INSTRUCTOR'S MANUAL FOR

PUTNAM'S GEOLOGY

FIFTH EDITION

Peter W. Birkeland Edwin E. Larson

Prepared by William D. Nesse
and Kenneth D. Hopkins

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WILLIAM D. NESSE
KENNETH D. HOPKINS
University of Northern Colorado

Includes test questions that can be photocopied

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PREFACE

This manual has been prepared to accompany the Fifth Edition of *Putnams's Geology*. It is intended to assist instructors in using the text and in presenting an interesting and effective geology course. Much of the manual is directed toward the instructor who is presenting his or her first introductory course, but the manual should be useful to any instructor. The comments and suggestions presented here inevitably reflect the author's teaching experiences and styles. Other instructors will approach the teaching of geology from a different perspective and will undoubtedly wish to follow a different direction in some areas. It is not our goal to foster our own particular teaching philosophy, but rather to promote the thoughtful consideration of how to present the subject of geology most effectively. The enlightenment and education of our students is the ultimate goal, and any approach that achieves that end should be pursued.

The contents of the manual have benefited substantially from discussions with Ed Larson, Pete Birkeland, our colleagues at the University of Northern Colorado, and above all, our students. Any errors or omissions, however, are solely our responsibility.

Greeley, Colorado
November, 1988

W.D.N.
K.D.H.

CONTENTS

INSTRUCTOR'S MANUAL

PUTNAM'S GEOLOGY

INTRODUCTION

Putnam's Geology, which is intended to be used in an introductory physical geology course, is now in its fifth edition. Pete Birkeland and Ed Larson have retained the lucid, interesting, and easy reading style and high standard for illustrations that marked Bill Putnam's original text. With this edition, the text has been significantly reorganized. It now consists of four major parts. The first contains three chapters dealing with the earth's place in the cosmos, the nature of geology and geologic time, and an introduction to rocks and minerals. The second contains six chapters dealing with internal processes of the earth. The third part contains nine chapters dealing with the surface of the earth and the processes which operate there. The last section contains one chapter dealing with geologic resources. In addition, there is a table of metric conversions. Because instructors may wish to follow an organization different from that followed by the text, the chapters have been written to be as self-contained as possible.

Each chapter includes a summary of the important points made in the text, a list of questions for discussion or student study, and a list of publications to which the student or instructor may wish to refer for additional information. The metric system is used throughout, but because many students in the United States are not conversent with metric units, English equivalents are given in parentheses. Newly introduced terms are printed in bold type to make them stand out and a glossary is provided at the end of the text.

THE INSTRUCTOR'S MANUAL

This manual is written to assist instructors in using the Fifth Edition of *Putnam's Geology* . Much of the material is directed toward persons teaching an introductory course in geology for the first time. However, there should be something of value for even a seasoned instructor. The contents of this manual reflect the authors' experience and teaching styles but the authors recognize that there are many effective ways of teaching. Each instructor will have to develop an approach that works for himself or herself. If this manual stimulates the effective teaching of geology, then it will have served its purpose.

Each chapter of the text is presented individually; included are a summary of the topics covered, a list of instructional objectives, and a discussion of some of the difficulties that may be encountered and the topics that often give students trouble. Suggestions for lecture demonstrations, films, and additional references for background reading not otherwise listed in the text are provided, as are about two dozen questions that can be duplicated either as reviews or tests.

COURSE OUTLINES

Course outlines for a one-quarter and a one-semester introductory geology course are given below. The sequence of topics largely follows the organization of the text. This sequence develops the subject of geology in a logical order, but is by no means the only logical development. Some instructors, for example, may wish to present sedimentary rocks (Chapter 17) along with igneous and metamorphic rocks (Chapters 7, 8, and 9). Because the chapters are self-contained, an instructor should find it possible to present the material in a wide range of orders. Publications 4, 5, 6, 8, and 12 of the American Geological Institute (5205 Leesburg Pike, Falls Church, VA 22041) can provide helpful information on the organization of a course, and the *Journal of Geological Education* (published by the National Association of Geology Teachers Inc., 1041 New Hampshire St., Lawrence, KS 66044) is a good source of material.

