



*Fundamentals
of
Physical Geography*

Arthur H. Doerr



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of
Physical Geography*

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with cartographic assistance of

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Preface

The chess-board is the world; the pieces are the phenomena of the universe; the rules of the game are what we call the Laws of Nature.

T. H. Huxley, *A Liberal Education*

Geography, and especially physical geography, was one of the earliest of the sciences to be studied and developed. The Greeks were in the vanguard of those who formulated general principles concerning the nature of the earth and its place in the cosmos. Nature study and the naturalist emanated from early efforts to discover the secrets of the earth and the position of people on it. Because so much of the earth's surface was unknown territory, travels and voyages of discovery were essential to fill in blank spaces on the map and to add new knowledge concerning the nature of the earth. This *terra incognita* (unknown land) was gradually stripped away in early times, but the pace of discovery quickened during the Age of Exploration, and virtually every inch of the surface of the terrestrial globe has now been explored, at least in a perfunctory fashion.

As scientific inquiry developed and became more sophisticated, geography spawned other sciences like geology, meteorology, and climatology. As these individual sciences prospered, geography, notably physical geography, became impoverished in intellectual force and fashion. It was derided by some as a "synthetic science" and, in the last several years, the physical aspects of the field have yielded center stage to new techniques and approaches in the cultural realm. Physical geography is certainly a "science of synthesis" in which meaning is sought by integrating environmental parts into whole spatial patterns of complex interrelationships. The linkages and connections of various elements of the physical environment and associations with cultural landscape expressions of people give the holistic character to the discipline.

Briefly, physical geography deals with land, water, air, and life and their mutual interrelationships. The face of the land and its constant changes, the restless stirrings of the earth's waters, the invisible and varying breath of the atmosphere, and the pulse of life—all of which create and respond to a physical environment—are the stuff of physical geography. The temporal and spatial patterns, which develop from the interconnectedness of environmental elements, are of interest to and value for development and planning of human pursuits.

Physical geography is an intimate and vital subject. The flashy pyrotechnics of volcanism and the dramatic quivering of earthquakes as well as the subtle changes in the physical landscape wrought by agencies of weathering, erosion, and deposition are everyday concomitants of living. A warm spring day, a howling blizzard, or a roaring hurricane reminds us that weather and climate are ever-present features of daily life. Floods impress on us that land clearing and urbanization accelerate runoff and accentuate the effects of a downpour or seasonal precipitation, which is greater than normal. A drought makes us realize how vulnerable we are to climatological conditions that stray from the normal. Forest vastnesses or desert emptiness intrude on our consciousness. Our senses perceive the sights, sounds, smells, and feel of our physical world during every waking second. We are at once responsive to environmental conditions and responsible for a modification of the physical environment, while simultaneously creating a cultural landscape.

Fundamentals of Physical Geography provides an understandable operational framework of our physical world. With such an understanding, it is my fond and expectant hope that readers of this work will be able to make individual and collective rational decisions about living and environmental uses. The nature and nurture of our good blue-green earth require understanding and right actions.

This book provides information about the earth and the processes that continue to shape it. The illustrative materials add form, dimension, and interpretation to the face of the land.

Numerous illustrations are provided in the body of the text to clarify or reinforce verbal statements, but the perceptive reader will find that a good atlas is an appropriate companion piece. Any topic discussed in the body of the text could be expanded significantly, but this book is designed to serve the needs of students and instructors in a one-term course in physical geography. It will serve equally well for students who will have only this limited exposure to geography and for those who will undertake further geographic study.

Public agencies have produced a number of exceptionally useful illustrative materials. Among the most important are National Aeronautics and Space Administration (NASA), National Oceanic and Atmospheric Administration (NOAA), National Science Foundation (NSF), United States Department of Agriculture (USDA), and United States Geological Survey (USGS). As appropriate, these abbreviations will be used in credits for illustrative materials.

