THE FIELD GUIDE TO GEOLOGY

David Lambert
and the Diagram Group

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The Diagram Group

Editors Denis Kennedy
Annabel Else

Indexer Mary Ling

Designers Arthur Lockwood
Richard Hummerstone

Illustrator Graham Rosewarne

Artists Joe Bonello, Alastair Burnside, Richard Czapnik, Brian Hewson, Lee Lawrence, Chris Logan, Paul McCauley, Philip Patenall, Micky Pledge, Jane Robertson, Debbie Skinner

FOREWORD

This book provides perhaps the most concise yet comprehensive key to the ingredients and processes that forged our planet. Hundreds of illustrations – large, clearly labeled diagrams, "field-guide" illustrations, and maps – help readers grasp important concepts instantly. Images are integrated with text explaining scientific terms in simple language. Together, text and pictures offer an up-to-date guide for all, from the inquiring eleven-year-old to the budding scientist.

There are twelve chapters. Each has a brief explanatory introduction, followed by topics arranged under bold headings.

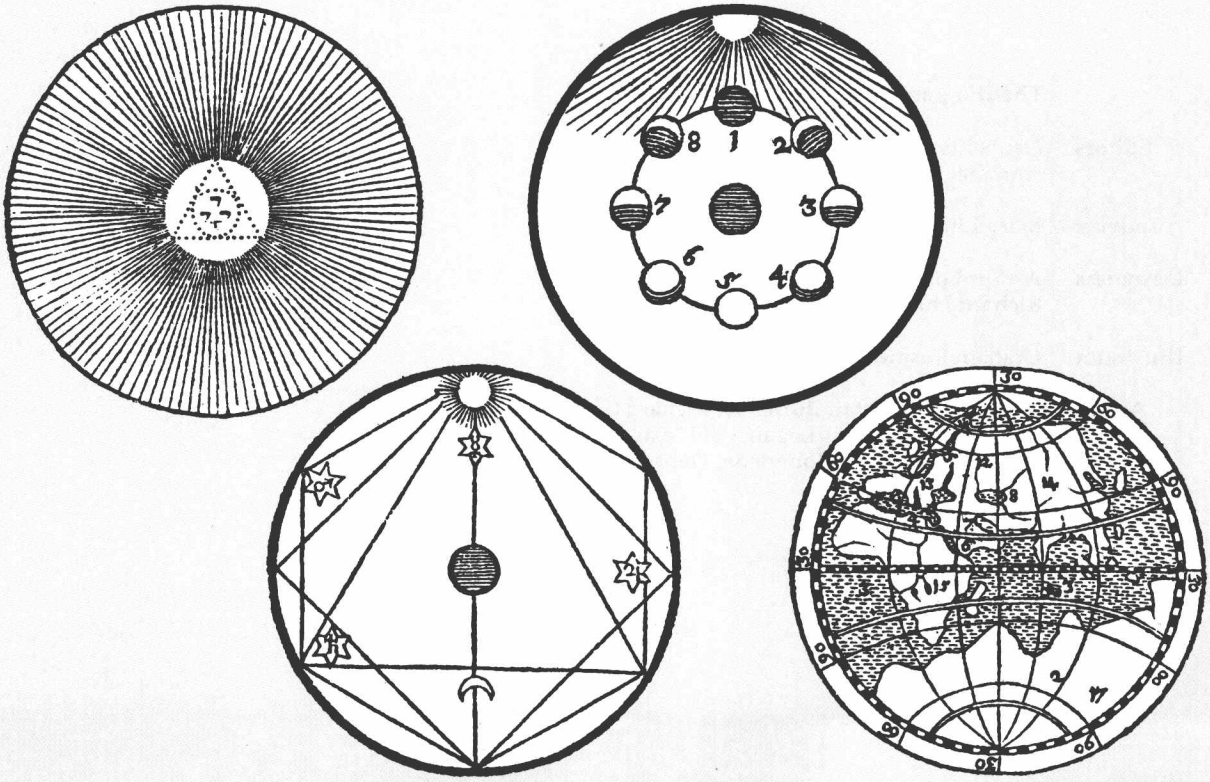
Chapter 1 (Sizing up the Earth) gives an overview of our planet's origins and raw materials.

Chapter 2 (The Restless Crust) explains the astonishing processes that shape and reshape continents and oceans and recycle rocks.

Chapter 3 (Fiery Rocks) deals with igneous rocks – rocks formed from molten matter, the stuff from which all rock derives.

Chapter 4 (Rocks from Scraps) covers sedimentary rocks – rocks mostly formed from reconstituted bits of igneous or other rocks.

