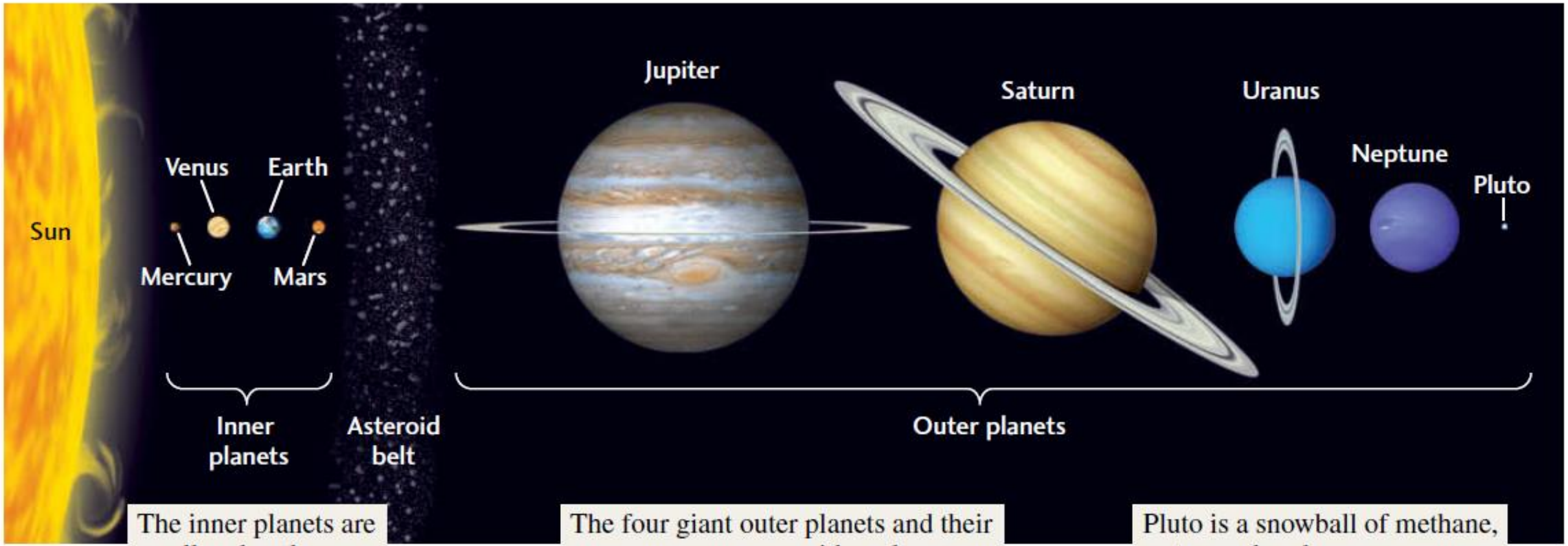

FIGURE 9.3 ■ The solar system. This diagram shows the relative sizes of the planets as well as the asteroid belt separating the inner and outer planets. Although considered one of the nine planets since its discovery in 1930, Pluto was demoted from that status by the International Astronomical Union in 2006. With this revision, there are only eight true planets, not nine.

What is Earth Science?

To know about the origin of the Earth, how it formed, how it evolved, how it works, and how to sustain it for the generations to come

What is Earth Science?

(a) Cliff exposures in the desert of Utah.

What is Earth Science?

Average temperature of inner planets

T~460℃ **T~15℃** **T~ – 55℃**

FIGURE 3-1 Venus, Earth, and Mars, shown roughly to scale. (*Source:* NASA (left and center) and Photodisc/Getty Images (right).)

