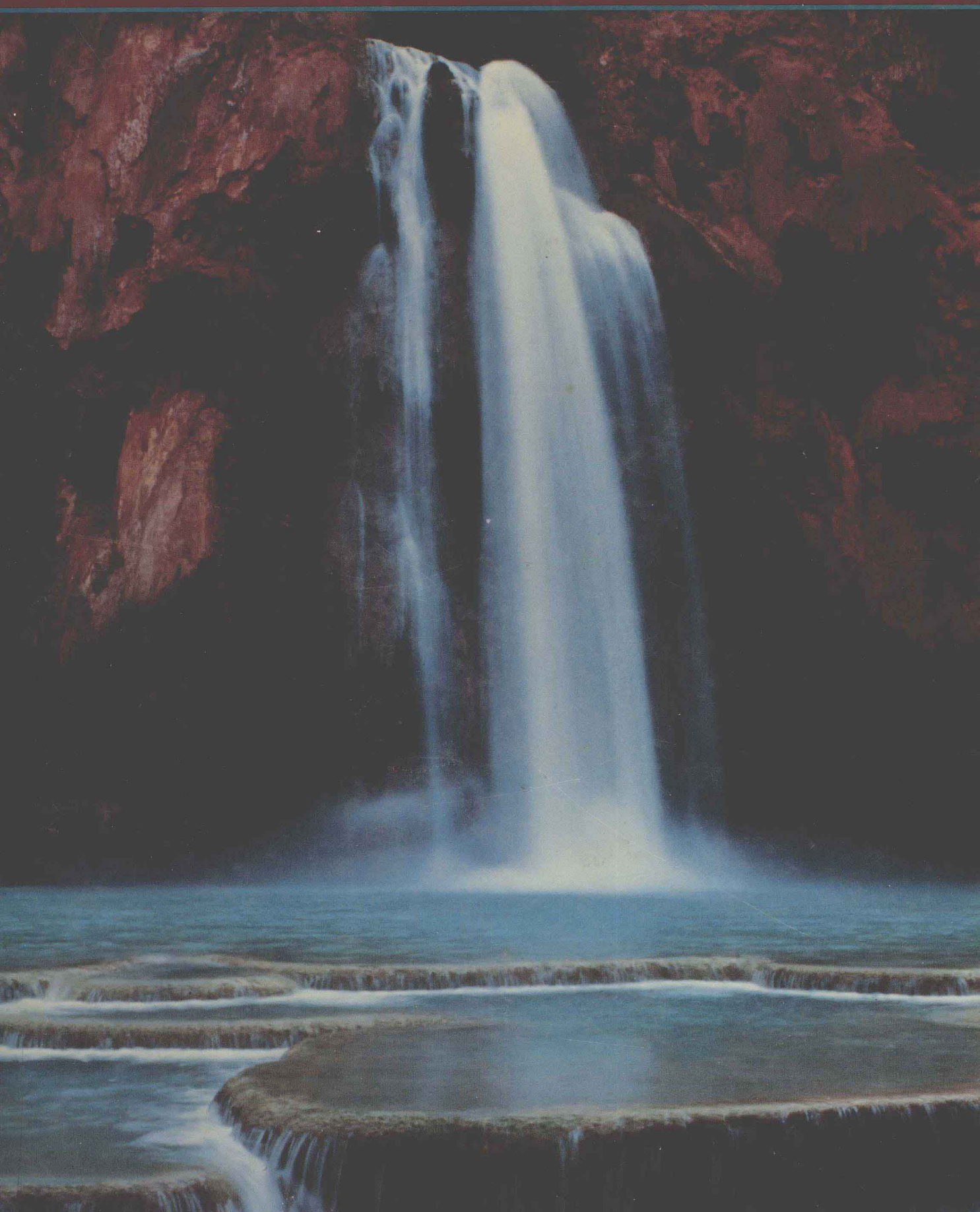


Tom L. McKnight

PHYSICAL GEOGRAPHY

THIRD EDITION

A Landscape Appreciation



THIRD EDITION

Physical Geography *A Landscape Appreciation*

Tom L. McKnight

University of California, Los Angeles

With cartographic collaboration of
Patricia Caldwell Lindgren, Ph.D.,
Caldwell & Associates
Mill Valley, California



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*To JJ,
the wind beneath my wings . . .*

Preface

Despite having a highly literate and educated society, U.S. citizens are probably the world's most geographically ignorant people. In many other countries, geography is a basic field of study in both primary and secondary schools, as well as being a firmly established university subject. Over much of the world, schoolchildren are exposed to geographic training for most of their school years. This applies not only to such developed countries as England, Sweden, and New Zealand but also to such less-developed lands as India, Tanzania, and Ecuador. Not so in the United States, where a pupil last hears the word *geography* in about the third grade, and the rare introduction of geographic course content at any higher level is usually muffled under the heading of "social studies."