Chapter 5 (Deformed and Altered Rocks) investigates processes that displace crustal rocks and change one kind of rock into another.



Chapter 6 (Crumbling Rocks) examines the work of weather in destroying rocks, building soil, and sculpting slopes.

Chapter 7 (How Rivers Shape the Land) traces the role of rivers in carving valleys, shaping plains, and deltas, and creating lakes.

Chapter 8 (The Work of the Sea) tells how the sea destroys and builds land.

Chapter 9 (The Work of Ice and Air) explains how glaciers and ice sheets mold cold lands, and winds sculpt desert landscapes.

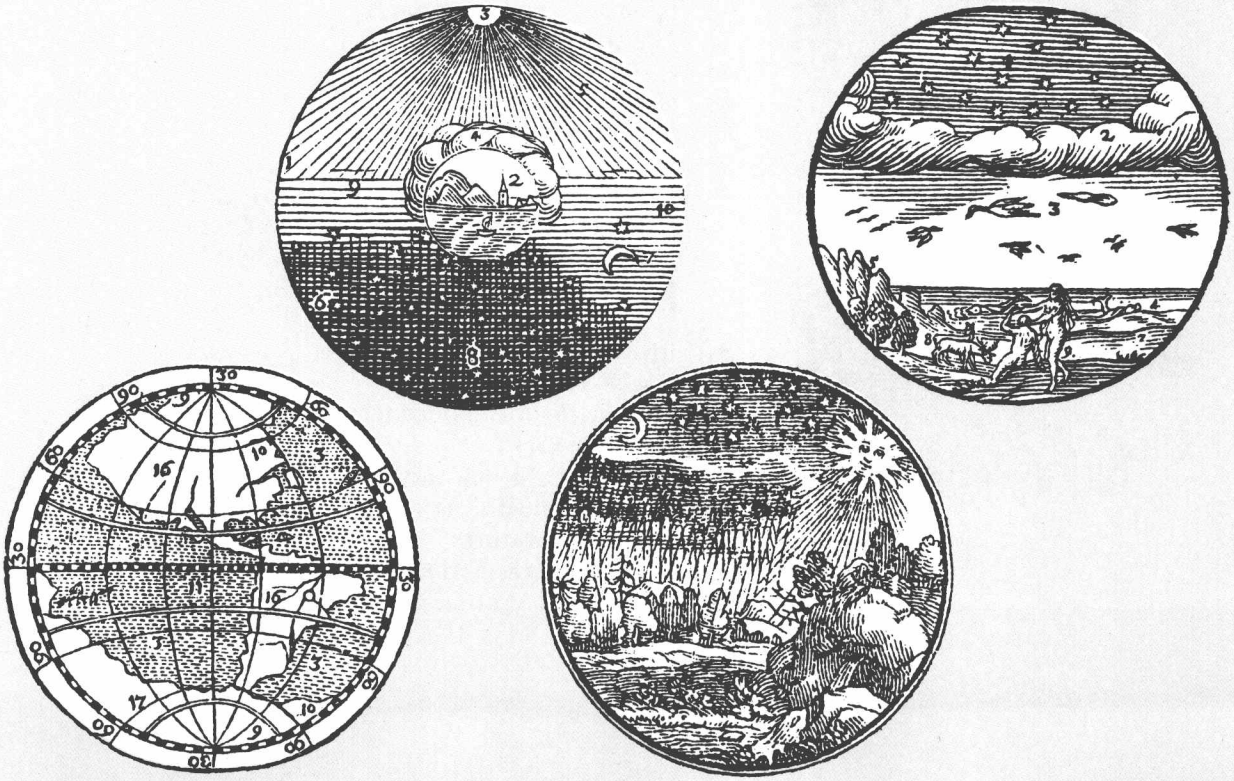
Chapter 10 (Change Through the Ages) shows how geologists read the record of Earth's history in rocks, and what the oldest rocks reveal.

Chapter 11 (The Last 600 Million Years) covers the great changes that have formed, reformed, and repositioned continents since rocks acquired a detailed fossil record.

Chapter 12 (Rocks and Man) describes how geologists find and exploit useful rocks and minerals. The chapter ends with achievements of famous geologists and a worldwide list of geological displays.

Lastly there is a list of books for further reading, and an index.

The producers of this guide would like to thank the many experts whose work has helped to make this book more accurate and up to date.