Arthur H. Doerr

As an instructional aid to those who have elected to use this text in their courses, several ancillary materials are available in conjunction with *Fundamentals of Physical Geography*. A set of 32 overhead transparencies are reproduced from selected textbook illustrations. An Instructor's Manual includes a test item file with questions from each chapter. All of the questions are available on WCB TestPak, a computerized service that enables you to create customized exams. For each exam, you can choose up to 250 questions; you can print it yourself or have WCB print it. Printing it yourself requires access to an IBM personal computer that uses 5.25- or 3.5-inch diskettes, an Apple IIe or IIc, or a Macintosh. Diskettes are available through your local WCB sales representative or by phoning Educational Services at 319-588-1451. If you don't have a computer, you can use WCB's call-in/mail-in service. First, determine the chapter and question numbers, and any specific heading you want on the exam. Then, call Pat Powers at 800-351-7671 (in Iowa, 319-589-2953) or mail information to: Pat Powers, Wm. C. Brown Publishers, 2460 Kerper Blvd., Dubuque, IA, 52001. Within two working days, WCB will send a test master, a student answer sheet, and an answer key to you via first-class mail.

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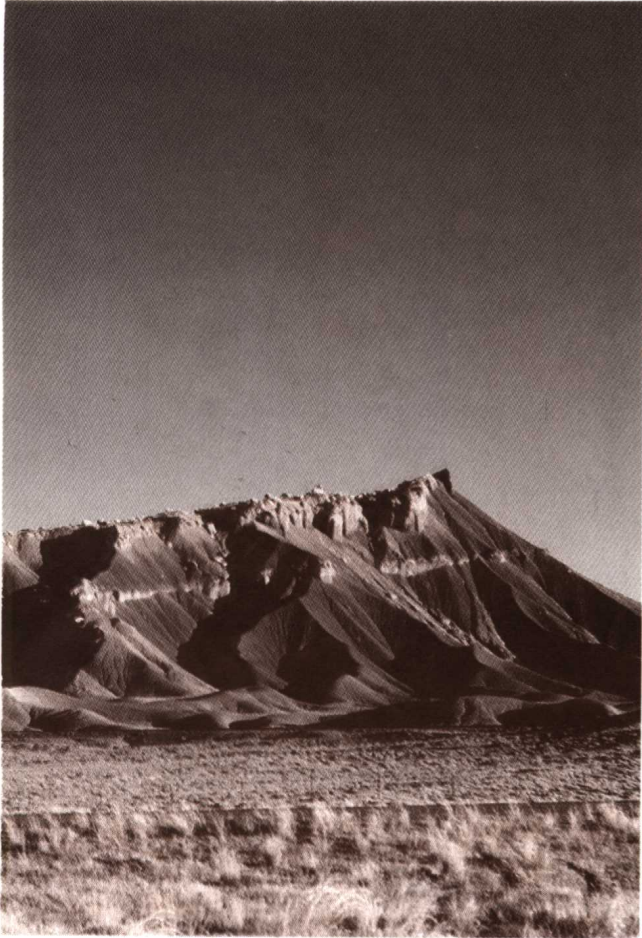
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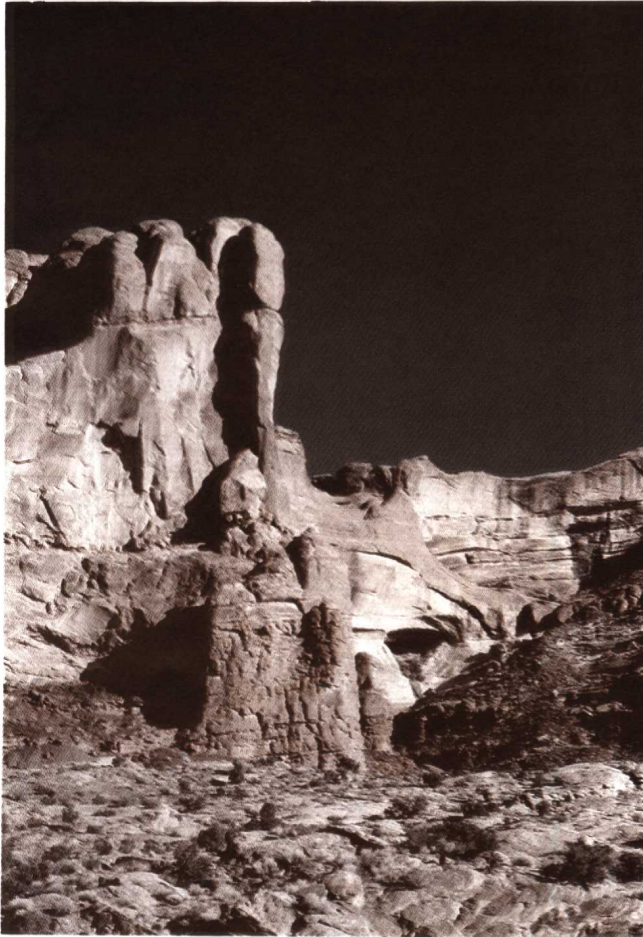
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The Nature of Geography



