

## CHAPTER 2

# The Origin and Evolution of the Earth

CBSE Class 11 · Geography · Fundamentals of Physical Geography · Chapter 2

CBSE · Geography · Class 11

### WHAT THIS CHAPTER DOES

**A**

Recall the early theories of the earth's origin and attach the right scientist to each.

**B**

Explain the modern Big Bang (expanding-universe) theory and its evidence.

Boards prep that builds confidence, not anxiety.

## TODAY'S MISSION

# Today's mission

- 1 Recall the early theories of the earth's origin and attach the right scientist to each.
- 2 Explain the modern Big Bang (expanding-universe) theory and its evidence.
- 3 Trace the formation of stars, the solar system and the planets, and tell terrestrial from jovian.
- 4 Explain how the early earth differentiated into core, mantle and crust, and how its atmosphere, oceans and life arose.

## WHY THIS MATTERS

# Why this chapter matters

**1**

It is your **FIRST** deep dive into geomorphology — the physical-geography branch met in Chapter 1.

**2**

Worth 5-7 marks, usually as one Big-Bang / atmosphere / differentiation answer plus an MCQ.

**3**

It sets the foundation for every later chapter on the earth's interior, rocks and landforms — you cannot study the earth's surface without knowing how the earth itself formed.

TOPIC

**A**

# Early theories of the origin of the earth

## TOPIC

# How scientists first explained the earth's birth

## KANT'S GASEOUS & LAPLACE'S NEBULAR

The earliest scientific ideas were the GASEOUS and NEBULAR hypotheses. The German philosopher Immanuel Kant first proposed (in 1755) that the planets formed from a slowly rotating cloud of hot gases. The French mathematician Pierre-Simon Laplace revised

## THE PLANETESIMAL HYPOTHESIS

The American scientists Thomas Chamberlin and Forest Moulton put forward the PLANETESIMAL HYPOTHESIS in the early twentieth century. They suggested that a wandering star passed close to our sun, and its gravity dragged out a long arm of material. This

## THE TIDAL HYPOTHESES (JEANS & JEFFREYS)

The British scientists Sir James Jeans and later Sir Harold Jeffreys proposed the TIDAL (or gaseous-tidal) hypothesis. Like the planetesimal idea it invoked a passing star, but here the intruding star's gravity raised a huge TIDAL bulge — a cigar-shaped filament of gas — out of the sun. As

## WHY THE EARLY THEORIES FELL SHORT

All these early hypotheses shared problems that led scientists to look elsewhere. The nebular hypothesis could not explain why the sun, with most of the solar system's mass, has so little of its angular momentum. The dualistic theories (planetesimal

TOPIC

**B**

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# The modern theory: the Big Bang

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**THEOREM · LOAD-BEARING RESULT**

# The Big Bang (expanding-universe) theory



The currently accepted theory of the origin of the UNIVERSE is the Big Bang theory: about 13.7 billion years ago the entire universe existed as a tiny, extremely hot and dense state which then expanded rapidly, and it has been expanding ever since.

## STATEMENT

**Stage 1** — all matter and energy were concentrated in an unimaginably small, dense, hot 'ball'. **Stage 2** — a sudden expansion (the Big Bang) caused this to expand enormously within fractions

## WHY THIS MATTERS

- The chief evidence is Edwin Hubble's observation (1920s) that galaxies are receding from us — and the farther a galaxy, the faster it recedes
- This galaxy recession shows the universe is still expanding, which, run backwards in time, points to a single hot, dense origin.

## WATCH OUT FOR

**NOTE** Do not describe the Big Bang as an ordinary explosion in empty space — space itself began and expanded. And keep the timeline straight: the universe is ~13.7 billion years old, but the earth is only ~4.6 billion years old.