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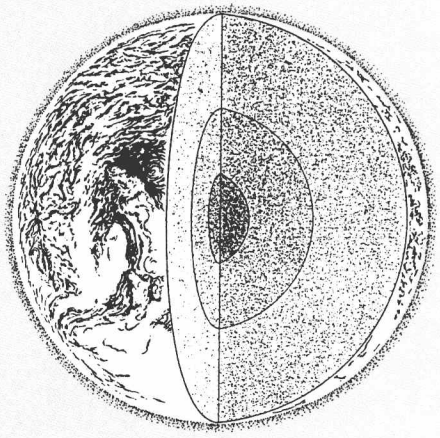

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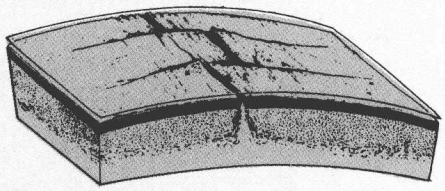

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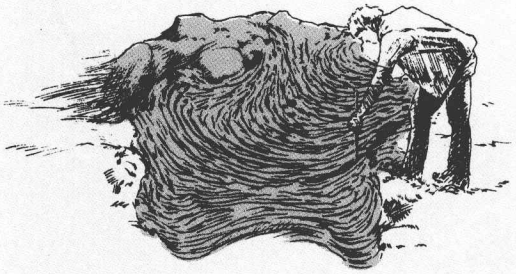

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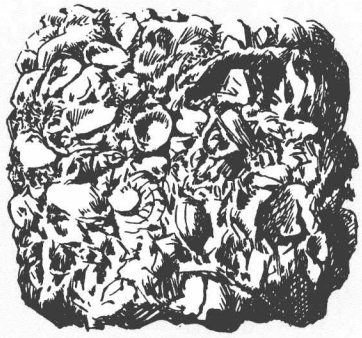

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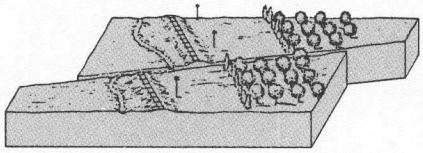

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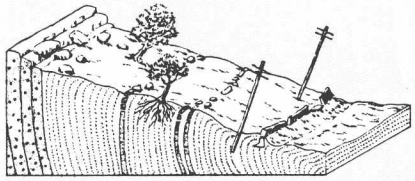

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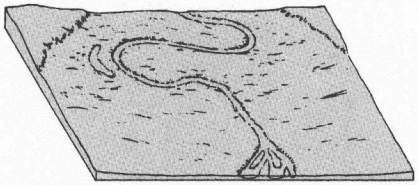

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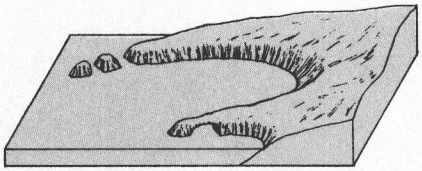

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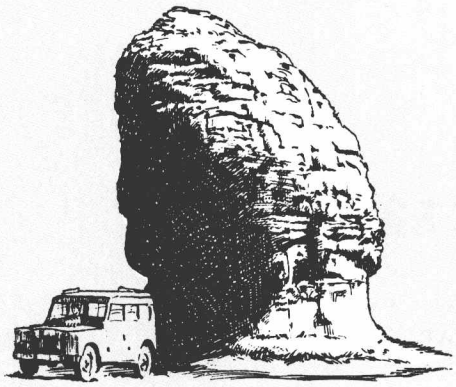

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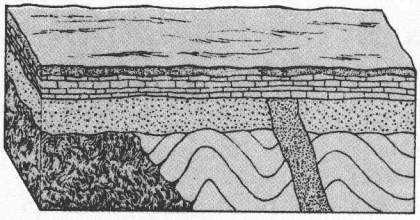

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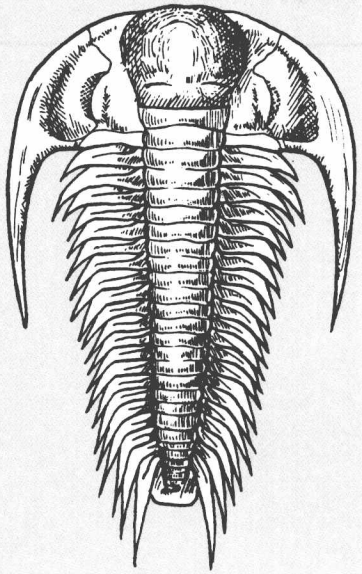

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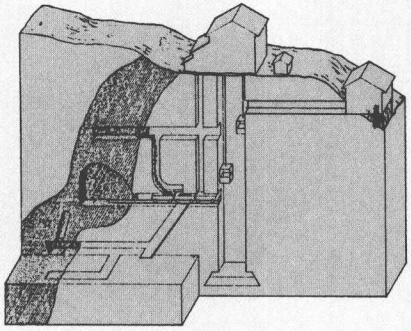

