

Introduction to Earth Science

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Key concepts, major branches, and foundational principles

1. What Is Earth Science?

Aspect	Description
Definition	The interdisciplinary study of the Earth's physical components, processes, and history.
Goal	Explain how the planet works, how it has changed over time, and how those changes affect life and human societies.
Scope	Includes the solid Earth, oceans, atmosphere, and biosphere, plus the interactions among them.
Approach	Combines observation, fieldwork, laboratory analysis, modeling, and remote sensing.

2. Major Branches

Branch	Primary Focus	Typical Tools & Methods
Geology	Rocks, minerals, plate tectonics, geological history	Rock hand specimens, thin?section microscopy, geophysical surveys
Geophysics	Physical properties of Earth's interior (gravity, magnetism, seismic waves)	Seismometers, gravimeters, magnetometers, satellite altimetry
Geochemistry	Chemical composition and processes of rocks, soils, water, and gases	Mass spectrometry, X?ray fluorescence, isotopic dating
Hydrology / Hydrogeology	Distribution, movement, and quality of water on and beneath the surface	Stream gauges, groundwater wells, remote?sensing imagery
Meteorology / Atmospheric Science	Weather, climate, atmospheric dynamics	Weather stations, radiosondes, climate models

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Branch	Primary Focus	Typical Tools & Methods
Oceanography	Physical, chemical, biological, and geological aspects of the oceans	CTD profilers, autonomous floats, sonar mapping
Environmental Science	Human–Earth interactions, pollution, resource management	GIS, ecological surveys, life?cycle analysis

3. Fundamental Concepts

3.1 The Spherical Earth Model

- **Shape:** Oblate spheroid (equatorial radius ~6,378 km; polar radius ~6,357 km).
- **Layers** (from surface inward):
 1. **Crust** – continental (~30–70 km thick) & oceanic (~5–10 km).
 2. **Mantle** – upper (rigid lithosphere + asthenosphere) & lower (viscous flow).
 3. **Core** – liquid outer core (Fe–Ni alloy) & solid inner core.

3.2 Plate Tectonics

- **Lithospheric plates** (~15 major, many minor) float on the ductile asthenosphere.
- **Boundary types:**
 - **Divergent** – seafloor spreading, rift valleys.
 - **Convergent** – subduction zones, mountain building.
 - **Transform** – lateral slip (e.g., San Andreas Fault).
- **Consequences:** earthquakes, volcanism, continental drift, seafloor magnetic anomalies.

3.3 The Rock Cycle

Process	Resulting Rock Type	Typical Environment
Cooling & solidification	Igneous (intrusive/extrusive)	Magma chambers, lava flows
Weathering & erosion	Sediment	Rivers, wind, glaciers
Lithification	Sedimentary	Burial, compaction, cementation
Metamorphism	Metamorphic	Heat & pressure (or fluid) in orogenic belts
Melting	Returns to magma	Subduction zones, mantle plumes

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3.4 Energy Sources Driving Earth Processes

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