Because time in a one-quarter or one-semester course is limited, and the subject of geology is broad, it is almost impossible to cover each topic in as much detail as might be desired (particularly topics close to the instructor's heart). Considerable thought should be given to deciding what to include and what not to include in the lectures based on the nature of the course, the needs and interests of the students, the local geology, and the strengths and weak-

SUGGESTED LECTURE SCHEDULE: 30 LECTURES

TOPIC	CHAPTER	TOPIC	CHAPTER
1. The earth and its place in the cosmos	1	13. Igneous rocks	7
2. The nature of geology	2	14. Volcanism	8
3. Matter and minerals	3	15. Metamorphic rocks	9
4. Minerals and rocks	3	16. Weathering and soils	10
5. Geologic time	2	17. Weathering and soils	10
6. Geologic time	2	18. Mass movements	11
7. Plate tectonics	4	19. River systems	12
8. Internal processes: earthquakes	5	20. River systems	12
9. Internal processes: earthquakes	5	21. Desert features	13
10. Internal processes: deformation	6	22. Glaciation	14
11. Internal processes: mountains	6	23. Glaciation	14
12. Igneous rocks	7	24. Shoreline features	15
		25. Ocean basins	16
		26. Sedimentary rocks	17
		27. Sedimentary rocks	17
		28. Groundwater	18
		29. Resources and energy	19
		30. Resources and energy	19

nesses of the instructor. It takes careful planning to stick to a schedule and not consistently run behind. Yet, flexibility is often required, as it is desirable to integrate into the course such current events as volcanic eruptions, earthquakes, and landslides that students hear about in the news. Also, it may be appropriate to spend additional time on a topic in which a class develops a particular interest.

AUDIO-VISUAL MATERIALS

Slides (35 mm) are a staple of most lectures because they are versatile, convenient, and low in cost. Students can take notes from a discussion of what is shown on a slide if the room is not completely darkened, but it is usually best to use slides to illustrate material already discussed in lecture. The student's attention is probably best directed to the screen and not to his or her notebook. A number of firms that sell 35 mm slides are listed below. Perhaps the best general-purpose collection is that of John Shelton. Despite the availability of commercial slides, most instructors will want to develop their own collections, particularly related to the local geology. Computer-based systems are also available to prepare slides and other audiovisual materials.

Sources for 35 mm Slides and Related Materials

American Association of Petroleum Geologists, P.O. Box 979, Tulsa, OK 74101
Crystal Productions, P.O. Box 12317, Aspen, CO 81612

SUGGESTED LECTURE SCHEDULE: 45 LECTURES

	TOPIC	CHAPTER
1.	Introduction	1
2.	The planetary system	1
3.	The nature of geology	2
4.	Matter and minerals	3
5.	Minerals	3
6.	Rocks, introduction	3
7.	Geologic time	2
8.	Geologic time	2
9.	Plate tectonics	4
10.	Plate tectonics	4
11.	Internal processes: earthquakes	5
12.	Internal processes: earthquakes	5
13.	Deformation	6
14.	Deformation	6
15.	Mountain building	6
16.	Igneous rocks	7
17.	Igneous rocks	7
18.	Volcanism	8
19.	Volcanism	8
20.	Metamorphic rocks	9
21.	Metamorphic rocks	9
22.	Weathering	10
23.	Soils	10
24.	Mass movements	11
25.	Mass movements and related hazards	11
26.	River systems	12
27.	River systems	12
28.	Landform evolution	12
29.	Desert landforms	13
30.	Desert landforms	13
31.	Glaciation	14
32.	Glaciation	14
33.	Glaciation	14
34.	Shoreline features	15
35.	Shoreline features	15
36.	Ocean basins	16
37.	Ocean basins	16
38.	Sedimentary rocks	17
39.	Sedimentary rocks	17
40.	Sedimentary rocks	17
41.	Groundwater	18
42.	Groundwater	18
43.	Natural resources introduction	19
44.	Mineral resources	19
45.	Energy resources	19

Educational Images Ltd., P.O. Box 3456, West Side, Elmira, NY 14905
Educational Materials and Equipment Co., Old Mill Plain Road, Danbury, CT 06811
Geological Education Aids, 17 Leisure Drive, Kirksville, MO 63501
Geo-Tech Imagery, P.O. Box 3216, San Clemente, CA 92672
GeoPhoto Publishing Co., P.O. Box 1960, Orem, UT 84057
Geoscience Resources, 2990 Anthony Road, Burlington, NC 27215
Gould Media Inc., 44 Parkway West, Mount Vernon, NY 10552
Hubbard Scientific, P.O. Box 104, Northbrook, IL 60065
JLM Visuals, 920 7th Avenue, Grafton, WI 53024