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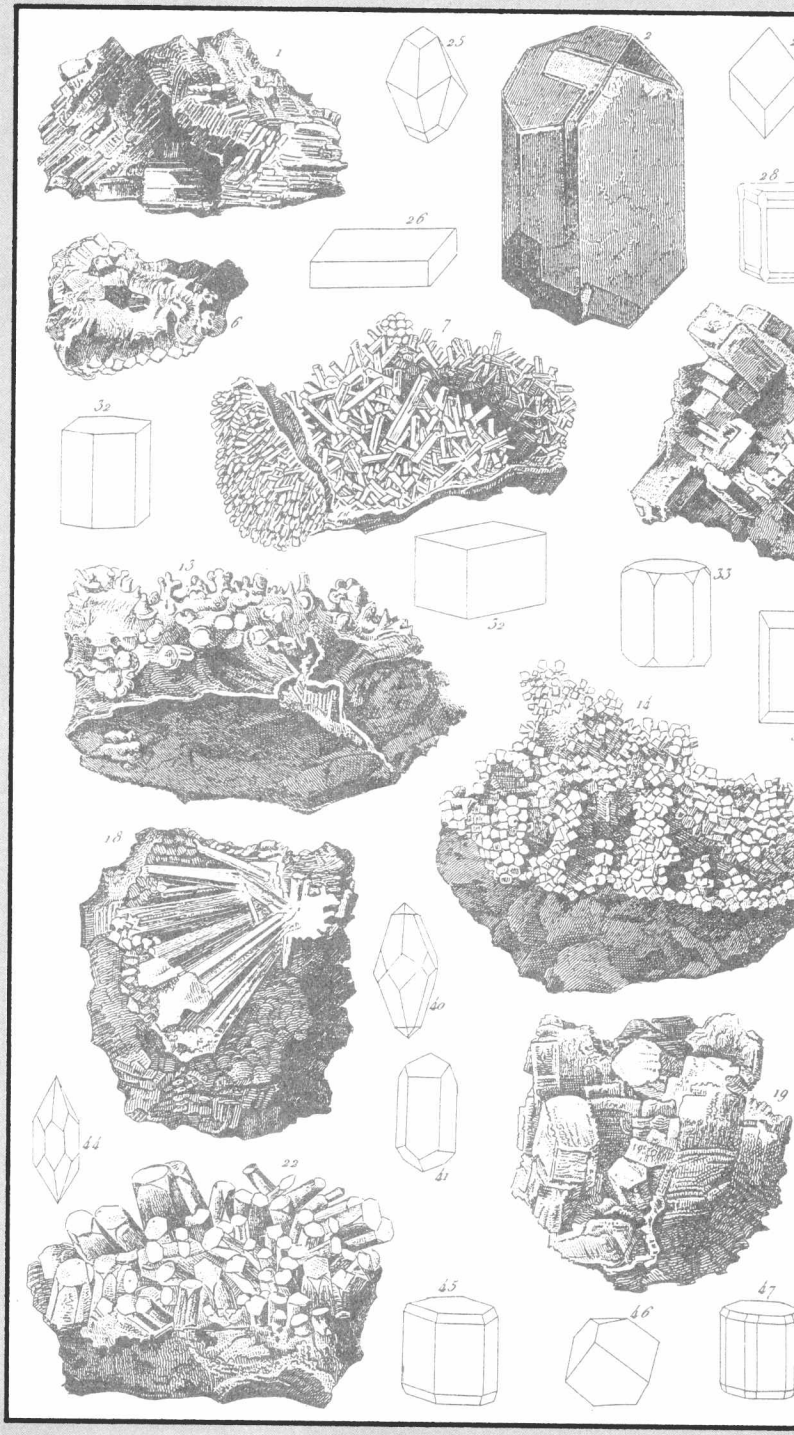
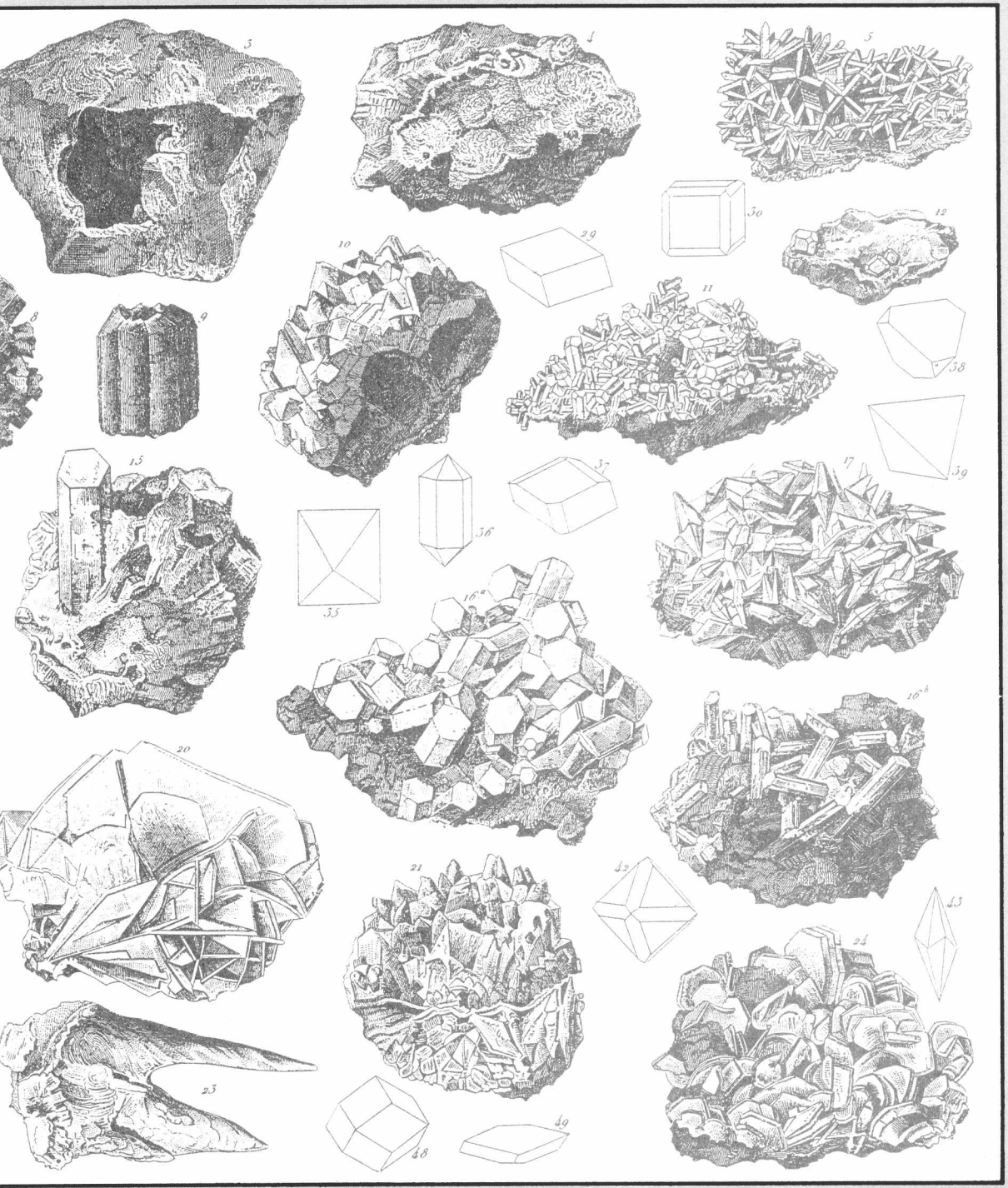
Chapter 1

