BRITANNICA GLOBAL GEOGRAPHY SYSTEM

Overview

BGGS Overview

BGGS is the *Britannica Global Geography System,* a modular electronic learning system which combines the latest pedagogical approach to geography learning with interactive multi-media materials enabling students and teachers to immerse themselves in exciting geographic investigations. BGGS is made up of the following components:

- *Geographic Inquiry into Global Issues* (GIGI) Student DataBooks
- Teacher's Guides with Overhead Transparencies in a three-ring binder
- Laminated Mini-Atlases to accompany each module
- BGGS CD-ROM with User's Manual
- 3 BGGS Videodiscs with Barcode Guides
- 3 thematic posters

This section of your Teacher's Guide will examine each component and demonstrate how the components work together to facilitate some very exciting geography learning for you and your students!

I. GIGI

Geographic Inquiry into Global Issues (GIGI) is the foundation of the BGGS. GIGI is a series of modules developed at the Center for Geographic Education at the University of Colorado at Boulder. The modules are independent of one another and can be presented in any order. They use an inquiry approach and are organized around ten world regions:

South Asia
Southeast Asia
Japan
Former Soviet Union
East Asia
Australia/New Zealand/Pacific
North Africa/Southwest Asia
Africa-South of the Sahara
Latin America
Europe

Each GIGI module is centered around a particular question, such as "Why are people in the world hungry?" and "Is freedom of movement a basic human right?" The lead question is explored in one region of the world, then, in most modules, in a second region, before being investigated in North America.

The modules can be used in geography classes, or selected modules can be used in other courses, such as Earth Science, Global Studies, or Economics. Twelve modules constitute ample material for a full year's geography course. Each module is accompanied by sets of laminated mini-atlases which students can write on with dry-erase markers (provided by the teacher), then wipe clean to be re-used by the next class. This activity works well with cooperative groups of students.

Each module comprises a Teacher's Guide in a three-ring binder which includes Handouts and Activity masters for duplication and Overhead Transparencies; twenty-five Student DataBooks (additional Student DataBooks available) and the Mini-Atlases all packaged in a sturdy box suitable for storage when the class moves on to the next module. Since the Student DataBooks are soft-covered three-hole punched, non-consumable books, we recommend that each student have a binder to protect them. BGGS binders are available from Britannica, or you might ask each student to obtain one at the beginning of the course to keep the books in good condition for the next group of students that will use them. As the class completes a module, you can collect the Student DataBooks, place them in their storage box, and distribute the next module's DataBook to be placed in the student's binder.

GIGI print materials are organized in a unique fashion. The Teacher's Guide explains procedures to use in presenting the material found in the GIGI Student DataBook. Miniature layouts of student pages show the teacher how many pages of student material correspond with a given Teacher's Guide page. The Teacher's Guide includes Activities and Handouts to be copied and passed out to the class and Overhead Transparencies to enhance each lesson. All of a module's Activities, Handouts, and Overheads are located behind the third tab divider in each Teacher's Guide.

The teacher needs to become familiar in advance with both Teacher and Student material in order to effectively engage the class in meaningful geographic inquiries. There is a comprehensive "Memo to the Teacher from the GIGI Staff" in each Teacher's Guide which explains in detail the goals and principles behind the inquiry approach to geography learning.

The electronic components of the ***Britannica Global Geography System*** further empower students and teachers alike to engage in meaningful investigations. They are explained in detail in the following section.

II. BGGS CD-ROM

The **BGGS CD-ROM** is a resource manager and reference tool designed to help both teachers and students get maximum impact from the ***Britannica Global Geography System.*** This CD-ROM contains the text of the GIGI Student DataBooks in both Spanish and English, as well as Britannica's innovative geography reference program Geopedia™ all on a single disk. Here are some of the ways you and your class can use this software:

- When preparing to teach a module, you can access the GIGI Student DataBook on the CD to find which other elements of the BGGS are keyed to that lesson. For example, if you are teaching Lesson 3 in the Population and Resources module (What is overpopulation and how is it distributed?), accessing that lesson on the CD-ROM will reveal that there is one clip on the *Economic Development* videodisc called "Population/Wealth Correlation." With this information, you can plan when to reserve your department's videodisc player to preview the clip and show it to your class.

Furthermore, you will discover that there is one GIGI mini-atlas activity related to this lesson, five articles in the Geopedia database, ten entries in

Geopedia's World Data, five maps in the Geopedia Atlas, and five learning activities in the Geopedia BrainTeasers. You may want to assign each student or small group of students a research project using these extra resources to be done over the course of the module, or you can create a set of questions which the students must complete using the information found in Geopedia.

These activities can serve as a performance-based assessment of what students have learned in studying each module.

Since many schools have a limited number of computers with CD-ROM drives available, you may wish to devise a rotating schedule or sign-up system to ensure that each student has a chance to get at the BGGS CD-ROM. If it takes 15 class periods for a class of twenty-five students to do one module, students working in pairs can each have one turn at the computer if they schedule their time at the outset of the module. Using the CD-ROM's resource managing capability, you will have a very good sense of what resources you have at your disposal and how to make the most of them.

- All GIGI lessons are indexed by word and by key topic. If your class is studying food shortages in the Hunger module, you can key in the word hunger, and immediately learn where else in the GIGI modules this word or key topic appears. You can go directly to those occurrences in the text. You will also be directed to appropriate Geopedia references and Brain Teaser activities. Figures, Maps and Tables from GIGI print modules do not appear in the CD-ROM. However, the caption describing each of them is part of the online text.
- If Spanish is the primary language of your students, GIGI lessons can be accessed and printed out in Spanish from the BGGS CD-ROM. The BGGS Videodiscs have a Spanish soundtrack as well.

III. BGGS Videodiscs

More than ever before, today's students are visual learners. The GIGI modules explore issues and regions of the world with which many students are unfamiliar. With this in mind, we have produced three videodiscs, one to correspond to each of three major strands we have identified in GIGI: *Earth's Environment and Society; Economic Development;* and *Global Political and Cultural Change.*

These videodiscs, with English and Spanish soundtracks, can take you and your class to the parts of the world you are investigating with the wave of a barcode wand. Your class will hear how Amazon native peoples feel about the exploitation of the tropical rain forests where they live, witness the eruption of a volcano, and see first-hand the environmental disasters human beings have brought about.

The Barcode Guide which accompanies each disc enables you to access with a light pen or barcode reader, segments which pertain to the lesson being investigated. The Guide includes barcodes in both English and Spanish. Teachers can use the segments to enrich lessons, and students can make use of segments to enhance a report or group presentation.

There is a full-color poster to accompany each videodisc cluster which engages the students by asking "How do these images connect to you?" The posters can provide a colorful springboard for classroom discussion.

Britannica Global Geography System Developers

GIGI Staff and Associates

Professor A. David Hill, Director and Developer
Dr. James M. Dunn, Developer
Dr. Phil Klein, Developer
Professor Robert W. Richburg, Consultant and Evaluator
Dr. Alan L. Backler, Consultant
Professor Joseph P. Stoltman, Consultant
Dr. H. Michael Hartoonian, Consultant
Lynn M. Jackson, Secretary
Sheila B. Tyrrell, Secretary
Jeffrey Jon Miller, Assistant
Aaron Howell, Assistant
Mathilde Snel, Assistant
Bryan Dorsey, Assistant

See individual modules for additional contributors.

EBEC Staff and Associates

Emily Clott, Project Manager
Martha Hopkins, Director, Educational Program Development
Proof Positive/Farrowlyne Assoc., Editorial, Design, and Production
Hazel Janke, Manufacturing Manager
Carol Smith, Senior Buyer
Richard Laurent, Logo and Package Design
Alison Witt-Janssen, Electronic Production Manager
Jeffrey Osier, Videodisc Editor
Dynacom, Inc. Software Development
Sharon Johnson, Videodisc Development and Photo Research
Laurie Kennard, Videodisc Development and Photo Research
Jean Araujo, Editorial Coordinator
Patrick Hogan, CD-ROM User's Manual Editor
Kim Bradshaw, Data Preparation
Carmen Schwarting, Data Preparation
Yolanda Vargas, Data Preparation
Alejandra Tcachuk, Translator
Dave Alexovich, Video Animation and Graphics
Dave Wood, Video Animation and Graphics
Scott Shearer, Video Animation and Graphics
Barbra A. Vogel, Manager EB Cartography
Dione E. Fortin, Cartography
Steven Bogdan, Cartography
Amelia R. Gintautas, Cartography
Michael D. Nutter, Cartography

BRITANNICA GLOBAL GEOGRAPHY SYSTEM

GIGI

Geographic Inquiry into Global Issues

Natural Hazards

Program Developers
A. David Hill, James M. Dunn, and Phil Klein

TEACHER'S GUIDE

Regional Case Study
Japan

Britannica
ENCYCLOPAEDIA BRITANNICA EDUCATIONAL CORPORATION
310 South Michigan Avenue Chicago, Illinois 60604