TOPIC

# From a nebula to the sun and planets

## THE EXPANDING UNIVERSE & GALAXIES

After the Big Bang the universe cooled as it expanded, and matter began to clump under gravity into vast clouds of hydrogen and helium gas. These clouds gathered into GALAXIES — enormous systems of billions of stars, gas and dust. Our own galaxy is the Milky Way. Within a

## BIRTH OF A STAR: NEBULA TO PROTOSTAR

A star forms inside a NEBULA. Gravity pulls the gas and dust of a region inward, so the cloud contracts and begins to spin, flattening into a rotating disc with a dense, hot centre. This still-growing centre is called a PROTOSTAR. As more matter falls in, its core grows hotter and

## FORMATION OF THE PLANETS

The planets formed from the leftover disc of gas and dust orbiting the new sun. Tiny dust grains stuck together and grew into PLANETESIMALS — small solid bodies kilometres across. These collided and merged under gravity (a process called ACCRETION), building up into larger

## TERRESTRIAL VS JOVIAN PLANETS

The eight planets divide into two groups. The TERRESTRIAL (inner) planets — Mercury, Venus, Earth and Mars — are small, dense and ROCKY, formed close to the sun where intense heat and the strong early solar wind prevented light gases from condensing or being

**WORKED EXAMPLE**

# Trace the solar system from nebula to planets

- 1** Start with a **NEBULA** — a cloud of gas and dust left over from the expanding universe; gravity makes a region of it contract and spin.
- 2** The contracting cloud flattens into a spinning disc with a hot, dense centre — a **PROTOSTAR**; when its core ignites nuclear fusion it becomes the **SUN**.
- 3** In the leftover disc, dust grains stick together into **PLANETESIMALS**, which collide and accrete into planets.
- 4** Result: near the hot sun, small **ROCKY** (terrestrial) planets form; far out in the cold, large **GASEOUS** (jovian) planets form — explaining the two planet families.

TOPIC

C

# The origin and early evolution of the earth

TOPIC

# From a hot ball to a layered planet

## ACCRETION OF THE EARLY EARTH

The earth formed about 4.6 billion years ago by the same ACCRETION process as the other planets — countless planetesimals and smaller bodies collided and merged in the inner, hot part of the solar nebula. Each collision added mass and, crucially, HEAT. The young earth

## HEATING AND DIFFERENTIATION

The early earth heated up from three sources: the energy released by the endless impacts of accretion, the gravitational compression of its growing mass, and the heat from the decay of RADIOACTIVE elements inside it. This heat partly melted the interior. In the molten

## THE LAYERED STRUCTURE: CORE, MANTLE, CRUST

Differentiation produced the layered earth we study for the rest of the year. At the centre lies the dense iron-nickel CORE; surrounding it is the thick silicate MANTLE; and at the surface sits the thin, light CRUST on which we live. The detailed sub-layers come in the later chapter

## BIRTH OF THE MOON

The chapter also notes the leading explanation for the moon's origin: the GIANT-IMPACT (or 'big splash') hypothesis. Soon after the early earth formed, a Mars-sized body is thought to have collided with it. The colossal impact blasted a huge amount of material — mostly from the earth's outer layers —

TOPIC

**D**

# The origin of the atmosphere, oceans and life

## TOPIC

# How the earth gained its air, oceans and life

### STAGE 1 — LOSS OF THE PRIMORDIAL ATMOSPHERE

The earth's evolution of the atmosphere happened in THREE stages. In the FIRST stage, the young earth held a thin PRIMORDIAL atmosphere of the lightest gases — HYDROGEN and HELIUM — captured from the surrounding solar nebula. But this earliest

### STAGE 2 — DEGASSING BUILDS A NEW ATMOSPHERE

In the SECOND stage, a new atmosphere was created from INSIDE the earth by a process called DEGASSING. As the hot interior churned, gases trapped within the molten rock were released to the surface through intense VOLCANIC eruptions and outgassing. These gases

### STAGE 3 — OCEANS, LIFE AND OXYGEN

As the earth cooled, the WATER VAPOUR released by degassing CONDENSED into rain; over millions of years this water collected in the surface depressions to form the OCEANS, roughly 4 billion years ago. LIFE then originated IN THE OCEANS about 3.8 billion years ago. In

### PUTTING THE SEQUENCE TOGETHER

The whole chapter is really one connected sequence, and writing it as a sequence is what earns marks. The UNIVERSE began with the Big Bang ~13.7 bya; gravity gathered matter into galaxies, then nebulae, then the sun and its planets; the EARTH accreted ~4.6 bya

**THEOREM · LOAD-BEARING RESULT**

# Differentiation — the key process



**DIFFERENTIATION** is the process by which the early, hot, homogeneous earth sorted itself by density into distinct layers — a heavy iron-nickel core, a silicate mantle and a light crust — as heavier materials sank and lighter materials rose.