Most American students, then, are surprised to find geography courses offered in colleges and universities. This discovery can evoke memories of third-grade recitations of people, places, and products and raises questions as to the intellectual validity of such a discipline. What can a grade-school subject like geography provide to the questing college student?

GEOGRAPHY AS A FIELD OF LEARNING

The fact of the matter is that geography is an ancient and honorable field of learning, with its roots firmly set in classical antiquity. The Greek derivation of the

word *geo-graphy* is "earth description." During the Hellenistic period, when Greek civilization, culture, and intellectual achievement dominated the "known world," many notable Greek scholars were more "earth describers" than anything else. Some of the prominent names that shine through the ages—such as Anaximander, Aristotle, Eratosthenes, Hecataeus, Herodotus, Hipparchus, Plato, Ptolemy—are famed as philosophers or historians or mathematicians or something else, but their contribution as geographers is at least as great.

An important corollary of this historical vignette is the realization that geography was (and is) a generalized—as opposed to a specialized—discipline. Its viewpoint is one of broad understanding. During the first centuries of the Christian era, there was a trend away from generalized Earth description and toward more specific scholarly specializations. This led to a variety of more specialized disciplines—such as geology, meteorology, economics, and botany—along with a concomitant eclipsing of geography. If "Mother geography gave birth to many offshoot sciences," as some geographers have said, it is clear that these developing disciplines soon became better known than their progenitor.

It was not until the 1600s that there began a rekindling of interest in geography in the European world, and it was another two centuries before there was a strong impetus given to the discipline by geographers from various countries, most notably the Germans Alexander von Humboldt and Karl Ritter in

the middle of the nineteenth century. A prominent theme that has persisted through the centuries in the history of the discipline, and one that was clearly enunciated by both Humboldt and Ritter, is that geographers study how things differ from place to place over the Earth—the areal differentiation of the Earth’s surface. There is a multiplicity of “things” to be found on the Earth, and nearly all of them are distributed unevenly, thus providing a spatial, or geographic aspect.

The following table provides an abbreviated listing of the kinds of “things” to which we are referring; in this context they can be thought of as elements of geographic study. They are divided into two lists: one of physical or environmental elements that are natural in origin, and the other of cultural or human elements that are the products of some sort of human endeavor. The list of physical elements is short and essentially complete as a broad tabulation. The list of cultural elements, on the other hand, is quite incomplete and is merely suggestive of a much longer inventory of both material and nonmaterial features.

The Elements of Geography

Physical	Cultural
Rocks	Population
Landforms	Settlements
Soil	Economic activities
Flora	Transportation
Fauna	Recreation activities
Climate	Languages
Water	Religion
Minerals	Political systems
	Traditions
	And many others

It is readily apparent that this tabulation of geographic elements contains no new words or concepts. The listed items are familiar to us all. This familiarity highlights another basic characteristic of geography as a field of learning: Geography has no peculiar body of facts or objects of study that it can call its own. The particular focus of geology is rocks, the primary interest of botany is plants, the attention of economics is fastened on economic systems, and almost all other academic disciplines have some distinctive assemblage of objects, facts, or concepts as a center of attention. Geography, however, like history, is a very broad field of inquiry and “borrows” its objects of study from related disciplines. Geographers, too, are interested in rocks, plants, and economic systems, but only in certain aspects of these elements. In simplest terms, geographers are con-

cerned with the spatial, or distributional, aspects of these various elements. Thus geography is neither a physical science nor a social science; rather, it combines characteristics of both and can be conceptualized as bridging the gap between the two. A geographer is not interested in the environment for the environment’s sake, nor in humans for humans’ sake. Indeed, geography is concerned with the environment as it provides a home for humankind and the way that humans utilize that environmental home.

Another basic characteristic of geography is its interest in interrelationships. One cannot understand the distribution of soils, for example, without knowing something of the rocks from which the soils were derived, the slopes on which the soils developed, and the climate and vegetation under which the soils evolved. Similarly, it is impossible to comprehend the distribution of agriculture without an understanding of climate, topography, soil, drainage, population, economic conditions, technology, historical development, and a host of other factors, both physical and cultural. Thus the elements tabulated in the table are enmeshed in an intricate web of interrelationships, all of which are encompassed in the field of geographic study. To summarize: Geographers are concerned with the distribution of phenomena, how that distribution came about, and the significance of that distribution (to an understanding of the geography of the world). Thus the fundamental question of geographic inquiry is, Why What is Where, and So What?