Geographic Inquiry into Global Issues (GIGI)
The Center for Geography Education
Department of Geography, Box 260
University of Colorado at Boulder
Boulder, CO 80309-0260

GIGI Project Staff
A. David Hill, Director
James M. Dunn
Phil Klein

Project Consultants
Alan Backler
Michael Hartoonian
Robert Richburg
Joseph P. Stoltman

Natural Hazards
First draft written by Kathryn Lapp and Corine O'Donnell
Reviewed by William Riebsame and staff of Natural Hazards Research and Applications Information Center, Boulder, Colorado

EBEC Production Staff and Associates
Project Manager: Emily Clott
Director, Educational Product Development: Martha Hopkins
Design, Editorial, Production: Proof Positive/Farrowlyne Associates, Inc.
Senior Buyer: Hazel Janke
Logo and Package Design: Richard Laurent

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Contents

Memo to the Teacher from the GIGI Staff

You have in your hands the GIGI Teacher's Guide. Teaching with GIGI is a departure from teaching with a conventional textbook. By taking the time to study this memo—about 30 minutes—you will gain a good understanding of the kind of teaching that's needed to be successful with GIGI. We hope you have a rewarding and enjoyable experience!

Goals

The three major goals of *Geographic Inquiry into Global Issues* (GIGI) are to help you teach your students the following:

1. Responsible citizenship
2. Geographic knowledge, skills, and perspectives
3. Critical and reflective thinking

We believe you can accomplish these goals as well as others by teaching real-world issues. GIGI presents these issues with an inquiry approach, using the information, concepts, skills, and perspectives of geography.

GIGI and the Britannica Global Geography System

GIGI offers you two instructional modules for each of ten world regions (Figure 1 on pages vi and vii). There is no necessary sequence of modules; each one is independent, so you can use them in any order you wish or put together smaller clusters of modules to fit your needs. A leading question frames the issue of each module, and student inquiry proceeds through a sequence of lessons, each of which requires one or more daily periods of class time.

Color photographs at the beginning and end of each Student DataBook graphically illustrate the topic under inquiry.

Modules typically begin with a broad introduction to the global issue. Then, a major case study of three to four lessons examines the issue in a real place within the selected world region. Students also explore, usually in a single lesson, a comparative case study in a *different* region, which gives a variant of the issue and a sense of its global nature. Modules also bring the students "back home" to focus on the issue as it may appear in the United States or Canada. We do this because although North America is not one of the 10 GIGI

regions, frequent comparisons to North America throughout each module achieve additional instruction on this "home region."

Each GIGI module requires from two to three weeks of teaching time (10 to 15 class periods of 50 minutes) and contains a Student DataBook, Teacher's Guide, and Mini-Atlas. These GIGI print materials are at the heart of the Britannica Global Geography System (BGGS), which extends and enhances the inquiry approach to real-world issues with a CD-ROM and three videodiscs.

The BGGS CD-ROM puts the text of the GIGI Student DataBooks on line in both English and Spanish, then enables both teacher and students to search the text by lesson, key topic, or word to find the resources in the system that will enhance each. Geopedia™, Britannica's multimedia geography program, is provided in the CD-ROM for follow-up research. It features an atlas with more than 1,000 new maps, an encyclopedia with more than 1,200 geography-related articles, statistical information on every country from Britannica World Data Annual, a chartmaker for creating charts and graphs, a selection of video clips exploring cities and regions, and an electronic notepad allowing teachers and students to clip and edit text right on the screen.

Three videodiscs, designed to electronically transport students to the regions of the world where GIGI case studies are focused, are another part of the BGGS. The discs emphasize three major strands of the GIGI investigations: *Earth's Environment and Society, Economic Development,* and *Global Political and Cultural Change.* Each videodisc has two soundtracks, English and Spanish, and is accompanied by a Barcode Guide that enables teachers and students to access the segments that accompany the GIGI lesson with a wave of the barcode reader. A poster accompanies each videodisc to reinforce the connnections between your students and the issue being studied.

A full explanation of the Britannica Global Geography System components and how they work together is located in the BGGS overview in the front section of this Teacher's Guide.

Geographic Inquiry into Global Issues (GIGI)

Issues, Leading Questions, and Case Study Locations

South Asia	**Population and Resources***	**Religious Conflict**
	How does population growth affect resource availability?	*Where do religious differences contribute to conflict?*
	Bangladesh	Kashmir
	(Haiti)	(Northern Ireland, United States)
Southeast Asia	**Sustainable Agriculture***	**Human Rights***
	How can the world achieve sustainable agriculture?	*How is freedom of movement a basic human right?*
	Malaysia	Cambodia
	(Cameroon, Western United States)	(Cuba, United States)
Japan	**Global Economy**	**Natural Hazards***
	How does trade shape the global economy?	*Why do the effects of natural hazards vary from place to place?*
	Japan	Japan
	(Colombia, United States)	(Bangladesh, United States)
Former Soviet Union	**Diversity and Nationalism**	**Environmental Pollution***
	How do nations cope with cultural diversity?	*What are the effects of severe environmental pollution?*
	Commonwealth of Independent States	Aral Sea
	(Brazil, United States, Canada)	(Madagascar, United States)
East Asia	**Population Growth**	**Political Change***
	How is population growth to be managed?	*How does political change affect peoples and places?*
	China	Hong Kong
	(United States)	(South Korea, Taiwan, Singapore, Canada)

Figure 1 Matrix showing GIGI modules. Geographic issues are in bold and leading questions are in italics. Major case study locations are followed by comparison examples in parentheses.

Geographic Inquiry into Global Issues (GIGI)

Issues, Leading Questions, and Case Study Locations

Australia/ New Zealand/ Pacific	**Global Climate Change***	**Interdependence**
	What could happen if global warming occurs?	*What are the causes and effects of global interdependence?*
	Australia and New Zealand	Australia
	(Developing Countries, U.S. Gulf Coast)	(Falkland Islands, United States)
North Africa/ Southwest Asia	**Oil and Society**	**Hunger***
	How have oil riches changed nations?	*Why are people hungry?*
	Saudi Arabia	Sudan
	(Venezuela, Alaska)	(India, Canada)
Africa—south of the Sahara	**Building New Nations**	**Infant and Child Mortality***
	How are nation-states built?	*Why do so many children suffer from poor health?*
	Nigeria	Central Africa
	(South Africa, the Kurdish nation)	(United States)
Latin America	**Urban Growth***	**Development***
	What are the causes and effects of rapid urbanization and urban growth?	*How does development affect peoples and places?*
	Mexico	Amazonia
	(United States)	(Eastern Europe, U.S. Tennessee Valley)
Europe	**Regional Integration**	**Waste Management***
	What are the advantages of and barriers to regional integration?	*Why is waste management both a local and global concern?*
	Europe	Western Europe
	(United States, Mexico, Canada)	(Japan, United States)

* The 12 starred modules comprise the basic full-year's geography program. The eight additional modules are available for an additional cost.

Figure 1 (continued)

The **Student DataBook** contains the following features:

- Memo to the Student from the GIGI Staff
- An overview of the key questions and places explored in the module
- Lesson objectives
- Data presented in a variety of forms, including text, maps, graphs, tables, photographs, and cartoons
- Questions
- Glossary
- References

Students are not expected to learn the GIGI curriculum through the Student DataBook alone. Rather, they derive meaning from the DataBook when you use the Teacher's Guide to work through the curriculum with them. You may want to explain this process to students. Point out that you will be directing them to carry out various activities that are not specified in their text but are important in the sequence of learning.

Prior to teaching the first lesson, be sure students read the "Memo to the Student from the GIGI Staff" and the two-page overview, which gives the module's objectives in question form. Point out the Glossary and encourage its use as you work through the module, noting that glossary words are listed at the beginning of each lesson. So that students will know what they are expected to learn, they need to read carefully and understand the objectives listed at the beginning of each lesson.

This **Teacher's Guide** contains the following sections:

- Preparing to Teach This Module, a synopsis of the module's leading question, themes, and activities
- Module Objectives
- Number of Days Required to Teach the Module
- Suggestions for Teacher Reading
- Extension Activities and Resources

Most lessons include the following sections:

- Time Required
- Materials Needed
- Glossary Words
- Getting Started (suggested anticipatory sets)
- Procedures (for group and individual work)
- Modifications for older or younger students (in a different type face, printed in color)
- Questions and Answers (shown in tinted boxes)
- For Further Inquiry (suggestions for extensions and/or assessments)

- Masters of Overhead Transparencies and Activity masters and keys (located at the back of the Teacher's Guide)

Each module has its own accompanying **Mini-Atlas,** which provides four-color maps designed especially for use with that module. The Teacher's Guide explains how to use these maps. No additional atlases are required to teach the module, but large wall maps are highly recommended for your classroom. In addition to the maps in the Mini-Atlas, you will find numerous maps in the Student DataBook.