## STATEMENT

Given a uniform, partly molten body heated by accretion impacts, gravitational compression and radioactivity, gravity drives density-sorting: dense iron and nickel migrate to the

## WHY THIS MATTERS

- Differentiation links this chapter to the entire rest of the course: the core, mantle and crust it created are the layers studied in 'Interior of the Earth', and the crust it raised is where all landforms, soils and life exist.

## WATCH OUT FOR

**NOTE** Do not write that the earth was 'born layered'. State clearly that it began **HOMOGENEOUS** and hot, and that differentiation came **AFTER**, driven by heat and gravity. Name the three heat sources to secure full marks.

TOPIC

**E**

# Tying the story together

**WORKED EXAMPLE**

# Trace the earth's air, water and life

- 1** Stage 1: the earth's primordial atmosphere of hydrogen and helium is stripped away by the sun's intense early solar wind — the earth is left almost airless.
- 2** Stage 2: DEGASSING through volcanoes releases water vapour, carbon dioxide and nitrogen from the hot interior, building a second, oxygen-poor atmosphere.
- 3** As the earth cools, the water vapour condenses as rain and gathers in depressions to form the OCEANS (~4 bya).
- 4** Stage 3: life arises in the oceans (~3.8 bya); photosynthesis consumes CO<sub>2</sub> and releases OXYGEN, producing today's atmosphere. Order: air lost → degassing → oceans → life → oxygen.

## WHY THIS MATTERS

# The one-line takeaways

- 1 The UNIVERSE began with the Big Bang (~13.7 bya, Hubble's evidence); the EARTH accreted much later (~4.6 bya).
- 2 Early theories explained only the solar system — Kant/Laplace nebular, Chamberlin-Moulton planetesimal, Jeans & Jeffreys tidal.
- 3 DIFFERENTIATION made the layers; DEGASSING made the air; the oceans then formed and life began in them ~3.8 bya.

TOPIC

# The Big Bang

TRAP → TRUTH

× **MISTAKE** The Big Bang was an explosion of matter into an already-existing empty space.

✓ **CORRECT** The Big Bang was NOT an ordinary explosion in space — it was the rapid expansion of space, time, matter and energy itself from an extremely small, hot, dense initial state about 13.7 billion years ago. There was no pre-existing empty space for matter to fly into; space itself began expanding. The galaxies are not moving through space away from a centre — space between them is stretching, which is why every distant galaxy recedes from us (Hubble's observation).

## TOPIC

# Early theories vs modern theory

### TRAP → TRUTH

× **MISTAKE** The nebular and planetesimal hypotheses are accepted today as the correct explanation of the universe's origin.

✓ **CORRECT** Those are EARLY theories about the origin of the EARTH / solar system, now largely superseded. The currently accepted explanation of the origin of the UNIVERSE is the Big Bang (expanding-universe) theory. The early hypotheses — Kant's gaseous, Laplace's nebular, Chamberlin-Moulton's planetesimal, Jeans & Jeffreys' tidal — are studied for their history and partial insights, not as today's accepted account of cosmic origin.

TOPIC

# Nebular hypothesis founders

TRAP → TRUTH

× **MISTAKE** Laplace was the first to propose the nebular hypothesis.

✓ **CORRECT** The gaseous / nebular idea was first put forward by the German philosopher Immanuel Kant (1755), and later revised mathematically by the French mathematician Pierre-Simon Laplace (1796). So the sequence is Kant first, Laplace's revision after — Laplace refined and popularised the nebular hypothesis but did not originate it. Reversing or merging the two is a common slip.

## TOPIC

# Terrestrial vs jovian planets

### TRAP → TRUTH

- × **MISTAKE** The outer (jovian) planets are rocky and the inner (terrestrial) planets are gaseous.
- ✓ **CORRECT** It is the opposite. The INNER, terrestrial planets (Mercury, Venus, Earth, Mars) are small, dense and ROCKY; the OUTER, jovian / gas-giant planets (Jupiter, Saturn, Uranus, Neptune) are large and GASEOUS. The terrestrials are rocky because they formed close to the sun where it was too hot for gases and ices to condense and the solar wind swept light gases outward; the jovians, far from the sun in the cold outer nebula, could hold on to vast amounts of hydrogen, helium and ices.