PHYSICAL AND HUMAN GEOGRAPHY

Geography is a broad and integrating discipline that brings together important aspects of both physical and social sciences as well as impinging on the humanities. As a field of learning, then, geography can be viewed as a dichotomous subject—one that lends itself to subdivision into two broad and separate subfields: physical geography and human geography. The subject matter of this book is physical geography. Thus an attempt is made to summarize the various components of the “natural” environment, considering the nature and characteristics of the physical elements, the processes involved in their development, their distribution over the earth, and their basic interrelationships. Relationships with the various elements of human geography are largely ignored except where they help to explain development or contemporary distribution patterns of the physical elements.

CONTENTS AND APPROACH

This book presents the physical or environmental portion of geography in terms of its essentials. Written and designed for an introductory survey of physical geography, the text assumes that the student has little or no prior formal training in geography. The level of presentation doubles as both a survey for the liberal arts undergraduate and as a broad and systematic overview for the student who plans to major in the subject. An informal writing style, devoid of excessive jargon, an abundance of high-quality four-color illustrations, and the use of “focus boxes” all work together to provide students with a solid background on which to build their future studies.

Written from a geographer’s point of view, the text continually explores the processes of physical geography, carefully explaining the interrelationships of phenomena. There is a preliminary assessment of the Earth’s planetary characteristics and a systematic presentation of the major components of physical geography with special emphasis on climate and topography. Within each chapter, “focus boxes” provide useful vignettes that expand on topics that are presented more briefly in the text. An innovative addition to this edition is a special series of new focus boxes—one per chapter—involving human/environmental interaction, the third of the five basic themes of geography.

The book begins with two chapters that are preliminary in concept and content. Chapter 1 provides an introductory look at the Earth, discussing particularly its planetary setting and the environmental effects of its relationship with the sun. Chapter 2 deals with the concepts and practicalities of portraying and representing the Earth’s surface in ways understandable and meaningful to interested humans. The traditional roles of globes and maps are presented, and the exciting new techniques of remote sensing are broadly introduced.

Chapters 3 through 8 focus on the atmosphere. Emphasis is on the nature of the weather elements and the dynamics of atmospheric processes, leading to a consideration of the interaction of air masses, fronts, and storms. This section concludes with a discussion of the general subject of climatic classification and a detailed presentation of the widely used Köppen system for the world.

Chapter 9 is an introduction to the hydrosphere, which surveys the principal components of the aqueous part of our environment.

Chapters 10 and 11 comprise a more systematic and coherent presentation of the biotic part of the

environment than is normally found in a physical geography textbook. The increasing ecological awareness of our populace calls for this extended treatment of the biosphere.

Chapter 12 is an expansive consideration of soils, dealing at some length with soil-forming factors, soil components, and soil-generating regimes. The latter half of the chapter considers soil classification in general and the United States Comprehensive Soil Classification in particular, outlining the world distribution pattern.

Chapters 13 through 20 focus on terrain analysis. These chapters proceed systematically from a conceptual introduction through a broad treatment of the internal crust-shaping processes (plate tectonics, diastrophism, vulcanism) to a more detailed consideration of the external processes of weathering, mass wasting, erosion, and deposition. The principal external land-shaping systems—fluvial, aeolian, coastal, solution, and glacial—are discussed in detail.

The writer believes that a useful definition of geography is “landscape appreciation” and has prepared this book with that theme in mind. “Landscape” is considered to include everything that one sees when looking out a window, everything that one hears upon listening at a window, and everything that one smells upon smelling at a window, referring to every window, actual and theoretical, in the world. “Appreciation” is used in the sense of understanding. Any proper exposition of geography should serve to heighten one’s understanding of all that is seen, heard, and smelled at the window, whether an actual experience at a nearby window or a vicarious experience on the other side of the Earth. Thus it is the purpose of this book to make the environmental landscape of the world more understandable to the reader, at least at an introductory level.

What do you see when you cross the Mohave Desert from Los Angeles to Las Vegas? Three hundred miles of Not Much? A geographer sees 300 miles of Quite A Lot. It is hoped that this book will help the reader expand his or her capacity for landscape appreciation from the former to the latter.