SIZING UP THE EARTH

This book begins by putting our planet in its universal context. We see how matter, stars, and the solar system evolved, and how the Earth acquired its layered structure, and slightly bulging shape. There is a brief overview of elements, minerals, and rocks – Earth's building blocks. The chapter ends with a look at the forces that keep the sea and air in motion, disturb the crust, and turn the Earth into a mighty dynamo.



A selection of minerals and their crystalline forms. (Engraving originally published in *The Iconographic Encyclopaedia of Science, Literature and Art* 1851)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Earth in space

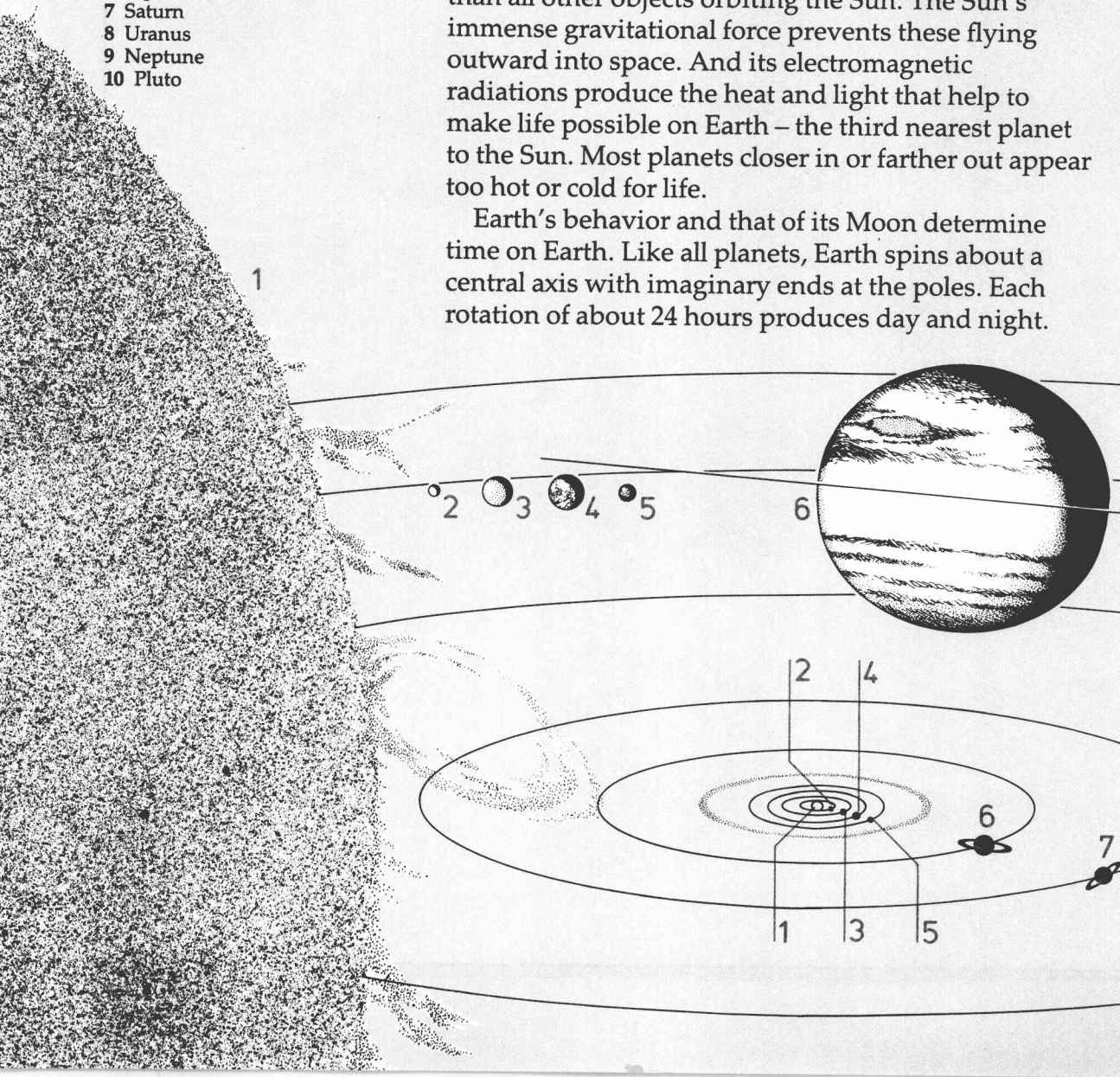
Sun and planets
Numbered items show (below) relative sizes of and (bottom) gaps between the Sun and planets. Asteroids (minor planets) lie between 5 and 6.

1 Sun
2 Mercury
3 Venus
4 Earth
5 Mars
6 Jupiter
7 Saturn
8 Uranus
9 Neptune
10 Pluto

Earth is a rocky, spinning ball – one of nine planets and many lesser bodies (moons, asteroids, and comets) orbiting a star (the Sun). All of these together constitute our solar system.

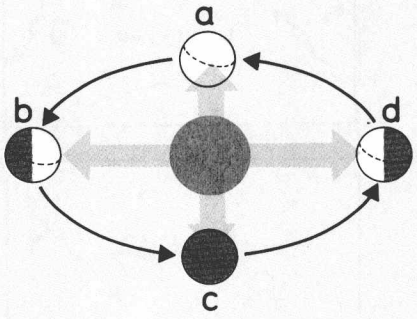
The Earth is tiny compared to the four largest planets. But our solar system's largest and most influential body is the Sun, a glowing ball of gases a million times the volume of the Earth, and far bigger than all other objects orbiting the Sun. The Sun's immense gravitational force prevents these flying outward into space. And its electromagnetic radiations produce the heat and light that help to make life possible on Earth – the third nearest planet to the Sun. Most planets closer in or farther out appear too hot or cold for life.