McGraw-Hill Book Company, 330 West 42nd Street, New York, NY 10036. *Slides for Geology* by David Rahm

Michael Jay Publications, P.O. Box 1565, Loomis, CA 95650

Michael and Rosario Douglas, P.O. Box 13753, Boulder, CO 80308

MMI Corporation, 2950 Wyman Parkway, P.O. Box 19907, Baltimore, MD 21211

National Geophysical Data Center, NOAA, Code E/GC4, 325 Broadway, Boulder, CO 80303

James L. Ruhle and Associates, P.O. Box 4301, Fullerton, CA 92634

Soil Science Society of America, 677 South Segoe Road, Madison, WI 53711

Technology Application Center, University of New Mexico, Albuquerque, NM 87131

W.H. Freeman, 660 Market Street, San Francisco, CA 94104. *Earth Science Slides* by John S. Shelton, and *Physical Geology* by Warren Hamilton

Wards Natural Science Establishment, P.O. Box 1712, Rochester, NY 14603, or P.O. Box 1749, Monterey, CA 93940

Films and video tapes can be used to good advantage in many lectures. Suggestions for some which may be of use are included in the discussion of each chapter. A number of film distributors are listed below. Additional information can be found in *Selected Films in Geology* by George T. Ladd and P.B. Snyder and available for a small sum from the American Geological Institute, 5205 Leesburg Pike, Falls Church, VA 22041. The American Association of Petroleum Geologists, P.O. Box 979, Tulsa, OK 74101, also publishes an index of films related to geology. Film reviews are also published in the *Journal of Geological Education* and in *Geotimes*.

Films are particularly valuable because they utilize such techniques as animation and time-lapse photography to show material that is otherwise difficult to present, and they have an impact that is impossible to achieve with a conventional lecture. However, students generally cannot take effective notes from films, and much of the information is not retained except in very general terms. In most cases, films should not be considered a replacement for lectures, rather they are a supplement to them.

Videotapes on a variety of subjects are now available, and it is possible to record television programs on relatively inexpensive equipment. Many of the Public Broadcasting System presentations such as NOVA are particularly recommended. However, TV programs generally are copyrighted, so permission, and often payment, is required before they may be used. Most schools have an audio-visual department that can assist in obtaining the necessary permission for program use. Videotapes have the disadvantage that most television sets have small images compared to films. Unless large-screen projection equipment is available, videotapes should be restricted to small classes.

Films and videotapes may be purchased from the suppliers listed here. Additionally many films may be obtained from regional film libraries or cooperative exchange programs among groups of schools.

Transparencies used with an overhead projector are available from some of the suppliers listed here. In addition, many copying machines can make transparencies from line drawings and they can be prepared with felt-tip markers or grease pencils.