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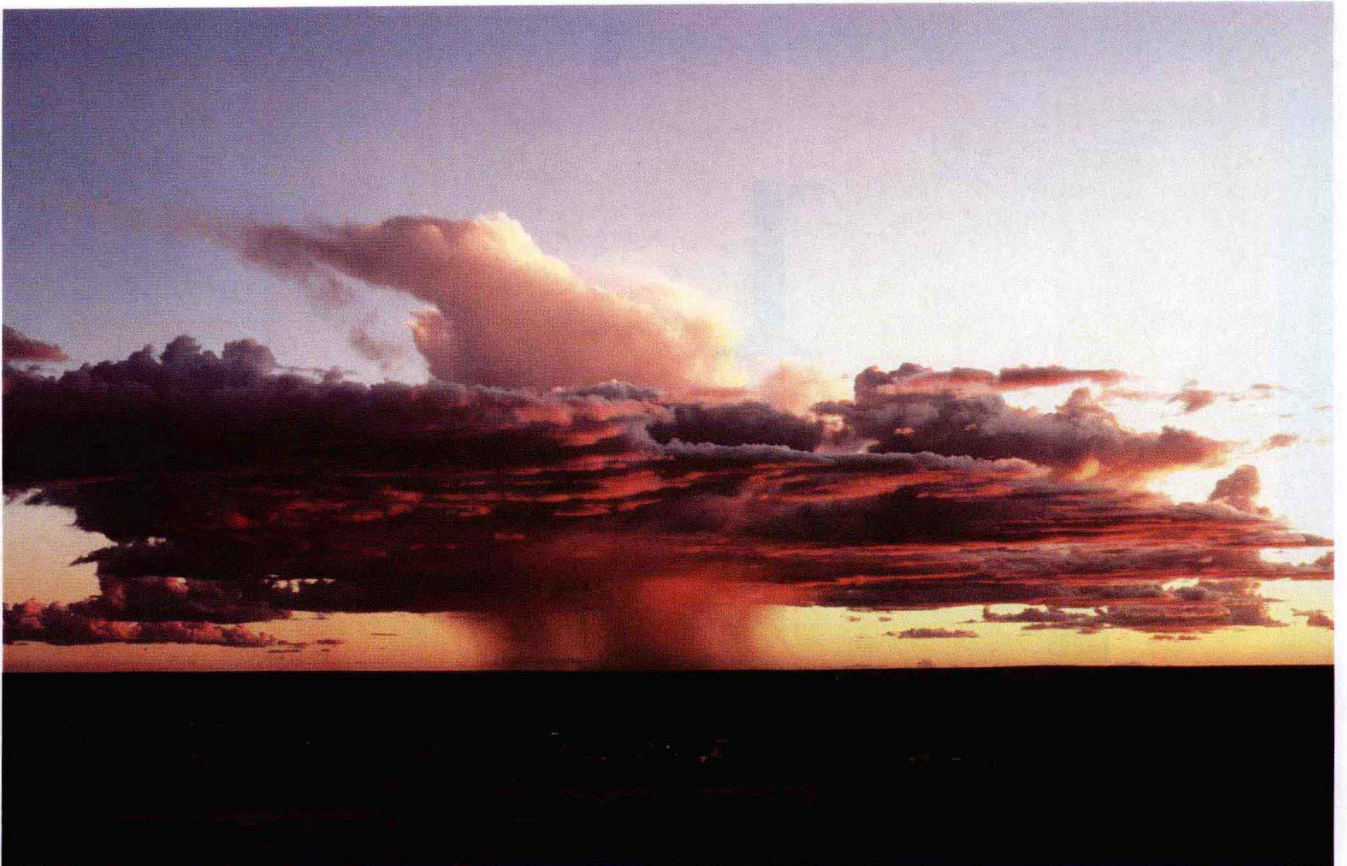
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T. L. M.



For every cloud engenders not a storm.

—William Shakespeare
Third Part of King Henry VI

Brief Contents

1 INTRODUCTION TO THE EARTH	1	11 TERRESTRIAL FLORA AND FAUNA	276
2 PORTRAYAL OF THE EARTH	26	12 SOILS	318
3 INTRODUCTION TO THE ATMOSPHERE	50	13 INTRODUCTION TO LANDFORM STUDY	354
4 INSOLATION AND TEMPERATURE	64	14 THE INTERNAL PROCESSES	380
5 ATMOSPHERIC PRESSURE AND WIND	94	15 PRELIMINARIES TO EROSION: WEATHERING AND MASS WASTING	418
6 ATMOSPHERIC MOISTURE	126	16 THE FLUVIAL PROCESS	440
7 TRANSIENT ATMOSPHERIC FLOWS AND DISTURBANCES	158	17 TOPOGRAPHIC DEVELOPMENT IN ARID LANDS	476
8 CLIMATIC REGIONS	188	18 COASTAL PROCESSES AND TERRAIN	506
9 THE HYDROSPHERE	228	19 SOLUTION PROCESSES AND KARST TOPOGRAPHY	528
10 CYCLES AND PATTERNS IN THE BIOSPHERE	252	20 GLACIAL MODIFICATION OF TERRAIN	536