## TOPIC

# Differentiation

## TRAP → TRUTH

× **MISTAKE** The earth was born already split into a core, a mantle and a crust.

✓ **CORRECT** The early earth was a largely homogeneous, hot, semi-molten body. Its layered structure formed **AFTERWARDS** by **DIFFERENTIATION**: as the earth heated (from accretion impacts, gravitational compression and radioactivity), the heavier elements such as iron and nickel sank to the centre to form the core, while lighter material rose toward the surface to form the mantle and crust. The layering is a **RESULT** of density-sorting under heat and gravity, not the earth's birth condition.

TOPIC

# Origin of the atmosphere

## TRAP → TRUTH

- × **MISTAKE** The earth's present oxygen-rich atmosphere is the same one it has had since it formed.
- ✓ **CORRECT** The present atmosphere is the THIRD stage. (1) The earth's earliest primordial atmosphere of hydrogen and helium was lost / stripped away by the intense solar wind. (2) A second atmosphere was built by DEGASSING — gases (water vapour, carbon dioxide, nitrogen, etc.) released from the earth's hot interior through volcanic eruptions. (3) Only later did photosynthesis by early life convert much of the carbon dioxide into oxygen, producing the modern oxygen-bearing atmosphere. Oxygen is a late, life-made addition, not original.

## TOPIC

# Origin of the oceans and life

### TRAP → TRUTH

× **MISTAKE** Life began on land soon after the earth formed, around the same time as the planet itself.

✓ **CORRECT** The oceans formed when the water vapour released by degassing condensed as the earth cooled, filling the depressions roughly 4 billion years ago. Life then originated **IN THE OCEANS** about 3.8 billion years ago — hundreds of millions of years **AFTER** the earth formed (~4.6 bya) — not on land and not at the planet's birth. Land life came very much later. The oceans were the cradle of life, which is why the sequence earth → oceans → life matters.

TOPPER TEMPLATE · MARK-BY-MARK

# 5-mark question: 'Explain the Big Bang theory of the origin of the universe.'

**1 STATE THE THEORY**  
1 m

Open with the claim: 'The Big Bang theory, also called the expanding-universe hypothesis, holds that the entire universe began about 13.7 billion years ago from an extremely tiny, hot, dense state and has been expanding ever since.' State the age and the core idea before the stages.

**2 GIVE THE STAGES IN ORDER**  
2 m

Describe the sequence: (i) initially all matter and energy existed as a 'tiny ball' of unimaginable density and temperature; (ii) a sudden expansion (the Big Bang) caused this to expand rapidly within fractions of a second; (iii) as the universe expanded it cooled, energy converted to matter, and over time atoms, gas clouds, stars and galaxies formed. Sequence in order earns these marks.

**3 CITE THE EVIDENCE (HUBBLE)**  
1 m

Give the proof: 'Edwin Hubble (1920s) observed that galaxies are receding from us, and the farther a galaxy, the faster it recedes — showing the universe is still expanding. This expansion is the chief evidence for the Big Bang.' Naming Hubble and the recession of galaxies secures this mark.

**4 CONCLUDE WITH THE TIMELINE / SIGNIFICANCE**  
1 m

Close: 'Thus the universe is not static but expanding from a single hot origin ~13.7 billion years ago; the solar system, including the earth (~4.6 bya), formed much later within this evolving universe.' A clear concluding line earns the final mark.

## TOPPER TEMPLATE · MARK-BY-MARK

# 3-mark question: 'Describe the three stages in the evolution of the earth's atmosphere.'

- 1 STAGE 1 — LOSS OF THE PRIMORDIAL ATMOSPHERE**  
1 m  
'In the first stage the earth's earliest (primordial) atmosphere, made of hydrogen and helium, was stripped away / lost owing to the intense solar wind during the sun's early, very active phase.' Name the gases and the cause.
- 2 STAGE 2 — DEGASSING**  
1 m  
'In the second stage, gases were released from the earth's hot interior through volcanic eruptions — a process called DEGASSING. This built a new atmosphere rich in water vapour, carbon dioxide, nitrogen and other gases, but with very little free oxygen.' The word 'degassing' must appear.
- 3 STAGE 3 — MODIFICATION BY LIFE (PHOTOSYNTHESIS)**  
1 m  
'In the third stage the composition was modified by living organisms: photosynthesis by early plants consumed carbon dioxide and released oxygen, gradually producing the present oxygen-rich atmosphere.' Linking oxygen to photosynthesis earns the final mark.