We believe GIGI enables you to probe global issues in various degrees of depth. This allows for the modules' use both over several grade levels (7–12) and over varying lengths of time at a grade level. The Teacher's Guides suggest alternatives for modifying instruction for different grade levels where appropriate. The reading level varies within each module: The Student DataBooks are approximately at grade 9 level, but some extracts from other sources are more challenging. These extracts are important because they show students that many people have contributed to the data, but younger students may need more time and help to understand them. The Teacher's Guides also include extension activities and resources that can maximize the grade-level flexibility of each module. Using the visuals included in the BGGS videodiscs and the activities built into the CD-ROM, you can further tailor instruction to your students. Obviously, you will determine whether particular lessons suit your students' abilities. When a range of required teaching time is given for a module, for example, 10 to 12 days, the greater amount of time should be planned for younger students. If you believe a lesson might be too difficult for your students, eliminate or simplify it. Rarely will the elimination of a lesson render a module ineffective. On the other hand, try to utilize the suggested extensions if the lesson does not adequately challenge your students.

In order to foster active learning and higher-level thinking, GIGI stresses issues-based geographic inquiry. Inquiry is essentially the method of science and of good detective work: It poses questions and proposes answers about the real world and it tests its answers with real data. Students do this with GIGI. Because this approach may be different from what students are familiar with, you may wish to pre-

pare them by describing the process and its connection to the real world. Also, their reading and discussion of the "Memo to the Student from the GIGI Staff" will help them understand the inquiry approach. GIGI is based on Frances Slater's inquiry activity planning model (1993). To reach GIGI's goals, your students study specific global issues by pursuing answers to geographic questions (Figure 2). They answer these questions by analyzing and evaluating data, using geographic methods and skills. This "doing geography" approach leads to significant outcomes in knowledge, skills, and perspectives. The progression from questions to generalizations "is crucial as a structure for activity planning and as a strategy for developing meaning and understanding. Meaning and understanding define the process of tying little factual knots of information into bigger general knots so that geography begins to make sense, not as a heap of isolated facts but as a network of *ideas and procedures*" (Slater 1993, page 60).

In truly free inquiry, students work independently, but with GIGI posing questions and providing data, you and your students explore the issues together. This approach supports and encourages your students in learning geography.

By using issues-based inquiry, you promote the development of a critical perspective in your students. They learn the habits of critical and reflective thinking. Multiple and opposing positions are inherent

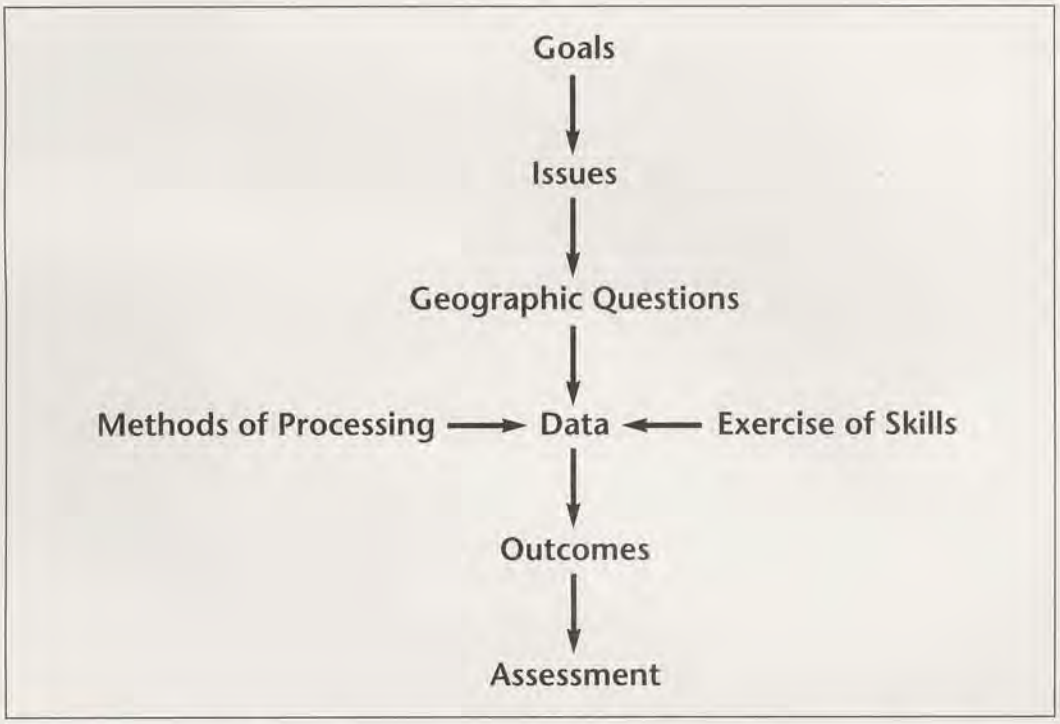

Figure 2 GIGI's model for issues-based geographic inquiry (after Slater 1993).

in these issues. Facts can be used to support different points of view. This is the context in which the habits of the critical perspective can develop, and *interpretation* is the key activity. With GIGI you foster these habits and abilities as you help your students interpret data guided by hypotheses, propositions, arguments, or questions.

An essential element of data-based, issues-oriented inquiry is to challenge your students by giving them opportunities to

- raise new questions,
- question the quality of the data,
- seek more useful or current data,
- articulate relationships they perceive,
- explain their processes of investigation, and
- defend their positions, decisions, and solutions.

Why These Issues Were Chosen

In planning GIGI, we sought timeless issues that are truly global in scope and that are of special concern to geographers. In this way, GIGI fosters what the National Geography Standards calls "the geographically informed person" needed by modern global citizenry (Geography Education Standards Project 1994).

The major case study, chosen to give solid grounding to the issue, is focused on a region where the issue is clearly expressed. The secondary case studies, based in other regions including the United States and Canada, show the *global* scope of the issue.

It is important to stress that, although GIGI contains a wide selection of case studies in all major regions (Figure 1) as well as frequent references to the global distribution of many geographic phenomena, GIGI is not a traditional regional geography. It does not attempt to provide basic geographic information for each region, such as one finds in traditional regional geography textbooks. In teaching a GIGI module, it is important to keep the emphasis on the issue and not get distracted with extraneous regional information.

Role of Questions

Each GIGI module is divided into six to eight lessons, each titled by a question; subquestions head individual sections of the lessons. Questions guide inquiry in order to merge the process of investigation with the drawing of conclusions. Directly linking questions and answers helps achieve an intellectually satisfying understanding of a problem (Slater 1993). When students are asked to learn only conclusions without learning how they are drawn, we perpetuate the tradition of an answer-centered education bereft of higher-level thinking. Therefore, it is important that students understand they are not

always expected to answer the questions when they first appear, but rather to keep them in mind as guides when they are reading or discussing.

GIGI asks both convergent and divergent questions, trying to reach a balance between the two. Supplement the questions in GIGI by asking your students many more of the types of questions suggested by Slater (1993). These are questions that encourage

- recall,
- classification and ordering,
- the use of data to draw conclusions,
- awareness of the limitations of data or of evaluation of data, and
- awareness of the processes of reasoning used.

According to the National Geography Standards, the "geographically informed person applies a comprehensive spatial view of the world to life situations" (Geography Education Standards Project 1994). In order to foster such a view of the world, GIGI asks *geographic* questions that ask where things are and why. By asking such geographic questions and by having students learn to ask them, you will reinforce GIGI's approach. A good question to begin with is: Where is this issue located? Then proceed to questions such as the following:

- Why does it take place there?
- How and why does this issue affect the people in this place?
- In what other places do people confront this issue?
- How and why are these places related?
- What alternatives do people have to improve their situation, and which alternatives do you recommend?

Fundamental Themes of Geography

In recent years, many geography teachers have learned that the five "fundamental themes" (Joint Committee on Geographic Education 1984) help them ask geographic questions. The theme of **Location** asks where things are and why things are located where they are. **Place** is the theme that inquires into human and physical characteristics of locations. **Human-Environment Interaction** examines how and why humans both adapt to and modify their environments as well as the consequences of these actions. **Movement** investigates not only how and why places are connected but also what is the significance of those interactions. The theme of **Region** seeks to identify and explain similarities and differences among areas and how and why these form and change. An extended explanation of the themes and their concepts, interrelationships, and applications is

given in Hill and McCormick (1989). The themes are useful because they encourage the kinds of questions required to help students develop the geographic perspective.