Contents

PREFACE

1 INTRODUCTION TO THE EARTH

1

The Environmental “Spheres”	1
The Earth as a Planet	2
Focus on Distance Measurement in Space	3
Focus on Numbers and Measurement	10
Earth and Sun Relations	18

2 PORTRAYAL OF THE EARTH

26

Focus on Map Essentials	28
The Nature of Maps	30
The Matter of Scale	30
The Role of Globes	32
Map Projections	32
Focus on Mercator: The Most Famous Projection	36
Remote Sensing	39
Focus on Interpretation of Thematic Mapper Imagery	46

3 INTRODUCTION TO THE ATMOSPHERE

50

Constituents of the Atmosphere	52
People and the Environment: Depletion of the Ozone Layer	54

Vertical Structure of the Atmosphere	56
Weather and Climate	59
The Study of Climate	59

4 INSOLATION AND TEMPERATURE

64

Solar Energy	65
Focus on the Electromagnetic Spectrum	66
Basic Processes in Heating and Cooling the Atmosphere	68
The Heating of the Atmosphere	72
Spatial and Seasonal Variations in Heating	74
Focus on Measuring Temperature	80
Temperature: Expression of Heat	82
Mechanisms of Heat Transfer	82
Vertical Temperature Patterns	85
People and the Environment: Urban Heat Islands	86
Global Temperature Patterns	88
Focus on Isolines	90

5 ATMOSPHERIC PRESSURE AND WIND

94

The Nature of Air Pressure	95
The Nature of Wind	97
Focus on the Measurement of Pressure	98

Focus on Wind Measurement and Terminology	100	Focus on Environmental Relationships	200
Focus on the Coriolis Effect	102	Focus on Climatic Distribution in Africa: A Practically Perfect Pattern	212
People and the Environment: Wind Energy	106	The Global Pattern Idealized	225
Vertical Variations in Pressure and Wind	107	People and the Environment: Global Warming: The Greenhouse Effect	226
The General Circulation of the Atmosphere	109		
Focus on Wind Chill	109		
Modifications of the General Circulation	118		
Focus on Monsoon Regions	120		
Localized Wind Systems	122		
6 ATMOSPHERIC MOISTURE	126	9 THE HYDROSPHERE	228
Water Vapor and the Hydrologic Cycle	127	The Nature of Water: Commonplace but Unique	229
Evaporation	128	The Hydrologic Cycle	231
Measures of Humidity	130	The Oceans	234
Focus on Measuring Moisture	130	Focus on Tides	236
Focus on Heat Index	133	"Permanent" Ice	241
Condensation	134	Surface Waters	242
The Buoyancy of Air	140	Underground Water	246
Precipitation	142	People and the Environment: Groundwater Mining: An Example from the Great Plains	248
People and the Environment: Acid Rain	146		
Global Distribution of Precipitation	149		
7 TRANSIENT ATMOSPHERIC FLOWS AND DISTURBANCES	158	10 CYCLES AND PATTERNS IN THE BIOSPHERE	252
Air Masses	159	The Geographic Approach to the Study of Organisms	253
Fronts	163	Biogeochemical Cycles	254
Atmospheric Disturbances	165	Food Chains	260
Major Midlatitude Disturbances	165	Focus on Biological Taxonomy	262
Hurricanes: Major Tropical Disturbances	172	The Search for a Meaningful Classification	264
People and the Environment: Allen, A Benevolent Hurricane	176	Seeking Pertinent Patterns	264
Minor Atmospheric Disturbances	178	Ecosystems and Biomes	264
Focus on Environmental Interactions as Shown by <i>El Niño</i>	184	Environmental Relationships	268
		People and the Environment: Rainforest Removal	272
8 CLIMATIC REGIONS	188	11 TERRESTRIAL FLORA AND FAUNA	276
Climatic Classification	190	The Consideration of Natural Distributions	277
Focus on the Thornthwaite Classification	192	Terrestrial Flora	281
World Distribution of Major Climatic Types	195	Terrestrial Fauna	292
		The Major Biomes	300
		Biomes and Climate	308
		Human Modification of Natural Distribution Patterns	309