- **Study of Earth Science requires broad knowledge of Physics, Chemistry, Biology, and Mathematics…**

- **Geology + Physics → Geophysics**
- **Geology + Chemistry → Geochemistry**
- **Geology + Biology → Geobiology**

…

TABLE P.1 Principal Subdisciplines of Geology (Geoscience)

Name	Subject(s) of Study
Engineering geology	Aspects of geology relevant to understanding slope stability or to building tunnels, dams, mines, roads, or foundations
Environmental geology	Interactions between the environment and geologic materials, and the contamination of the near-surface realm of the Earth by pollutants
Geochemistry	Chemical composition and behavior of materials in the Earth, and chemical reactions in natural environments
Geochronology	The age (in years) of geologic materials, the Earth, and extraterrestrial objects
Geomorphology	Landscape formation and evolution
Geophysics	Physical characteristics of the Earth (such as the Earth's magnetic field and gravity field) and causes of forces that affect the Earth
Hydrogeology	Groundwater, its movement, and its reaction with rock and soil
Mineralogy	Physical properties, structure, and chemical behavior of minerals
Paleontology	Fossils and the evolution of life as preserved in the rock record
Petrology	Rocks and their formation
Sedimentology	Sediments and their deposition
Seismology	Earthquakes and the Earth's interior as revealed by earthquake waves
Stratigraphy	The succession of sedimentary rock layers and the record of Earth's history that they contain
Structural geology	Rock deformation (bending and breaking) in response to the application of force associated with mountain building
Tectonics	The origin and significance of regional-scale geologic features
Volcanology	Volcanic eruptions and their products, and volcanic hazards

- **It is an Observational, Experimental, Theoretical, and Applied Science. (Interdisciplinary Science)**

- **Basic Requirement: An Earth Scientist must be a nature lover, adventurous, be intrigued with natural phenomena.**

Earth System Science

- **A System is a group of components that interact. The *Earth System* is composed of different parts:**

1) **Atmosphere: A thin envelope of gases that surrounds the Earth.**
2) **Hydrosphere: Reservoirs of water, ice (Cryosphere).**
3) **Biosphere: All living organisms.**
4) **Geosphere: All rocks.**

- **For example, human physiology where system approach is illuminating. Human body is made up of several systems that perform the vital functions of life: a respiratory system, a cardiovascular system, a digestive system etc.**