Importance of Local Examples

GIGI is a world geography, but it shows that issues work at various geographic scales—personal, local, regional, national, and global. Because it is sometimes difficult for younger students to identify with faraway places, success with GIGI in part depends upon the ability of both you and your students to relate the issues to examples in your local community. We strongly recommend that you refer in class to local examples of the issue being investigated. Just as important, we encourage you to have your students conduct local field studies related to this issue whenever possible. Issues having important geographic dimensions abound in every community (see the Extension Activities and Resources section at the end of this Teacher's Guide for examples). Peak educational experiences often come when students see things in the field that relate to their classroom studies. We discuss other reasons for local involvement in the next section.

Familiar people can be as important as familiar places in motivating students. The quality of personal engagement is at the crux of successful instruction. Using the BGGS videodisc segments that accompany most GIGI lessons is a powerful way to help your students find relevance by identifying the GIGI issues with real people. Similarly, you can connect GIGI issues to everyday life at a human scale, especially at the students' own age levels, by using current newspaper accounts or magazines that address the student's perspective.

As you gain familiarity with teaching local examples, as you develop field exercises for your students, and as you learn how to put a human face on these materials, you will begin to customize the GIGI modules to fit your particular environment. Our trial teachers reported that the more they taught GIGI modules, the more comfortable they became in adapting them to fit their needs.

Fostering Optimistic and Constructive Perspectives

The seriousness and complexity of the global issues studied in GIGI can overwhelm students unless you take care to foster optimistic and constructive perspectives toward issues. "Gloom and doom" needs to be balanced with examples of success and prospects for positive change. It is important to help your students develop a

sense of personal efficacy, an attitude that their actions can make a difference in solving global problems. The maxim, "Think Globally, Act Locally," speaks to the need to help students organize and conduct constructive actions that address local variants of the issues they are studying. As we noted earlier, student involvement in local projects enriches their educational experience. There is also good evidence that it actually produces an optimistic feeling—that their actions *can* make a difference—to help them deal with the often difficult and sometimes depressing world issues. GIGI modules often include lessons and activities to show possibilities for positive action.

Certain perspectives foster student optimism and constructive behavior. Geography students, especially, should learn to respect other peoples and lands, and they should come to cherish environmental unity and natural diversity. They should also learn to be skeptical about simplistic explanations, such as the theory that attempts to explain human characteristics and actions in terms of the physical environment alone, which geographers call "environmental determinism." Most important, optimistic and constructive perspectives accompany the development of empathy, tolerance, and open-mindedness. These traits are fostered by avoiding sexist and racist language, discouraging ethnocentricity, and challenging stereotypes, simplistic solutions, and basic assumptions.

References to Data

Unlike most textbooks, GIGI attributes its sources of data with in-text citations and full reference lists, which is another way of encouraging the critical perspective. In the Student DataBook, material that has been extracted from original sources is indented and printed in a different typeface. Long extracts are highlighted with background color. Use of these sources helps your students learn that real people construct ideas and data and that their concepts and information are not immutable. Instead, they often change through the critiques and interpretations of various people. By using these scholarly conventions, we intend to encourage your students to appreciate the tentativeness of knowledge and to value scholarship and academic integrity.

Updating

Real data quickly become obsolete. GIGI addresses this fact by discussing historical trends of data and by stressing concepts. You should reinforce this bias for concepts and also freely acknowledge the datedness of information by explaining why it is still used (for example, the lags between research and writing and publication and

use; the lack of more recent data). Whenever possible, guide students to update materials. Britannica's Geopedia, on the BGGS CD-ROM, contains data based on Encyclopædia Britannica's World Data Annual, which is also available in print form. Have students use these sources to supplement and update GIGI data. During the life of the adoption if requested, the publisher will provide a maximum of two updates to the BGGS CD-ROM.

Assessing Learning

Evaluation of student achievements with GIGI can be focused on two broad areas. The first is the developing ability of students to undertake geographic inquiry. The second is the acquisition of knowledge and perspectives about the module issue.

The ability of students to undertake inquiry in geography can be related to the primary questions that guide geographical study. They are noted earlier in this memo. As students work through the module, they are likely to become increasingly adept at asking and answering geographic questions. Seek to extend your students' competence in several clusters of skills that facilitate geographic inquiry. These clusters include the following:

- Identifying problems and issues. This may be done through observation, asking questions, brainstorming, reading, and in other ways.
- Inquiring into the problems and issues in many ways such as through map reading and interpretation, making surveys, and using results of surveys done by others.
- Making decisions and taking action, for example, through reviewing alternatives, establishing priorities and criteria, and communicating cooperatively with people in other ways.
- Reflecting at all stages of the process of inquiry, especially through careful consideration of diverse sources of evidence.

Students will acquire knowledge of the module issue as they make their inquiries. This knowledge can be tested and graded. Assessments may be based on the following:

- Knowledge and skills shown by work on Activities included in this Teacher's Guide and on questions in the Student DataBook.
- Observations of student participation in groups and in class discussions.

Specific assessment ideas are given at the end of some lessons in the section called For Further Inquiry. In addition, the Teacher's Guide ends with Extension Activities and Resources. Some of these extension activities can serve as authentic assessments.

Potential Uses

In addition to the flexibility offered by the free-standing nature of the modules, GIGI has a number of other characteristics that encourage widespread use. Modules can be extended and enhanced with the BGGS CD-ROM, videodiscs, and posters. Because GIGI's issues-based approach integrates several topics (for example, population, economic, political, physical, and cultural geography) in a single module, the modules are not conducive to using an approach in which topics are taught separately. On the other hand, GIGI may be used with a world regional approach because there are modules for each of 10 world regions. A year-long world geography or global studies course will have more than enough material by using 12 modules. Five to seven modules may constitute a one-semester, issues-based geography course covering several regions. You can define clusters of modules for your own curricular purposes. We have identified three clusters for interdisciplinary studies within the Britannica Global Geography System, each comprising six or seven GIGI modules. They are *Earth's Environment and Society, Economic Development,* and *Global Political and Cultural Change.* BGGS includes a videodisc and poster for each cluster. These strand packages could well be used in Social and Environmental Studies, Earth Science, Global Studies, and Area Studies classes. Activities in the modules also support math, language arts, and arts curricula.

GIGI encourages and facilitates the development of a variety of geographic skills that transfer widely into the natural and social sciences. Among these are skills of asking geographic questions and developing and testing geographic generalizations. These require other GIGI skills including examining and making a variety of maps; analyzing photographs; constructing and interpreting graphs and tables of spatial data; and collecting, interpreting, and presenting geographic information.

Finally, GIGI promotes a wide variety of linguistic, numeric, oral, creative, and social skills as well as geographic skills. In particular, GIGI emphasizes cooperative learning. We believe that one of the great strengths of the GIGI modules is that they give students practice in both group and individual problem solving. As students become more familiar with the global issues, they learn that finding solutions to world problems requires people to work together cooperatively.

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Preparing to Teach This Module

Natural Hazards

Why do the effects of natural hazards vary from place to place?

In this module, students inquire into natural events that become hazardous to people, such as earthquakes and destructive cyclones. Hazards caused by natural events are likely to be experienced by most people during their lifetime. Those who do not actually experience catastrophic natural phenomena will nevertheless be exposed to them through the media or may pay taxes to governments that mobilize state, national, and international emergency systems for those suffering their effects. Therefore, it is important to include in the curriculum the study of causes, consequences, and alternatives for dealing with natural hazards on a local, national, and international scale.

Many parts of the world are prone to natural disasters that can cause immense loss of life and damage to property. Geographers are concerned with questions such as: Can these natural events be predicted? How should societies prepare for them? Why are some natural events more disastrous in some parts of the world than in others?

The *Natural Hazards* module engages students in cooperative activities and in the use of data to investigate and draw conclusions about *Human-Environment Interaction*. This constitutes one of the five fundamental themes of geography. In Lesson 1, students read an article about one type of hazardous event—a volcanic eruption—to help them understand how such disasters affect people's lives.

In the second lesson, students plot earthquakes and volcanic eruptions to discover the Ring of Fire. Next, students, working in "jigsaw" cooperative learning groups, examine the causes of four natural events: earthquakes, volcanoes, tsunamis, and typhoons. (The Student DataBook includes an extensive Glossary to help students with unfamiliar terms.) In Lesson 4, students analyze and compare data to predict whether nature has become more hazardous to people today than in the past.