Rice planting on the Luzon Plain with clouds forming and mountains in background.

The etymology of the word **geography** provides the essence of the field (i.e., from the Greek, *geo*—the earth, and *graphein*—to write; hence, to write about or describe the earth). The description involves analysis and synthesis as well as the development of theories about relationships between the physical environment and the cultural realm. Constant changes initiated by natural forces as well as by people cause the field to remain dynamic and challenging. The parameters of geographic inquiry expand and contract, although the eclectic nature of the field makes it quite broad in concept and execution.

To a person uninstructed in natural history, his country or seaside stroll is a walk through a gallery filled with wonderful works of art, nine-tenths of which have their faces turned to the wall.

T. H. Huxley, *On the Educational Value of the Natural History Sciences*

Several other definitions of the field, which are, essentially, variations on a theme, provide a broader appreciation of the area of study. For example, geography may be defined as the study of the areal differentiation of the earth's surface; or, geography is the significance of differences from place to place. These definitions recognize that there are physical and cultural patterns on the surface of the earth, and, although the stress is on differences, it's clear that similarities are implied as well. The interrelationships among these different areas, in terms of their physical and biological attributes, are significant to people's occupancy of the earth, as well as their understanding and appreciation of it.

Figure 1.1

The ruins of Takht-i-Jamshid (Persepolis) illustrate that civilization is a long and persistent process. This city was begun about 500 B.C. and flourished during the height of the Persian Empire.



Other definitions include the following: geography is the study of the relationship of people to their environment. A more applicable variation might be: geography is a study of the mutual interrelationships between people and their environment. Some have said (while anthropologists wince) that geography is human ecology. These definitions all include people and the environment, and how people have adapted to or made modifications to their physical world while creating a uniquely human setting.

Spatial elements and the distributional patterns on, and immediately adjacent to, the earth's surface are central to all definitions of geography. The ultimate objective of geography and geographic inquiry is to understand, adapt to, and adjust to the world in which we live.

Geography occupies a special place among the academic disciplines since it serves as an intellectual bridge between the sciences and the social sciences. The field derives its power and persuasiveness from the synthesis of essential elements of the physical environment and elements of material culture. The holistic character of the discipline provides a unique perspective of the world as the home of people. This is a book about physical geography and is, therefore, scientifically oriented, but it is important to have some appreciation for those aspects of the field that lie outside the scope of this text; hence, a brief description of the social aspects of the field is in order.

Geography as a Social Science

Geographers consider elements of material culture as well as the physical environment. People's activities are not controlled by the physical environment, but natural forces and phenomena significantly affect economic and cultural developments. As people have become sophisticated users of numerous technological devices, the species has increasingly sought to modify the environment as well as to adapt to it. The more than 5 billion people now occupying the earth are constantly modifying its physical and cultural fabric.

In certain regions, a seemingly benign environment may foster people's economic and cultural pursuits, whereas in other regions, a hostile physical environment may deter human activities. Environmental shortcomings or attributes may be real or perceived, and perceptions may change over time or vary from group to group. One culture's problem is another culture's opportunity, and a problem at one time may become an opportunity at another. Environmental perceptions are powerful, and have a significant effect on the way a particular group of people relate to their physical world.