Earth's behavior and that of its Moon determine time on Earth. Like all planets, Earth spins about a central axis with imaginary ends at the poles. Each rotation of about 24 hours produces day and night.

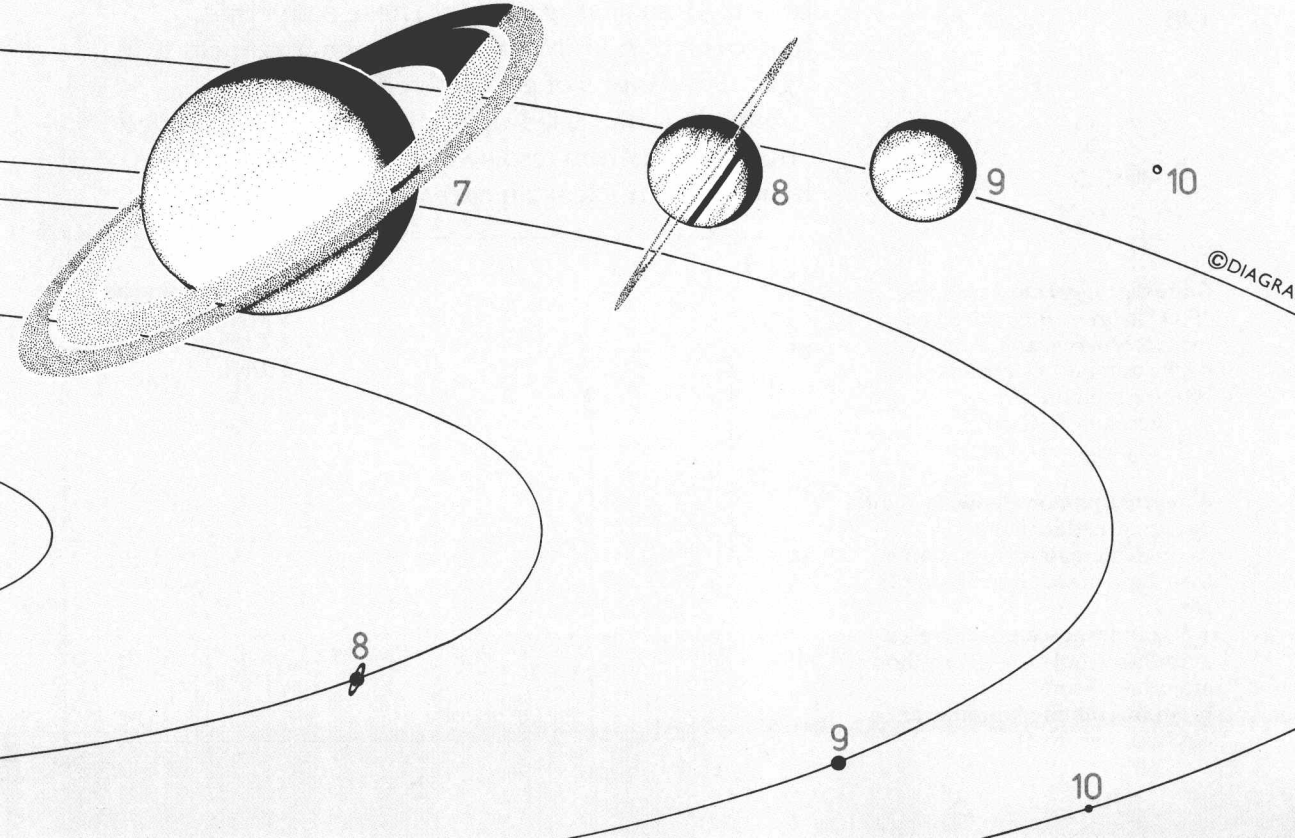


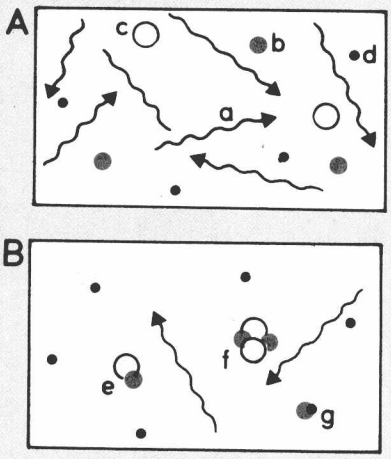
About once a month the Moon completes one revolution around the Earth. Earth itself completes one orbit of the Sun in about 365 days – an Earth year. Because Earth orbits in a tilted attitude, sunlight beams down directly upon its Northern and Southern hemispheres at different times of year, creating seasons.