Sources for Films

AIMS Media, Inc., 626 Justin Avenue, Glendale, CA 91201
Ambrose Video Publishing, Inc., 381 Park Avenue South, Suite 1601, New York, NY 10016
Australian Information Service, Australian Consulate-General, 636 Fifth Avenue, New York, NY 10111
Barr Films, P.O. Box 7878 Irwindale, CA 91706
Britannica, 425 North Michigan Avenue, Chicago, IL 60611
British Broadcasting Co.—Television, 630 Fifth Avenue, New York, NY 10020
Bureau of Audio Visual Instruction, University of Wisconsin–Extension, P.O. Box 2093, Madison, WI 53701
Bureau of Mines Audiovisual Library, Cochrans Mill Road, P.O. Box 18070, Pittsburgh, PA 15236
Circle Oaks Productions, 73 Girdle Drive, Katonah, NY 10536
Coronet Feature Video, Simon & Schuster School Goup, 108 Wilmot Road, Deerfield, IL 60015
Earth Science Films, Canada, 2846 Athol Street, Regina, Saskatchewan, Canada S4S 1Y2
Film Australia, Australian Information Service, Australian Consulate-General, 636 Fifth Avenue, New York, NY 10111
Films Incorporated, 5547 N. Ravenswood Avenue, Chicago, IL 60640
Films for the Humanities and Sciences, P.O. Box 2053, Princeton, NJ 08543
Geoscience Information Services, P.O. Box 3326, Reston, VA 22090
Hubbard, P.O. Box 104, Northbrook, IL 60065
INCO United States, Inc., One New York Plaza, New York, NY 10004
Indiana University Audio-Visual Center, Bloomington, IN 47405
Instructional Video, P.O. Box 21, Maumee, OH 43537
Iowa State University, Media Resources Center, Film/Video Library, 121 Pearson Hall, Ames, IA 50011
Journal Films, 930 Pitner Avenue, Evanston, IL 60202
Karol Media, 625 From Road, Paramus, NJ 07652
Los Alamos National Laboratory, Motion Picture/Video Production, Mail Stop D415, Los Alamos, NM 87545
Mar/Chuck Film Industries, P.O. Box 61, Mt. Prospect, IL 60056
The Media Guild, 11722 Sorrento Valley Road, Suite E, San Diego, CA 92121
MMI Corporation, P.O. Box 19907, Baltimore, MD 21211
Modern Talking Picture Service, 5000 Park Street North, St. Petersburg, FL 33709 (Distribution source for selected films of the U. S. Geological Survey)
Moonlight Productions, 2243 Old Middlefield Way, Mountain View, CA 94943
National Archives & Records Administration, National Audiovisual Center, 8700 Edgeworth Drive, Capitol Heights, MD 20743
National Audiovisual Center, 8700 Edgeworth Drive, Capitol Heights, MD 20743
National Aeronautics & Space Administration, Film/Video Distribution Library, 1020 Bay Area Boulevard, Suite 102, Houston, TX 77058.

National Film Board of Canada, 16th Floor, 1251 Avenue of the Americas, New York, NY 10020
National Geographic Society, 17th and M Streets N.W., Washington, D.C. 20036
National Water Well Association, P.O. Box 16737, Columbus, OH 43216
Ohio State University, Film/Video Distribution Center, Department of Photography & Cinema, 156 West 19th Avenue, Columbus, OH 43210
Open University Educational Enterprises Ltd., 12 Cofferidge Close, Stony Stratford, Milton Keynes, England
PBS Video, 1320 Braddock Place, Alexandria, VA 22314
Pennsylvania State University, Audio Visual Services, Special Services Building, University Park, PA 16802
Purdue University, Audio Visual Center, Stewart Center, West Lafayette, IN 47907
Pyramid Film and Video, P.O. Box 1048, Santa Monica, CA 90406
Time-Life Films/Video, 100 Eisenhower Drive, P.O. Box 644, Paramus, NJ 07652
Tropical Visions, P.O. Box 1423, Keaau, HI 69749
University of California, Extension Media Center, 2176 Shattuck Avenue, Berkeley, CA 94704
University of Texas at Austin, Film Library, P.O. Box W, Austin, TX 78718
University of Washington Press, P.O. Box C-50096, Seattle, WA 98145
University Media, 11526 Sorrento Valley Road, Suite J, San Diego, CA 92121
The Volcano Show, Hellusundi 6A, Reykjavik, Iceland
U.S. Geological Survey, Visual Information Services, 790 National Center, Reston, VA 22092

Several firms have recently developed interactive laserdisc systems which contain both still images and movie segments which can be displayed on a video monitor. Two sources for this new technology are:

Optical Data Corporation, 66 Hanover Road, Florham Park, NJ 07932
MMI Corporation, P.O. Box 19907 Baltimore, MD 21211

TESTS

Tests are an integral part of most college courses because of the necessity of assigning grades. They also provide an additional incentive for students to learn the material. It may be desirable to give short quizzes at the beginning of each lab period or in selected lecture periods. This helps to ensure that students keep up with their reading. Computer equipment can be adapted to provide review quizzes for students. Test questions related to each chapter are grouped at the end of this manual. They range from quite easy to rather involved. If time is available for grading them, it is strongly recommended that some essay questions be included in every test. Often it is painfully obvious how much or how little the students know when they are required to explain their answers. Essay questions also give students an additional opportunity to practice the art of writing.