In the final three lessons, students investigate how society's preparedness for natural hazards affects the consequences of these events in different places. Lesson 5 explores how the Japanese prepare for natural hazards. Students devise a plan to reduce the consequences of a major earthquake disaster and compare their plan to one actually developed by a Tokyo planning agency. In Lesson 6, students compare preparedness measures for earthquakes in the United States to those in Japan. Lesson 7 provides students with a chance to contrast preparedness for major cyclones in two countries with very different levels of economic development—Bangladesh and the United States. How effective is the prediction, prevention, and preparation for recovery in these two nations? The module concludes by shifting the focus to the local scale. Students, given an assignment at the beginning of Lesson 1, report on preparedness measures in their own school and community.

Using the BGGS CD-ROM can simplify lesson planning by making it easy to access the resources the system provides for each lesson. It shows exactly which Geopedia™ data and learning activities can be used in long-range and short-term assignments, and which videodisc clips will provide visual reinforcement for each GIGI lesson. The CD-ROM can also show you ways in which a lesson in one module relates to a lesson in another module. And it indicates where to find every reference in GIGI, Geopedia™, the Mini-Atlas maps, and the videodiscs to any key topic—for example, "tsunami" or "Bangladesh." The students will also be able to use the BGGS CD-ROM for further research and short-term or long-term range assignments. The BGGS multimedia components and their uses are explained fully in the tabbed BGGS section in the front of this Teacher's Guide.

The following are general modifications recommended for younger students:

- Plan for fifteen days because the activities will require more teacher explanation and support.
- Provide directions for homework assignments and monitor students' understanding and progress.
- Prior to assigning written activities requiring students to draw conclusions and summarize their findings, ask guiding questions and develop a sample outline on the chalkboard.

Module Objectives

- Investigate examples of natural hazards and analyze how these events affect the quality of human life.
- Explain why earthquakes, volcanoes, tsunamis, and destructive storms occur where they do.

- Describe why natural events become hazardous to people and conclude whether natural events are more hazardous to people today than they were in the past.
- Understand a system by which future hazard risks are predicted and compare and analyze plans for preparedness.
- Identify the varied levels of preparedness in three countries and explore reasons for different preparedness levels.
- Compare the responses of various countries to the consequences of natural hazards.

Number of Days Required to Teach *Natural Hazards*

Eleven to fifteen 50-minute class periods

Suggestions for Teacher Reading

Burton, Ian, Kates, Robert W., and White, Gilbert F. 1993. *The Environment as Hazard,* 2nd Edition. New York: The Guilford Press.

Haas, Eugene, Kates, Robert W., and Bowden, Martyn J. 1977. *Reconstruction Following Disaster.* Cambridge, MA: MIT Press.

Heppenheimer, T. A. 1986. Finally, a saturation attack on earthquake prediction. *Popular Science,* 229: 54–58.

Jensen, Holger. 1989. The origins of killer quakes: a feverish search for danger signs. *Macleans,* 102: 66–67.

Lawrence Hall of Science and the California State Seismic Safety Commission. 1986. California Earthquake Education Project (CALEEP) Sampler. Write to: CALEEP, Lawrence Hall of Science, University of California, Berkeley, CA 94720.

Lipkin, Richard. 1989. Cracking weather's secrets. *Insight,* January 9: 8–19.

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McPhee, John. 1989. *The Control of Nature.* New York: Farrar, Straus, and Giroux. Three essays giving examples of extreme measures people have taken to save their economy from natural hazards.

Popham, Peter. 1985. *Tokyo: The City at the End of the World.* Tokyo: Kodansha International Ltd.

Powell, William E. 1986. Beginning a geography course in hazards and disasters. *Journal of Geography,* 85: 26–27.

Ross, Katharyn. 1989. NCEER Bibliography of Earthquake Education Materials. National Center for Earthquake Engineering Technical Report #NCEER-89-R010. Write to: State University of New York at Buffalo, Red Jacket Quadrangle, Buffalo, NY 14261.

Seidensticker, Edward. 1990. *Tokyo Rising: The City Since the Great Earthquake.* New York: Alfred A. Knopf.

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Lesson 1

How do natural hazards affect the lives of people in Japan?

Time Required

One 50-minute class period

Materials Needed

Transparency of Overhead 1
Copies of Activity 1 for all students

Glossary Words

earthquake

magma

natural hazard

seismometer

volcano

Getting Started

- Have students read the Memo to the Student and the overview on pages 2–3 in the Student DataBook prior to beginning the module. Also make students aware that there is a Glossary in the back of their DataBooks.
- Display **Overhead 1** on the projector. Help students understand that a natural hazard occurs when people, their developments, and their landscapes are placed in jeopardy by the occurrence of a natural event. Many hazards, such as earthquakes and volcanoes, are simply the natural forces of nature. Others may be caused by the actions of people, such as deforestation in the Himalayas, which increases the hazard of severe flooding in Bangladesh. As the Overhead shows, human response to these hazards takes the form either of modifying the natural environment or modifying human behavior.

  Have students contrast a natural *hazard* to a natural *resource*. They should see that both of these concepts arise from our interaction with the natural environment, but hazards are those aspects of the natural world that pose a risk to human society. Resources are those things from the environment upon which society depends for its continuation.
- Ask students if they and their families or friends have ever experienced a natural disaster. Have them tell what the disaster was and where it occurred. Was there a warning? How did they respond? Did they move from the area because of the hazard? Why or why not?

Procedures

A. Tell students they will read a Japanese magazine article about an example of a hazardous event on Miyake Island, Japan. Help students locate Miyake Island [South of Tokyo] on Figure 1 (page 5 in the Student DataBook).

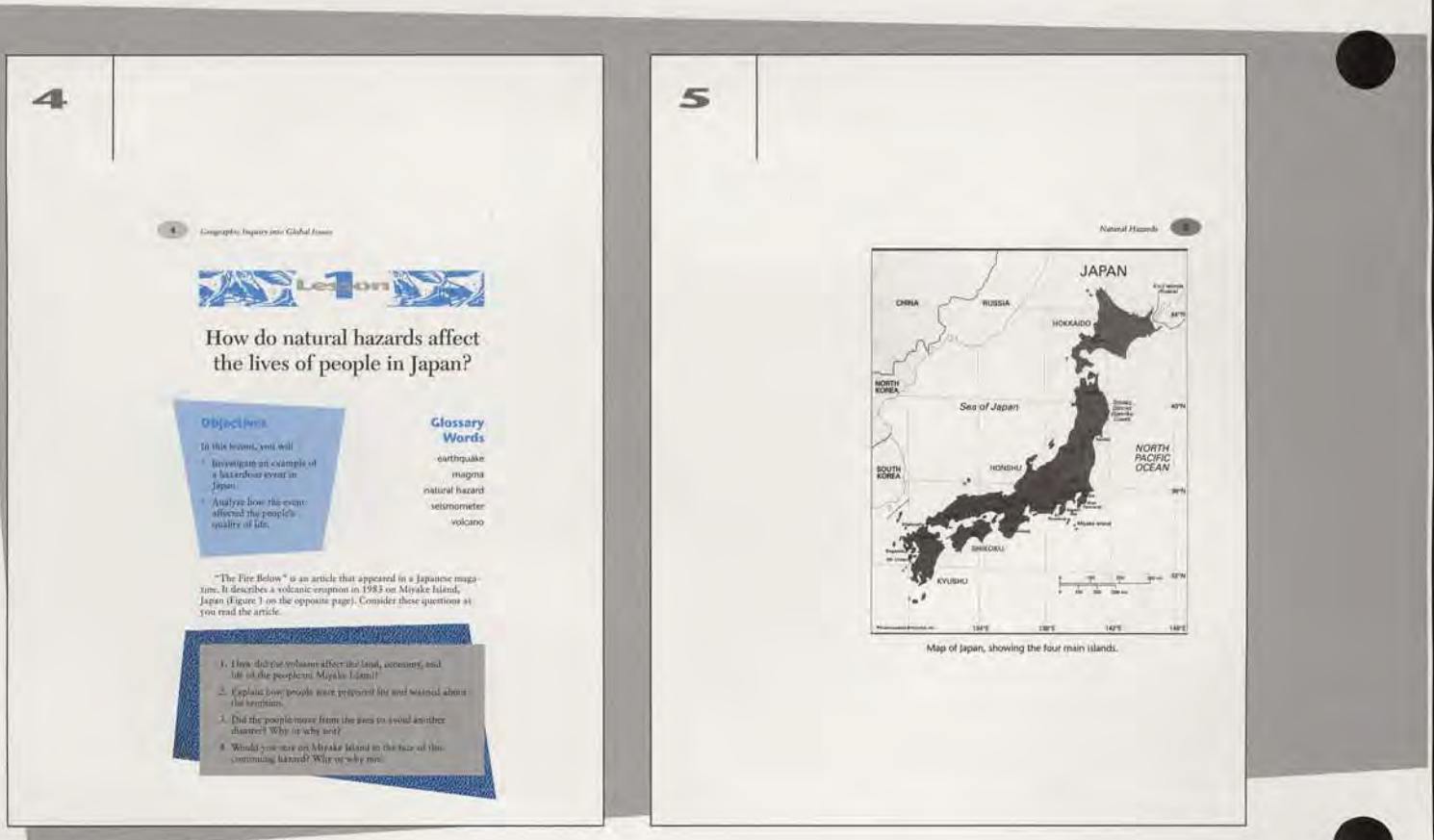
B. After students read the article, "The Fire Below," place them in pairs to answer Questions 1–4 preceding the article. Allow time for each pair to share its answers with the class.