Distributional Summation: Some Patterns Examined	311
People and the Environment: Ecological Disaster: An Oil Spill in Cold Wilderness Waters	312

12 SOILS 318

Soil and Regolith	320
Soil-Forming Factors	320
Soil Components	324
Soil Properties	327
Soil Chemistry	329
Soil Profiles	330
People and the Environment: Land-Capability Classification	330
Pedogenic Regimes	333
Soil Classification	335
Focus on the Tongue-Twisting Terminology of the Soil Taxonomy System	336
Global Distribution of Major Soils	344
Distribution of Soils in the United States	351

13 INTRODUCTION TO LANDFORM STUDY 354

Our Massive Earth	355
Composition of the Crust	357
Focus on Common Rock-Forming Minerals	358
Some Critical Concepts	365
The Front Range—Episode One: The Development of Terrain: A Continued Story	366
The Study of Landforms	367
People and the Environment: Comprehending the Magnitude of Geologic Time	368
Internal and External Geomorphic Processes	370
The Question of Scale	371
Focus on an Example of Scale	372
The Pursuit of Pattern	375

14 THE INTERNAL PROCESSES 380

Massive Crustal Rearrangement	381
Diastrophism	391
Focus on Earthquakes	394

Focus on Volcanic Abruptness: The Example of Parícutín	400
Vulcanism	401
People and the Environment: The Lessons of Mount St. Helens	404
The Complexities of Crustal Configuration	412
The Front Range—Episode Two: Batholithic Intrusion and Uplift	414

15 PRELIMINARIES TO EROSION: WEATHERING AND MASS WASTING 418

Weathering	420
Focus on Jointing	422
Focus on Some Important Examples of Chemical Weathering	428
Mass Wasting	428
People and the Environment: Landslide Catastrophes	432

16 THE FLUVIAL PROCESS 440

Some Fundamental Concepts	442
Stream Channels	447
Stream Systems	451
Focus on Drainage Patterns	454
The Shaping and Reshaping of Valleys	457
Deposition in Valleys	462
People and the Environment: Human Modification of a River System: The Mississippi	464
Theories of Landform Development	466
Stream Rejuvenation	470
Fluvially Produced Topography	471
The Front Range—Episode Three: Erosion and More Erosion	472

17 TOPOGRAPHIC DEVELOPMENT IN ARID LANDS 476

Specialized Environmental Characteristics	477
People and the Environment: Desertification	480
Unique Landscape Types of the Desert	481
Running Water in Waterless Regions	483
The Work of the Wind	489
Some Characteristic Desert Landform Assemblages	494

Focus on Death Valley: A Primer of Basin-and-Range Terrain	496
Focus on Mesa Verde: An Example of Mesa-and-Scarp Terrain	500
<hr/>	
18 COASTAL PROCESSES AND TERRAIN	506
Coastal Processes and Forms	507
Focus on Waves	510
People and the Environment: Human Influences on Coastal Topography	516
Coastal Types	523
Focus on Coral and Its Creations	524
<hr/>	
19 SOLUTION PROCESSES AND KARST TOPOGRAPHY	528
The Actions Involved: Solution and Precipitation	530
People and the Environment: Sinkhole Subsidence: The Collapse of Florida	531
Caverns and Related Features	532
Karst Topography	532
Hydrothermal Features	533
<hr/>	
20 GLACIAL MODIFICATION OF TERRAIN	536
Glaciations Past and Present	538
Regimen of Glaciers	544

Continental Ice Sheets	550
Glaciation in Mountainous Areas	554
The Front Range—Episode Four: Pleistocene Glaciation	560
Are We Still in an Ice Age?	563
The Front Range—Episode Five: Resumed Fluvial Action	564
<hr/>	
Appendix I TOPOGRAPHIC MAP SYMBOLS	567
<hr/>	
Appendix II THE WEATHER-MAP STATION MODEL	570
<hr/>	
Appendix III METEOROLOGICAL TABLES	576
<hr/>	
Appendix IV THE INTERNATIONAL SYSTEM OF UNITS—SI	578
<hr/>	
GLOSSARY	581
<hr/>	
INDEX	601

Introduction to the Earth

THE ENVIRONMENTAL "SPHERES"

THE EARTH AS A PLANET

- Location in the Universe
- The Solar System
- Influence of Stars and Planets on the Earth
- Surface Gravity of the Earth
- Size and Shape of the Earth
- The Geographic Grid
- Telling Time

EARTH AND SUN RELATIONS

- Movements of the Earth
- The Annual March of the Seasons

The Earth is the ancestral, and thus far the only, home of humankind. As such it is the only planet of true interest for geographic study. See Figure 1–1. People live on the surface of the Earth in a physical environment that is extraordinarily complex, extremely diverse, infinitely renewing, and yet ultimately fragile.