FIELD TRIPS

Field trips are an essential part of any introductory geology course for they can make what seems to be dry, irrelevant lecture or lab material come alive. However, the time spent in the field must be thoughtfully organized to provide the maximum benefit to the students. For example, it is probably more valuable (and cheaper) to spend an afternoon examining erosion and sedimentation processes in a nearby stream and to examine closely a few clear exposures of sedimentary rocks than to drive all over the countryside attempting to see the complete stratigraphic section of the area. Students need to see how the principles described in lecture, lab, and the text apply in the field and to gain experience in interpreting geology. It is often useful to ask the students to write descriptions of what they see (as opposed to slavishly recording what the instructor says) to provide the basis of discussion. All too often students will numbly wait for the instructor to tell them what they are looking at rather than try to find out for themselves. An effective ploy that can make field trips more valuable is to pose a problem for which the students can find a solution by carefully examining outcrops, geomorphic features, and so forth. The key is to make the students active participants rather than passive spectators. Our long-run objective should be to help the students learn to observe and interpret what they see.

A practical matter to consider in any field trip is to assure that the amount of time spent in travel between outcrops and to and from campus is reasonable in relation to the amount of time actually spent doing geology. As a rule, the amount of travel time should be no more than the amount of field time.

LABORATORY

A weekly laboratory period usually is included as part of an introductory geology course for the study of minerals, rocks, topographic and geologic maps, and other topics. The labs should be integrated with related lectures if possible. Selected laboratory manuals are listed below.

It is often advantageous to develop rock and minerals collections for student use from material collected at local outcrops. Local rockhound groups often can be a good source for materials or locations. Local material costs less, replacement samples are easily obtained, and the lab material can be more effectively keyed to field trips. Samples which are not locally available can be obtained from the firms listed below. Additional suppliers can be found in the advertising in *Geotimes*.

Maps, aerial photographs, satellite images, and a variety of other materials useful in lecture and laboratory can be obtained from the organizations listed below.

Laboratory Manuals

Bates, R.L., 1986, Laboratory Manual in Physical Geology, Merrill Publishing, Columbus, OH, 177 p. Developed under the auspices of the American Geological Institute and the National Association of Geology Teachers.

Hamblin, W.K., and Howard, J.D., 1980, Exercises in physical geology, Burgess Publishing Co., Minneapolis, MN.
Dallmeyer, R.D., 1987, Physical geology, laboratory text and manual (3rd edition), Kendall/Hunt Publishing Co., Dubuque, Iowa, 384 p.
Zumberg, J.H., and Rutford, R.H., 1988, Laboratory Manual for Physical Geology, 7th edition, W.C. Brown, Dubuque, IA, 189p.

MAPS AND RELATED SUPPLIES

Carolina Biologic Supply, 2700 York Road, Burlington, NC 27215
Crystal Productions, P.O. Box 12317, Aspen, CO 80612
Geological Map Service, Telberg Book Corp., Sag Harbor, NY 11963
Geoscience Resources, 2990 Anthony Road, Burlington, NC 27215
Hubbard, P.O. Box 104, Northbrook, IL 60065
Wards Natural Science Establishment, P.O. Box 1712, Rochester, NY 14603
Williams & Heintz Map Corporation, 8119 Central Avenue, Capitol Heights, MD 20743

U. S. Geological Survey

Maps: U.S. Geological Survey, Map Distribution, Federal Center, Box 25286, Denver, CO 80225
Books: U.S. Geological Survey, Books & Open File Reports, Federal Center, Box 25425, Denver CO 80225
Periodicals: Superintendent of Documents, Government Printing Office, Washington, D.C. 20402

State Geological Surveys

Alabama: Geological Survey of Alabama, P.O. Box 0, 420 Hackberry Lane, Tuscaloosa, AL 35486-9780
Alaska: Alaska Department of Natural Resources, Division of Geological and Geophysical Surveys, 3601 C St. (8th Fl.), Pouch 7-028, Anchorage, AK 99510
Arizona: Arizona Geological Survey, 845 N. Park Ave., Tucson, AZ 85719
Arkansas: Arkansas Geological Commission, 3815 West Roosevelt Road, Little Rock, AR 72204
California: California Division of Mines and Geology, 1516 Ninth Street, Fourth Floor, Sacramento, CA 95814-5504
Colorado: Colorado Geological Survey, Department of Natural Resources, 1313 Sherman Street, Room 715, Denver, CO 80203