C. Ask students to draw some conclusions about why people continue to live where there are recurring natural hazards. Lead them to include appeal of physical environment, economic opportunities, history and culture, and technology that reduces the risk.

D. Assign **Activity 1** as a long-term project. Students will not yet be able to complete all of the tasks on this Activity, but they can get started now and complete it as the module proceeds. This assignment concludes the module by asking "How prepared is your community for a natural hazard?" You can end the module by having students present their findings orally, or have them turn in a written study. You may want to encourage students to work in pairs or teams to carry out the project.

Use Overhead 1 to show students that human interaction with the environment creates hazardous situations such as building houses on unstable land, in a floodplain, or in an avalanche path. The class should identify the reasons for the hazard in their community—the confluence of settlement patterns and physical forces that together have created a potential hazard.

Encourage students to seek data from a variety of sources. They may wish to ask their grandparents or other elderly residents about the area's hazards and history of response to those hazards. Historical local newspaper



Map of Japan, showing the four main islands.

reports should also be used as primary sources of data. Students may also learn about local planning efforts from calls to the responsible local agencies.

Explain that the project is a homework assignment and it is the student's responsibility to use the guiding questions in the Activity to identify and gather data regarding the hazard and the degree of local preparedness. The data should be used to support conclusions in the student's report.

As an evaluation strategy for this assignment, you may want to establish a time line for the independent study project with periodic checks and points for progress.

Questions and Answers for page 4

1. How did the volcano affect the land, economy, and life of the people on Miyake Island?
   - The people live with the anticipation that a volcanic eruption could again destroy their village, as in the past.
   - The island's volcanic soil is too acidic to grow high-profit crops such as rice. Therefore, the people earn a living by selling products such as fish, honey, and butter.
   - The beauty of the volcanic island—with forests, wildlife, and quaint villages—has made tourism one of the island's most important industries.

2. Explain how people were prepared for and warned about the eruption.
   - Early signs: A fisherman's report that the ocean was approximately 6° warmer than usual; an American marine biologist's report that he saw dozens of weasels head for the sea the morning of the eruption; earth tremors that began several hours before the eruption and intensified as it neared.
   - Warning and evacuation: Loudspeakers set upon poles throughout each village warned the people to evacuate; villagers and schoolchildren had participated in earthquake evacuation drills and evacuation centers were established ahead of time; ships delivered emergency supplies, food, blankets, and water in a timely manner.

3. Did the people move from the area to avoid another disaster? Why or why not?
   - Most did not move because they were born on Miyake Island. It is the home of their ancestors, and the people love the pines and ocean breeze. Instead, the people rebuilt their villages—even in Ako village where 80 percent of the homes were destroyed. Although some young people leave the island for social and economic reasons, most do not leave on account of the potential for volcanic eruptions.

4. Would *you* stay on Miyake Island in the face of this continuing hazard? Why or why not?
   - Answers will vary, but encourage students to support their decisions with logical reasons.

6

THE FIRE BELOW

The volcanic explosion was sure to come—but when?

The earth shook. Fountains of fire and ash blossomed from the side of the mountain. It looked and felt and sounded and smelled like the end of the world. The people of Miyake Island, an overnight boat ride south of Tokyo, knew it was coming. Somewhere, deep in their hearts, they'd always known. But not now, when things are going so well, when there are crops to harvest, fish to catch, the good life to live.

But at 3:35 P.M., October 3, 1983, a chain of gaping vents burst on the mountainside, one after another. A strafing zig-zag of craters. An unceasing, rhythmic bombardment of noise. In moments, the southwest ridge was aflame. Rockets of sparks shot high into the air—awesome, beautiful, horrible. Thick cables of smoke twisted upward—as high, it was said, as the island is long. Glowing magma gushed from the vents, the blood of the mountain, a glacier of fire. It oozed downward, faster and faster, across the island's only highway, even downward, toward the village. It had come.

Something was wrong, somehow strange, long before the eruption. Not everyone felt it, but one who did was fisherman Akira Negishi, 63. For a month, he'd been telling people, "The ocean's too hot, close to 30°C. This time of year, it should be about six degrees lower." Animals sensed it, too. Jack Moyer, an American marine biologist residing on the island for some 30 years, was on the beach near his home the morning of the eruption. "Weasels—dozens of them. They were headed for the sea in droves. The big waves didn't bother them; they just kept going." It was about 10 A.M.

By 1 P.M., the signs were even stronger. A series of slight but unmistakable tremors jiggled the windows, rippled the surface of tea in the cups, raised the hairs on the backs of necks. After an hour or so of this, tourism worker Tanaka, 43, picked up his phone and dialed the island's meteorological station. "Volcano or just an earthquake?" he asked. The station's seismometers were monitoring the tremors, they said. So far, nothing was definite, one way or the other. But the tremors continued, strengthening by the minute. In a sweet-potato field near her home in Ako Village, a housewife was taking her 3 o'clock break, sitting on the ground with some friends. "I felt 'zoom, zoom, zoom,' a tingling, as if my bottom were going to sleep." In the back of her mind was a drill the villagers had practiced back in August, a drill most of the children had thought was silly: something about what to do in case of an earthquake . . . or an eruption.

Silly? Older folks didn't think so. Twice in their lifetimes the mountain had trembled, twice before it had vomited fire. The 1940 eruption ripped out the side of a mountain called Sanchichi and smothered the fields below with a crust of lava that even today is as brittle and black-red as firebrick. The 1962 burst was worse, devastating every house of the same eastern sector of the island, scattering and gushing its way clear down to the surf line and hissing out into the sea.

Ako Village, on the west coast of the tiny island, had been spared in those latest eruptions, and in most of the others—some 16 in all since 1085 . . .

About half of the island's 4,467 full-time residents live in the clustered subvillages of their ancestors, in old wooden houses with wasya dirt yards and flowers and trees behind chest-high walls of cement blocks or rocks. The people tend to be clannish, and social life is rather limited. Young people resent this, and complain that on Miyake, if you stand up too quickly, you bump into your neighbor looking over your shoulder. Quite a number of children leave as soon as they are old enough, seeking jobs in the more liberal cities on the main islands. But city air doesn't taste of pines and salt, and many of them eventually return.

Some minutes past 4 P.M., about a half-hour after the eruptions on the ridge had been confirmed, an official in Ako flicked a switch and said into a microphone, "Evacuate, evacuate!" Thanks to the warning, no lives were

Fountains of fire and ash blossomed from the side of the mountain.

7

Villagers push a cart carrying their belongings as they flee a volcanic eruption.

8

Aftermath of a volcanic eruption.

lost in the Miyake disaster. But as people boarded buses for an Evacuation Center, in a school gym in the northern part of the island, they carried almost nothing with them. "I expected to be back soon. I just couldn't believe my home was in danger," cried a woman at the center. "This is all I brought—just look." She held up a baby bottle in one hand and a half-empty pack of cigarettes in the other. Strapped to her back was a sleeping infant. She had remembered to bring him, too.

In the gym, safely 15 or 20 kilometers away, she joined the hundreds of evacuees crowded before a color TV and watched silently as cameras in helicopters recorded the scene. About 6 P.M., the river of lava crossed the highway above deserted Ako Village. By morning, 12 hours later, the TV screen showed little more than steaming lava. Eight out of [every] 10 of Ako's 521 houses had vanished.

More than 300 residents fled the island on the following day, heading for Tokyo on the very same ships that had earlier delivered emergency supplies of food, blankets, and water. Those who remained said they would try to resettle in the Ako area, even if this meant living in the flimsy temporary huts that already were being set up by the authorities.

When telephone service had been established, among the flood of calls was one from the daughter of a 59-year-old Ako woman. "She wants me to come and live with her in Tokyo," said the woman. "But the graves of my ancestors are here. And even though the lava buried my house, the land underneath it is still mine. I'm staying."

Her feelings were echoed by many. A 71-year-old farmer's wife: "Live in Tokyo? No, the air hurts my eyes." An 11-year-old schoolboy, his eyes puffy from lack of sleep and from crying, but his voice as steady as a rock: "Of course there'll be another eruption someday. So what? I'm staying, too." And a 49-year-old construction worker with a tanned and leathery face: "Are we weasels, running into the sea at the first sign of danger? This is my land, my Miyake. Born here, live here, die here. That's what I believe" (*Japan Pictorial* 1984, pages 29–33).