For example, before air travel became commonplace, mountainous terrain, deserts, oceans, and jungles were significant barriers to human penetration. Before irrigation and winter recreation, snowfall in the mountains was a nuisance, now it may be a recreational boon in the mountains and meltwater may foster agriculture in adjacent areas. Remote places have yielded their secrets and their treasures more readily as modern transportation and communication have made them accessible. For example, regions in high latitudes remained little understood, and detailed knowledge awaited twentieth century exploration. Now, permanent scientific stations exist at the South Pole where explorers died less than seventy-five years ago in a quest to reach the pole. The North Pole has yielded to repeated over- and under-the-ice sorties, and aircraft regularly criss-cross polar skies flying short great-circle routes in an area that was an inaccessible goal a century ago. Amateurs may be quickly transported into polar remoteness in this decade where experienced explorers feared to tread less than a century ago.

In using more effective tools and technologies, people have produced a dazzling array of cultural attributes (e.g., cultivated land, transportation facilities, manufacturing facilities, urban environments, and vast networks for sharing information). In addition, however, people have altered the physical environment in ways hardly dreamed about just a century ago. For example, human exploitation has destroyed literally thousands of species of animal life; vast areas have been devegetated, falling to the plow

Figure 1.2
These Qashqai nomads depend on their herds for survival.



Figure 1.3
The urban population of Manila requires a reliable water supply.



Figure 1.4
Transportation is an essential ingredient in modern civilization.
Association of American Railroads.



or the saw; soil erosion has been accelerated; air and water pollution have become commonplace; and environmental degradation has extended to even the most remote corners of the globe.

As the population soars, and as requirements for food, fuel, and amenities increase, people expand the cultural landscape while modifying the physical environment. The processes of nature have been altered and accelerated by the activities of people. More often than not, this human interference has degraded the pre-existing environment, although it could be argued that certain practices, like fertilization, have improved the pedological (soil) environment, at least in some places and from the perspective of the agriculturalist.

Several examples of geography as a social science include: economic geography, urban geography, human geography, and transportation geography. **Economic geography** examines how people earn a living, including the areal distribution and linkages of the several elements of production, distribution, and consumption of goods and services. Primary, secondary, tertiary, and quaternary activities are considered as part of an increasingly sophisticated and interconnected aspect of human occupancy of

a region. **Urban geography** examines the patterns of urban agglomerations, including the distribution of different facilities, such as those associated with housing, manufacturing, warehousing, and commerce. **Human geography** considers the human response to environmental conditions, and finds expression in the modes of earning a living and in the facilities constructed to provide shelter and amenities. **Transportation geography** is a study of linkages, flows, and patterns in the movement of people, goods, or ideas (figure 1.4).

Figure 1.5

Primitive agricultural techniques like those employed by these rice winnowers in the Philippines are still used by many people in the developing countries.



Basically, the social science aspects of geography include an assessment of the patterning of human responses to environment. The scientific aspects of geography, on the other hand, assess the environment in terms of patterns and relationships based on analysis of data according to principles of universality. The development of theories from either deductive or inductive processes is characteristic of all aspects of the discipline. In fairness, it should be pointed out that the unpredictability of human response to environment makes theory development and testing more difficult than in the physical portions of the discipline. Further, long-term temporal factors may resist testing within a reasonable time frame. Nevertheless, an active group of economic and cultural geographers are at work to develop principles of universality in those aspects of the field.

Geography as a Science

The scientific aspects of geography include a study of the physical components of the environment at or near the earth's surface as well as a synthesis of the various interrelationships that exist. The planetary relationships that permit life; the ebb and flow of seasons; the inexorable march of time; the elevation, slope, and relief of the land; the amount and rate of erosion and deposition; crustal disturbances resulting in mountain building and land formation or destruction; the quantity and distribution of precipitation; the march of temperature from place to place and season to season; and the ecological succession and patterns of animal and plant life distribution are all parts of the scientific considerations of geography. These and other elements of the environment are inextricably linked together in producing a physical world, which is the home of man and of the millions of species of plants and animals

Figure 1.6

Modern industrial states use an array of manufacturing and facilitative activities to provide goods and services to their citizens.