This habitable environment exists over almost the entire face of the Earth, which means that its horizontal dimensions are exceedingly vast. Its vertical extent, however, is very limited; the vast majority of all earthly life inhabits a zone less than 3 miles (5 km) thick, and the total vertical extent of the life zone is less than 20 miles (32 km).

THE ENVIRONMENTAL "SPHERES"

From the standpoint of physical geography, the surface of the Earth comprises a complex interface where the four principal components of the environment meet and to some degree overlap and interact. The solid, inorganic portion of the earthly fundamant is the **lithosphere**, comprised of the rocks of the Earth's crust as well as the broken and unconsolidated particles of mineral matter that overlie the unfragmented bedrock. The vast gaseous envelope of air that surrounds the Earth is the **atmosphere**. The waters of the Earth—mostly consisting of oceans, lakes, rivers, and glaciers—compose the **hydrosphere**. All living

Much of the Northern Hemisphere is shown in this spacecraft view of our planet. The Pacific Ocean is on the left, the Mediterranean Sea is on the right, and the Greenland icecap is conspicuous near the top of the image. (Courtesy of NASA.)



Figure 1—1. Spaceship Earth, as seen from the moon, 240,000 miles (390,000 km) away. (*Apollo 11* photo, courtesy of NASA.)

things, plant and animal, collectively comprise the **biosphere**.

These four “spheres” are not discrete and separated but are considerably intermingled. This is readily apparent when considering an ocean or other large expanse of water, a body that is clearly a major component of the hydrosphere and yet may contain a vast quantity of fish and other organic life that are part of the biosphere. An even better example is soil, which is composed largely of bits of mineral matter (lithospheric components), but also contains life forms (biosphere), soil moisture (hydrosphere), and air (atmosphere) in pore spaces.

Thus lithosphere, atmosphere, hydrosphere, and biosphere are not separate subsystems within a single earthly system. They are more properly considered as interconnected components of the environment of the Earth’s surface. Moreover, they can serve as important organizing concepts for the systematic study of the Earth’s physical geography and will be used in that sense as the basic units of the framework of this book.

Before focusing our attention on these four spheres, however, we set the stage by considering the planetary characteristics of the Earth and noting the salient relationships between our planet and its basic source of energy, the sun. Our Earth is merely an infinitesimal speck in the vastness of space. Yet it is the only speck on which we are sure that life exists. Its locational relationship within the totality of the universe is still imperfectly understood, but at least we can put it into perspective.

THE EARTH AS A PLANET

We live on an extensive (to us), rotating, complicated mass of mostly solid material that orbits an enormous fireball of burning hydrogen. That fireball, our sun, is moving at great speed toward another burning fireball, the star Vega, and it is our destiny to go along with it. The sun and Vega are but two of an uncountable number of celestial bodies that are in continuous motion in the vastness of the universe, in an airless vacuum from which we are shielded by a thin envelope of atmospheric gases that adheres to the Earth by gravity. Despite the obvious hazards of our journey through space, we exist in a physical environment that is extraordinarily benign in comparison with any other known planetary environment.

Prior to considering the nature of the Earth itself, let us try to visualize our setting in space.

Location in the Universe

The geographer’s concern with spatial relationships properly begins with the location of our spaceship Earth within the universe. The Earth is one of the nine planets of our solar system. The solar system also contains at least 44 moons or satellites (of which the Earth’s moon is exceptional in that it is so large compared with its parent planet) revolving around the planets, scores of comets, thousands of asteroids, and millions of meteors (most of them tiny specks of dust). The sun is the central star of our solar system and makes up more than 90 percent of its total mass (yet many stars in other solar systems and galaxies are several thousand times larger than it). Our sun is also a star in the Milky Way galaxy—one of perhaps 100,000,000,000 stars in a disk-shaped galaxy that is some 100,000 light-years in diameter and 10,000 light-years thick at the center. The Milky Way galaxy is only one of at least 1 billion galaxies in the universe!

The vastness of the universe is clearly beyond normal comprehension. As a small sample of astronomical distances, we might consider a model at a reduced scale. If the distance between Earth and sun could be reduced from its actual figure of 93,000,000 miles (150,000,000 km) to just 1 inch (2.5 cm), the distance to the nearest star would be a mere 4.5 miles (7.25 km), the distance to the nearest galaxy would become about 150,000 miles (240,000 km), and the distance to the Andromeda galaxy would be close to 2,000,000 miles (3,200,000 km).