Lesson 2

Why does Japan have so many earthquakes and volcanoes?

Time Required

One 50-minute class period

Materials Needed

Transparency of Overhead 2
Copies of Activity 2 for all students
Mini-Atlas maps 1 and 2

Glossary Words

asthenosphere
crust
earthquake
island arc
lithosphere
magma
plate tectonics
subduction
tectonic plates
volcano

Getting Started

Ask students to identify places where earthquakes or volcanic eruptions occur frequently. If they have already studied plate tectonics, they may know of many places, but usually students think of California, or maybe Japan. After several places have been listed, you may want to review latitude and longitude, since the remainder of the lesson has them plotting locations on a grid map.


9

Natural Hazards 9

Lesson 2

Why does Japan have so many earthquakes and volcanoes?

Objectives
In this lesson, you will
- Identify the locational patterns of earthquakes and volcanoes.
- Understand the relationship of plate tectonics to earthquakes and volcanoes.

Glossary Words
asthenosphere
crust
earthquake
island arc
lithosphere
magma
plate tectonics
subduction
tectonic plates
volcano

Where are earthquakes and volcanoes concentrated in the Pacific Ocean region?

Table 1 on the following page reports the latitude and longitude of several earthquakes and volcanic eruptions in the Pacific region. You can plot these locations on a map to see a pattern over a large area.

Procedures

Where are earthquakes and volcanoes concentrated in the Pacific Ocean region? (pages 9–10)

A. Have students read this section. Then distribute **Activity 2** and have small groups plot each event in Table 1 (page 10 in the Student DataBook) using different symbols for earthquakes and volcanoes. The locations were chosen because they represent the boundaries of the Ring of Fire. Although students may not readily call it a "ring," they should be able to discover and describe it.

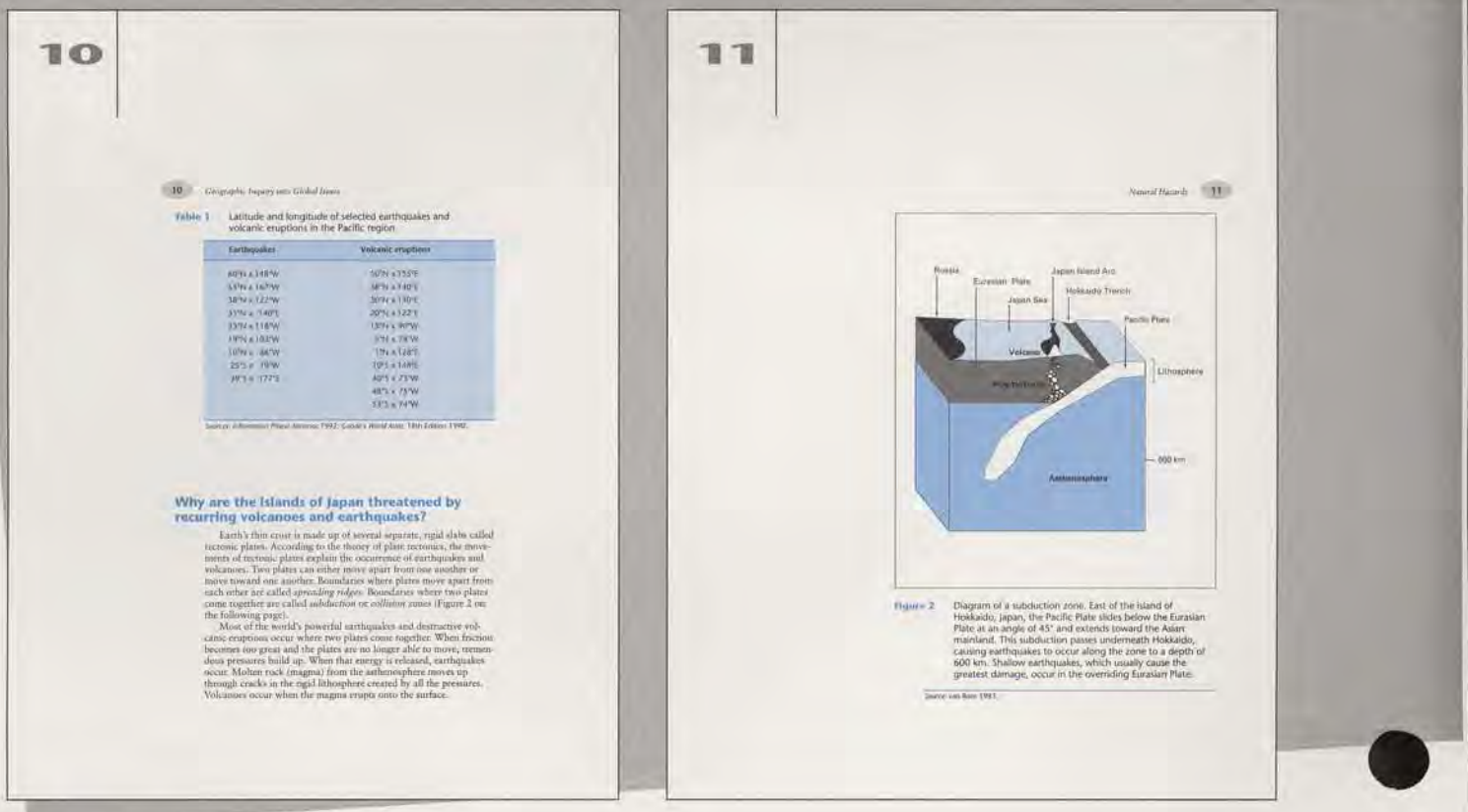
Younger students may need more time and help to plot Table 1. Older students may want to consult an almanac and supplement the list with more events.

Ask what the belt of earthquake and volcanic activity that encircles the Pacific Ocean is called. [Ring of Fire] Students should trace with a finger the Ring of Fire from the southern tip of South America north to Alaska, then west to Asia, and south through Japan, the Philippines, Indonesia, and New Zealand.

Why are the islands of Japan threatened by recurring volcanoes and earthquakes? (pages 10–11)

B. After students read this section, ask them to study the text information on Figure 2 on page 11 in the Student DataBook and then show them the map in **Overhead 2**. Ask them to explain why the least stable areas of Earth's crust are along the edges of the tectonic plates. Explain that in the next lesson, they will learn in greater detail why the tectonic plates threaten Miyake and the other Japanese islands with recurring earthquakes, volcanoes, and tsunamis.

Focus students on the map key and the symbols for "spreading boundary" and "collision boundary" on Overhead 2 (direct them to the Glossary to define the term *subduction*). Use Figure 2 to help clarify these concepts. Have the class identify areas of subduction and



10

10 *Geographic Inquiry into Global Issues*

Table 1 Latitude and longitude of selected earthquakes and volcanic eruptions in the Pacific region

Earthquakes	Volcanic eruptions
60°N x 148°W	50°N x 155°E
53°N x 167°W	38°N x 140°E
38°N x 122°W	20°N x 130°E
33°N x 140°E	20°N x 122°E
33°N x 118°W	19°N x 99°W
19°N x 103°W	5°N x 78°W
10°N x 86°W	1°N x 128°E
25°S x 70°W	19°S x 169°E
39°S x 177°E	40°S x 73°W
	48°S x 73°W
	53°S x 74°W

Source: *Information Please Almanac 1992; Canada's World Atlas*, 18th Edition 1990.

Why are the Islands of Japan threatened by recurring volcanoes and earthquakes?

Earth's thin crust is made up of several separate, rigid slabs called tectonic plates. According to the theory of plate tectonics, the movements of tectonic plates explain the occurrence of earthquakes and volcanoes. Two plates can either move apart from one another or move toward one another. Boundaries where plates move apart from each other are called *spreading ridges*. Boundaries where two plates come together are called *subduction* or *collision zones* (Figure 2 on the following page).

Most of the world's powerful earthquakes and destructive volcanic eruptions occur where two plates come together. When friction becomes too great and the plates are no longer able to move, tremendous pressures build up. When that energy is released, earthquakes occur. Molten rock (magma) from the asthenosphere moves up through cracks in the rigid lithosphere created by all the pressures. Volcanoes occur when the magma erupts onto the surface.

11

Natural Hazards 11

Figure 2 Diagram of a subduction zone. East of the island of Hokkaido, Japan, the Pacific Plate slides below the Eurasian Plate at an angle of 45° and extends toward the Asian mainland. This subduction passes underneath Hokkaido, causing earthquakes to occur along the zone to a depth of 600 km. Shallow earthquakes, which usually cause the greatest damage, occur in the overriding Eurasian Plate.