Immense distances separate the Earth from other bodies in space. From Earth to the Moon is about 1.25 light-seconds, the distance covered in that time by light, which travels at 186,000mi per second (300,000km per sec). From Earth to Sun is 8 light-minutes; the solar system is 11 light-hours across; from Earth to the nearest star beyond the Sun is 4 light-years. Our solar system, plus dust, gas, and 100,000 million stars (some no doubt with solar systems of their own) comprise our galaxy – a flattened disk 80,000 light-years across. At least 10,000 million galaxies are scattered through the universe.

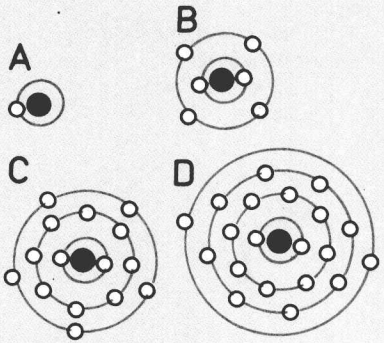


The seasons (above)
The Earth's tilt brings the midday sun overhead north or south of the equator at different times of year, so creating seasons.
a 21 March: Sun over the equator
b 21 June: Sun over the Tropic of Cancer
c 23 September: Sun over the equator
d 21 December: Sun over the Tropic of Capricorn





The first atoms (above)
A Post big-bang radiation (**a**) and subatomic particles: protons (**b**), neutrons (**c**), and electrons (**d**)
B Subatomic particles combined as nuclei of deuterium ("heavy hydrogen") (**e**), helium (**f**), and hydrogen (**g**)



Building bigger atoms (above)
"Star factories" forged heavier, more complex atoms, indicated by the number of electrons orbiting their nuclei:
A Hydrogen, **B** Carbon, **C** Phosphorus, **D** Calcium

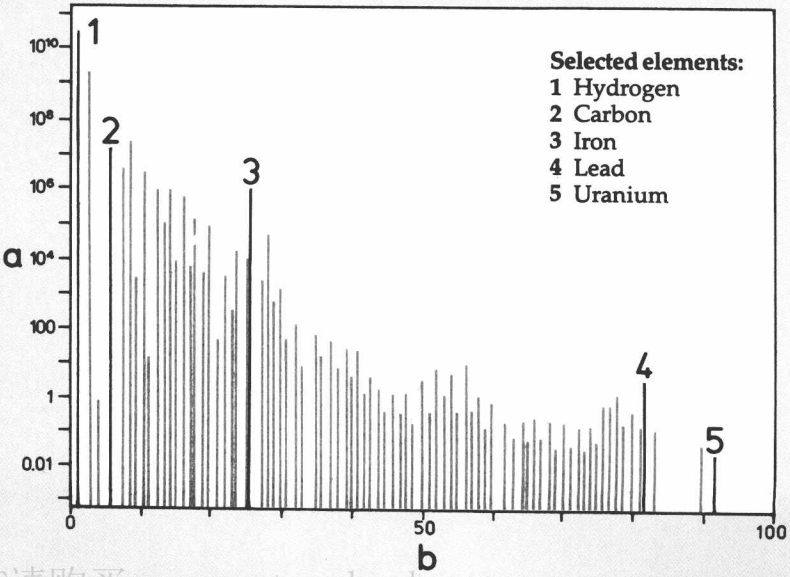
How everything began

Earth's origins lie in the creation of the universe. Just how this came about remains unclear, but many scientists accept some version of the "big bang" theory, which goes like this. At first all energy and matter (then only subatomic particles) was closely concentrated. About 15,000 million years ago a vast explosion scattered everything through space. Star studies prove the universe is still expanding, and background radiation hints at its initial heat.

The big bang sparked off processes producing atoms forming different elements – the chemically indivisible building blocks of stars and planets. (More than 90 elements occur on Earth alone.)

Hydrogen and helium, the lightest, most abundant elements, would have begun forming as subatomic particles within minutes of the big bang. Hundreds of millions of years later, condensing clouds of hydrogen formed galaxies. Here mighty blobs of gas contracted under gravitation. This process warmed the gas and triggered nuclear reactions. These converted hydrogen to helium and gave off energy including light. Thus blobs of gas evolved into stars.

Stars that had used up all their hydrogen started "burning" helium and swelling into "red giants." Inside their nuclear furnaces atomic evolution



Rare and common elements (right)
Elements made of large, complex atoms tend to be scarcer than those made of small, simple atoms.
a Logarithmic scale of universal abundance (relative to 1 million atoms of silicon.)
b Atomic number (number of electrons per atom)