Figure 1.7

Mt. Mayon in the Philippines is an active volcano.



that share this planet with us. Although the linkages and connections are almost infinitely complex, scientific investigations are slowly unraveling the associations while developing theories to serve as platforms for prediction.

Several elements of the physical environment are appropriate fields of study and inquiry in their own right, but a number of them are essential to the scientific study of the environment. **Geomorphology** is the study of landforms, including their orogeny, evolutionary development, and patterns of distribution. **Pedology** is the study of soil development, characteristics, and distribution (figure 1.8). **Hydrology** considers the origins, patterns, and distribution of water at or near the earth's surface (figures 1.9 and 1.10). **Meteorology** is the study of weather, including prediction (figure 1.11). **Climatology** is an analysis of climatic characteristics, a study of the distribution of climatic

Figure 1.8

The development of soil from weathered rock materials has made the earth's vegetative mantle possible.



Figure 1.9

The waters of the sea occupy most of the earth's surface.



Figure 1.10

The waters of the land support life while they etch and sculpt the surface.



Figure 1.11

The cirrus clouds in this photograph are a fair weather aftermath of the recent snowfall.



patterns, and projections of long-term trends or tendencies. **Biogeography** is a study of the ecological developments and biological distributions that exist at or near the earth's surface (figure 1.12). Further, since the areal phenomena on the earth's surface are central to an appreciation for an understanding of the physical environment, a study of **cartography** (the art and science of map making) must be considered.

Actually, these represent only some of the elements of that intricate network of physical factors that make up the physical environment (figure 1.13). The complicated interconnected aspects of the natural environment are fragile and subject to unraveling when one aspect goes awry or when man's activities upset a delicate balance. It is especially important to understand existing interrelationships to avoid or minimize catastrophic disruptions. Indeed, those who read this book are enjoined to learn to appreciate our earth and to do their part to ensure the continued habitability of the planet.

Essentially, the examples of geographic inquiry that have been described represent topical or systematic aspects of the discipline. These investigations are designed to permit the development of generalizations and principles. Geographers also undertake regional studies that provide an integrative analysis of the facets of a specific area, which give it a particular character.

This book involves primarily topical investigations, although elements of regional inquiry are also included. Elements of analysis and synthesis are introduced to provide an appreciation for patterns that are a part of the earth's mosaic. The spatial character of these patterns is particularly important, and a sense of place is integral to a description and understanding of the earth.

Figure 1.12

These Rocky Mountain sheep resting on a high alpine meadow adjacent to a woodland are a part of the earth's biological fabric.

© Peter Kresan.