A schematic representation of our galaxy shows that our sun is on the Orion arm, an outer spiral arm

Focus on Distance Measurement in Space

On a historic day in 1969, a human first walked on the moon. One of the minor sidelights to that event was the communication delay between Houston Mission Control and the moon-walking astronaut. When Mission Control asked a question, almost 3 seconds elapsed before the astronaut's reply was heard. The reason for the delay was that it took 1.28 seconds for the radio message to reach the moon and a similar time for the return message. Radio waves travel at the speed of light, which is 186,282 miles (299,793 km) per second.

Similarly, the sunlight that we see departed from the sun $8\frac{1}{8}$ minutes before it reached us, and traversed more than 93 million miles (150,000,000 km) of space. Beyond our solar system, the staggering immensity of space can be visualized by considering the travel time for starlight. Light from the nearest star requires more than 4 years to reach the Earth, whereas starlight from the prominent Andromeda galaxy needs 2,200,000 years to travel to the Earth. If at some time we were able to receive a meaningful radio signal from Andromeda and replied immediately

to that message, the sender on Andromeda would have to wait nearly $4\frac{1}{2}$ million years for the response!

Distances in space are so enormous that a unit of measure larger than the familiar miles or kilometers is needed to avoid numbers so large that they would be difficult to write or to imagine. Since the speed of light is believed to be unvarying throughout the universe, the distance that light can travel in a year can be calculated to be almost 6 trillion miles (10,000,000,000,000). This unit of length, known as a *light-year*, is used to measure distances in the universe.

The distance that light travels in one year thus serves as an indication of the vast extent of the universe. The equivalent of a light-year in miles can be determined by multiplying the speed of light (officially 186,282.3976 mi/s) by the 60 seconds in a minute, then by the 60 minutes in an hour, then by the 24 hours in a day, and finally by the 365.2422 days in a year

$$\begin{array}{r} 186,282.3976 \text{ mi/s} \\ \times \quad 60 \\ \hline 11,176,943.85 \text{ mi/min} \end{array}$$

$$\begin{array}{r} \times \quad 60 \\ \hline 670,616,631.3 \text{ mi/h} \\ \times \quad 24 \\ \hline 16,094,799,150 \text{ mi/day} \\ \times \quad 365.2422 \\ \hline 5,878,499,648,919 \text{ mi/yr} \end{array}$$

So, 1 light-year is equal to almost 6 trillion miles. The distance to the Andromeda galaxy—2,200,000 light-years—is equivalent to 12,932,700,000,000,000,000 miles (12 quintillion, 932 quadrillion, 700 trillion mi). It is easy to see why the use of light-years as a unit of measurement greatly increases our ability to express and comprehend such vast distances.

For the relatively shorter distances within our own solar system, however, the light-year is too long, whereas miles or kilometers are still awkwardly tiny. For these “intermediate” measurements, we can use the average distance from the Earth to the sun, called the **astronomical unit (AU)**, which is 92,955,806 miles \pm 3 miles (149,597,892 kilometers \pm 5 km).

of this thin, disk-shaped outer edge of our galaxy. Our sun is some 30,000 light-years from the center of our galaxy, and it moves in a nearly circular path around the center at a speed of 124 to 186 miles (200 to 300 km) per second.

As we look up into the nighttime sky, we can see a few of the nearby stars that are also on Orion's arm. For example, our nearest neighbors, Proxima Centauri and Alpha Centauri, only 4.2 light-years away from the Earth, are the brightest stars in the sky of the Southern Hemisphere. But when we look back from the edge of our galaxy into the densest part of its disk, we see what appears as a long foggy pathway of stars across the sky; thus the name of our galaxy—the Milky Way.

The Solar System

Most astronomers believe that the celestial patterns in the universe began to develop some 15 to 20 billion years ago with a massive cosmic explosion, or “big bang,” after which all the material began dispersing at enormous speeds. Our solar system apparently originated when a **nebula**, a cold, diffuse molecular cloud of gas and dust perhaps 1 light-year in diameter, began to contract inward, forming a hot, dense “protosun.” This hot center—our sun—was surrounded by a cold, revolving disk that formed the planets. It is thought that the *outer* (or *Jovian*) planets—Jupiter, Saturn, Uranus, Neptune, Pluto—formed as subconcentrations in this revolving disk, whereas the *inner*