Earth System Science

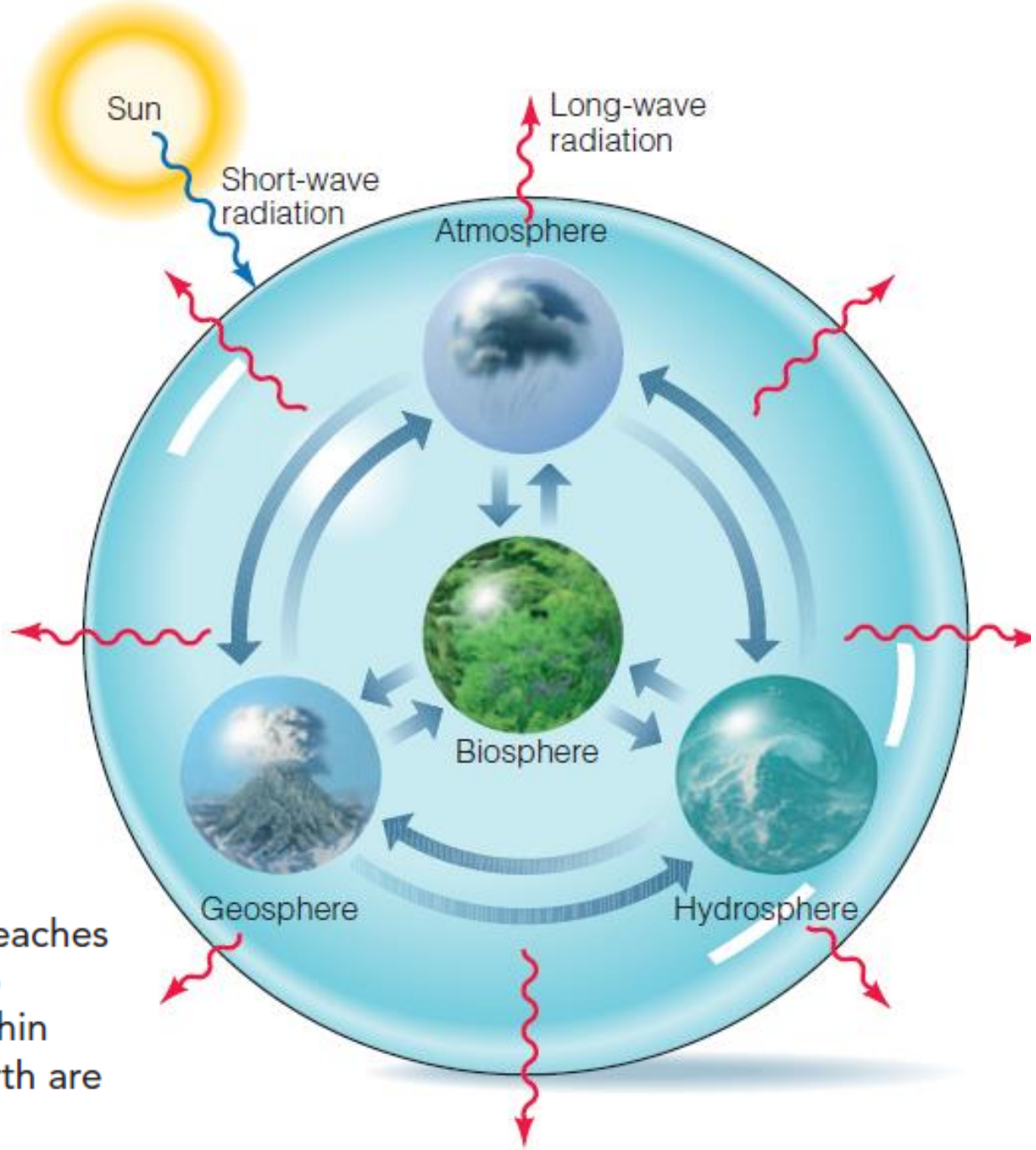

FIGURE 1.7 Earth as a closed system
Earth essentially operates as a closed system. Energy reaches Earth from an external source and eventually returns to space as long-wavelength radiation, but the matter within the system is basically fixed. The subsystems within Earth are open systems, freely exchanging matter and energy.

Earth System Science

(a) In this scenic view in Switzerland, we see many aspects of the Earth System—air, water, ice, rock, life, and human activity.

Geological Time

- **Human Perspective**
  Seconds, Hours, Years

- **Ancient Human History**
  Hundreds to thousands of years or so

- **Geological History**
  Millions (10^6) and billion (10^9) years

Why Earth Science study is necessary?

- **It is critically relevant to human existence.**
  - ✓ **21st century is defined by grand challenges, such as climate change, availability of water, energy and mineral resources.**
  - ✓ **Understanding ideas and concepts of Earth Science is critical for human society to respond successfully to these challenges and thrive in the decades to come.**

Different form of Earth Science Study

- **The Earth Scientists use multiple lines of evidence taken from field, experimental, theoretical, and modeling studies to interpret observations about the Earth and forecast Earth's future.**

- **Earth Science examines processes that occur over spatial scales ranging from subatomic to planetary and over timescales ranging from nearly instantaneous to gradual over billions of years.**

Different form of Earth Science Study

- **Most of the Earth's interior is inaccessible to direct observations.**
  - ✓ **Earth Scientists use complex remote methods to examine the structure, composition, and dynamical processes of Earth's interior.**
  - ✓ **These investigations include data from seismic waves, gravitational and magnetic fields, radar, sonar, and high temperature-pressure laboratory experiments and computer simulations on the behavior of Earth forming materials.**

Different form of Earth Science Study

- **Earth Scientists determine the history of rocks by examining their structure, composition, fabric, texture, and mineral grain size.**

- **Earth Scientists reconstructs the history of life and of planet from fossil evidence.**

- **Earth Scientists devise methods to locate mineral deposits, coal, petroleum, and nuclear fuels crucial for the sustenance of human civilization.**

Different form of Earth Science Study

- **Earth Scientists explore the space to know about planetary evolution.**

Before They Go to Space, Astronauts go to Geology Camp
By Meghan Bartels (published March 07, 2019)

https://www.space.com/astronaut-training-geology-field-work.html