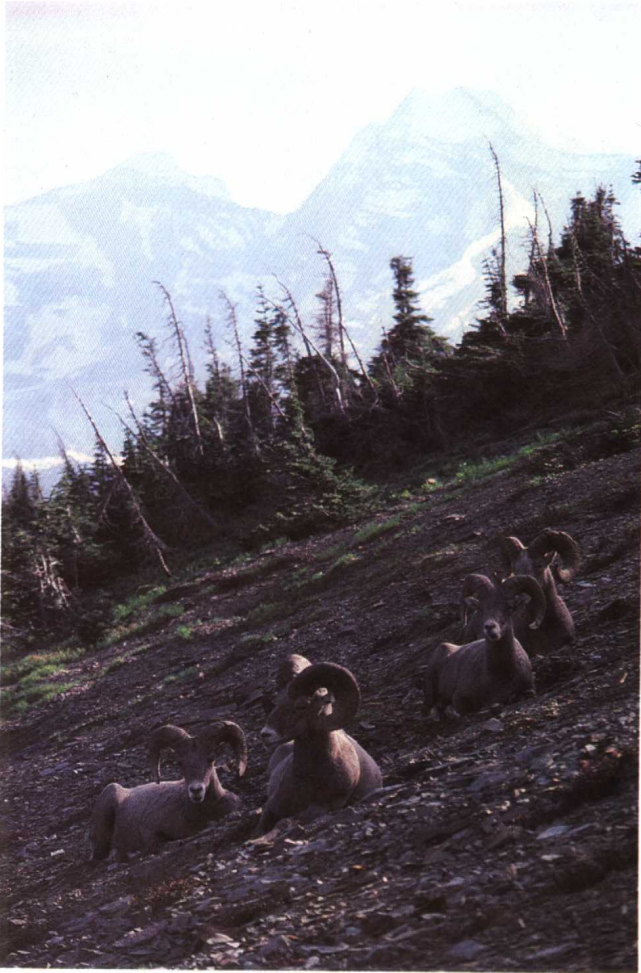
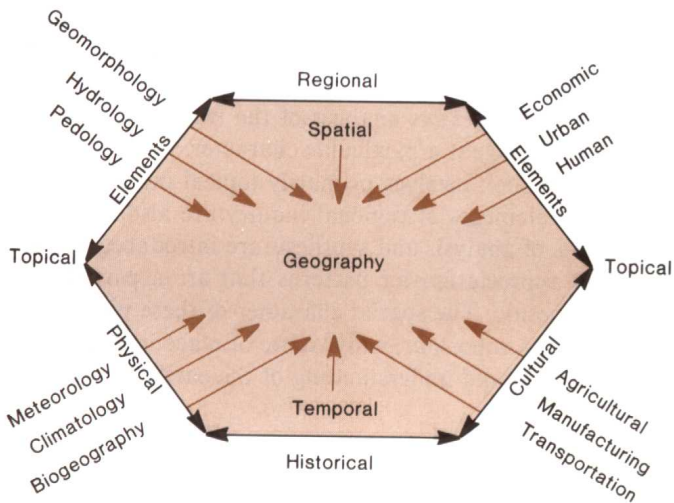


Figure 1.13

The various elements of geography are closely related.



Nature of Geographic Inquiry

As various elements of the physical environment are examined, the basic principle of uniformitarianism is employed. Essentially, **uniformitarianism** asserts that all physical processes are operating in the same way and at the same rate as they always have. A Scotch geologist, James Hutton, proposed the theory in the face of a great deal of skepticism, especially by Christian clergymen who objected to the enormous time scale attaching to the evolution of earth and life forms. The continuing controversy between creationists and evolutionists is, essentially, a derivative from these notions of progressive change. Actually, uniformitarianism does not reject the notion of a divine plan. Process and change are certainly not antithetical to religious precepts and concepts. In a sense, uniformitarianism is a basic concept (with the exception that modern people may have the capacity to accelerate or upset several physical processes) that forms the basis for rational analysis of environmental patterns and interrelationships.

It should also be recognized that uniformitarianism applies only to the last several million years of geologic history, since significant changes have occurred over the eons in the lithosphere, hydrosphere, atmosphere, and biosphere of the earth. For example, an earth without free oxygen weathered at a vastly different rate than one with the present atmospheric composition. The pre-oceanic world was vastly different from what we now know. An earth with significantly different biological assemblages weathered, eroded, and changed in different ways than have been experienced in the last several million years. It's clear that modern people, especially, because of numbers and technology may accelerate or slow natural processes in certain circumstances. Even primitive people caused environmental change, especially in the use of fire to remove vegetation. Nevertheless, uniformitarianism is the essential concept that undergirds modern physical landscape analysis. It seems clear that the theory is basically true for our world. It seems equally clear that a new corollary will have to be added to the concept as human activities affect the earth's landscape in broader and more pervasive ways.

Environmental Determinism Over time, geographers have flirted with the concept of **environmental determinism**, which suggested that human response was determined by the physical environment. It became obvious that this concept was too limiting. Different cultural groups living in the same or analogous settings developed quite different responses to environments. The same groups also adjusted to the same environment in different ways at different times.