TOPPER TEMPLATE · MARK-BY-MARK

# 5-mark question: 'Explain how the early earth developed its layered structure through

**1 DESCRIBE THE EARLY HOMOGENEOUS EARTH**

1 m

Open: 'The early earth, formed by the accretion of planetesimals about 4.6 billion years ago, was a largely homogeneous, hot and partly molten body with no separate layers.' Establish the starting condition.

**2 EXPLAIN THE SOURCE OF HEAT AND MELTING**

2 m

'It heated up from three sources — the energy of countless impacts during accretion, gravitational compression of the growing mass, and the decay of radioactive elements. This heat partly melted the interior, allowing the materials to move and sort themselves by density.' Naming the heat sources earns these marks.

**3 STATE THE DIFFERENTIATION / DENSITY-SORTING**

1 m

'In the molten state, the heavier elements — chiefly iron and nickel — sank toward the centre, while the lighter materials rose toward the surface. This density-sorting is called DIFFERENTIATION.' The term must be defined.

**4 NAME THE RESULTING LAYERS AND CONCLUDE**

1 m

'Differentiation produced the layered earth: a dense iron-nickel CORE at the centre, a thick silicate MANTLE around it, and a thin, light CRUST at the surface. Thus the earth's layers are a product of differentiation, not its birth condition.' Naming core-mantle-crust secures the final mark.

## PYQ PATTERNS

# Top PYQ patterns to drill

**#1**

Explain the Big Bang theory of the origin of the universe. (3-5 marks)

CBSE SQP 2020,  
2022; School  
Annual  
recurrently

**#2**

Describe the three stages in the evolution of the earth's atmosphere. (3-5 marks)

CBSE SQP 2019,  
2021; very  
common at  
school level

**#3**

Distinguish between terrestrial planets and jovian planets, giving reasons for the difference. (3 marks)

CBSE SQP 2022;  
School Annual  
2021, 2022

**#4**

Explain the early theories (nebular / planetesimal / tidal) of the origin of the earth and their founders. (1-3 marks)

School Term  
papers, MCQ +  
short answer

**#5**

What is meant by differentiation? How did the earth develop its layered structure (core, mantle, crust)? (3-5 marks)

CBSE SQP 2023;  
School Annual

**RECAP · MEMORISE THESE**

# 5-line revision

**1** Theories — Early: Kant gaseous (1755) → Laplace nebular (1796) → Chamberlin-Moulton planetesimal → Jeans & Jeffreys tidal. Modern (universe): BIG BANG, ~13.7 bya, Hubble's evidence.

**2** Sun, planets, earth — Nebula → protostar → Sun + planets. Terrestrial (inner) = rocky; jovian (outer) = gaseous. Earth accreted ~4.6 bya as a hot homogeneous ball.

**3** Layers, air, life — DIFFERENTIATION → core-mantle-crust. Atmosphere: H+He lost → DEGASSING → photosynthesis adds O<sub>2</sub>. Oceans formed, then LIFE in the sea ~3.8 bya.

**TRY IT · SOLVE BEFORE YOU PEEK**

# Check yourself (60 seconds)

Work it out before you flip the answer.

**SOLUTION**

**WHAT'S NEXT**

# What's next

- Chapter 3 — Interior of the Earth (the core, mantle and crust that differentiation produced, in full detail).
- Sit the 15-MCQ Quick Drill (companion PDF) — under 20 minutes, target  $\geq 12/15$ .
- Then the full term-pattern paper — 30 marks, 60 minutes, with model answers.

# From the Big Bang to the blue planet — locked.

Theories, planets, differentiation, atmosphere — you have the whole sequence. Take the drill, sit the paper, beat the chapter.

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