Source: van Rees 1983.

collision around the world. Ask what events are associated with these areas. [Volcanoes and earthquakes]

Have students identify the three tectonic plates that meet in the vicinity of the Japanese islands. [The Eurasian, Pacific, and Philippine Plates] Have students identify other areas of the world where plates converge. [The Mediterranean, Himalayas, etc.]

C. Distribute **Mini-Atlas maps 1 and 2** to each group. Have the class compare the world map of earthquake/volcano risk (Overhead 2) to Mini-Atlas map 2. [Students may note that many coastal areas are both densely populated and prone to earthquake/volcano hazards. Note that typhoons in Japan are similar to hurricanes in the United States.] Also using Mini-Atlas map 1, have the groups compare the locations of major earthquakes and volcanoes to the population density. Ask if any part of Japan is "safe" from natural hazards. [No—all areas are at some risk.]

Suggestions for Using Overhead 2

Overhead 2 shows the boundaries of the major tectonic plates of the lithosphere. The lithosphere (composed of both Earth's crust and the uppermost part of its mantle) is divided into about 20 major plates. The tectonic plates are huge—some the size of entire continents—and rigid slabs of rock. These rigid plates, which include the oceanic crust and the continental crust, move very slowly over a layer of the mantle called the asthenosphere. This part of the mantle, which lies below the lithosphere, is so near the melting point for rock that it can flow readily. In effect, the asthenosphere acts like a large conveyor belt. The tectonic plates are carried along atop the asthenosphere, moving slowly with respect to one another. The average rate of movement is several centimeters per year—about as fast as your fingernails grow.

Lesson 3

Why do natural events become hazardous to the people of Japan?

Time Required

Two 50-minute class periods

Materials Needed

Transparency of Overhead 3
Copies of Activities 3 and 4 for all students

Glossary Words

crust
cyclone
earthquake
epicenter
fault
hurricane
island arc
lithosphere
magma
mantle
prefecture
seismic waves
subduction
tectonic plates
tsunami
typhoon
volcano

Getting Started

- Have students generate a list of natural hazards in the world. The following are some examples:

volcanoes
earthquakes
tsunamis
floods
fires
drought
dust storms
hail storms
thunderstorms
typhoons/hurricanes/cyclones
temperature extremes
bacterial, fungal, and viral diseases
landslides/mudslides
avalanches
blizzards
lightning
locust infestations

- Help students classify the events identified as being hazards of the atmosphere, lithosphere, hydrosphere, or biosphere. Explain that sometimes natural events in one or more categories combine to cause a secondary hazard: Volcanic ash (lithosphere) and heavy rain (atmosphere) may create a severe mud slide. Human activities also provoke the onset of some natural events. For example, a dust storm may be the direct result of drought and strong winds, but it could have been indirectly caused by humans who removed the natural vegetation.
- Display **Overhead 3** on the projector and involve students in a discussion with the following suggested questions:

  a. Which types of disasters have occurred most frequently in the past 25 years? [Floods and typhoons/hurricanes]

b. The measures used for determining which hazards are the most deadly are "frequency" and "percentage of deaths." What other measures might have been used to determine the degree of hazard intensity? [Their speculations may include the magnitude of the event, damage to property, disruption of human services, destruction of crops, and/or changes in a country's gross national product.]

c. Compare the index of frequency to the percentage of deaths on the chart. Does frequency always correlate with percentage of deaths? Why? [Not always—frequency alone may or may not present a hazard to humans. Population density, warning systems, and peoples' preparedness influence the number of deaths.] Help students understand that some natural events have large-scale and long-term effects, such as temperature extremes. Others, such as hurricanes, are intensive, short-lived, and affect smaller areas.

d. Explain to students that this lesson focuses on four natural events (earthquakes, volcanoes, tsunamis, and typhoons) as they relate to Japan. Which of the four events are among the chart's most deadly natural hazards? [Earthquakes, typhoons, and volcanoes]

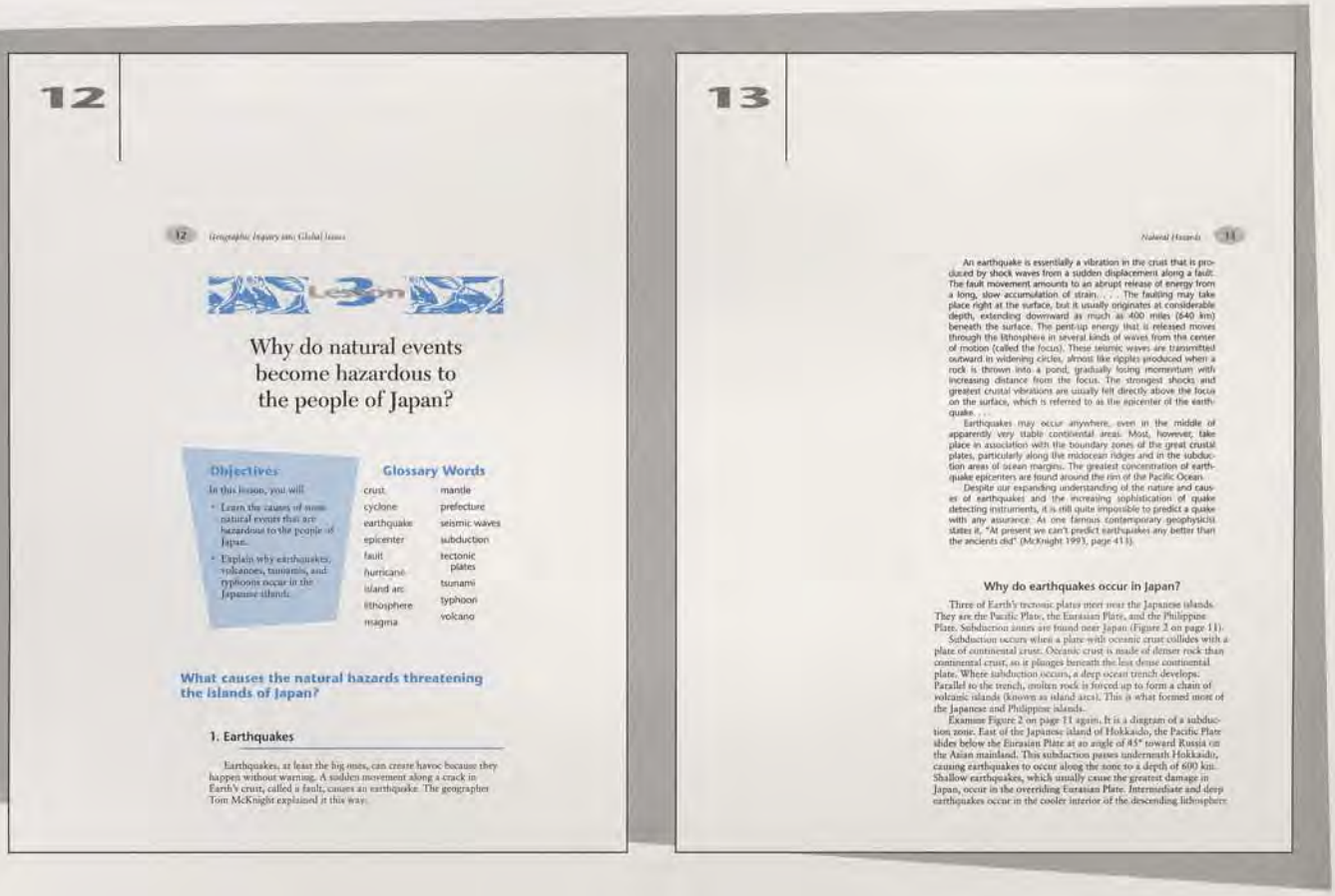
Procedures

What causes the natural hazards threatening the islands of Japan? (pages 12–18)

A. Cooperative Learning Jigsaw Activity A: Become an Expert!

a. Form four "expert" groups. Each group will address *one* natural event. Assign each group to investigate either earthquakes, volcanoes, tsunamis, or typhoons. Explain to students that each one of them will be responsible for teaching another group of students about his or her assigned event.

Students capable of handling more challenging material might be assigned to the groups learning about earthquakes and volcanoes;



12

12 Geographic Inquiry into Global Issues

Lesson

Why do natural events become hazardous to the people of Japan?

Objectives

In this lesson, you will

- Learn the causes of some natural events that are hazardous to the people of Japan.
- Explain why earthquakes, volcanoes, tsunamis, and typhoons occur in the Japanese islands.

Glossary Words

crust, cyclone, earthquake, epicenter, fault, hurricane, island arc, lithosphere, magma, mantle, prefecture, seismic waves, subduction, tectonic plates, tsunami, typhoon, volcano

What causes the natural hazards threatening the islands of Japan?

1. Earthquakes

Earthquakes, at least the big ones, can create havoc because they happen without warning. A sudden movement along a crack in Earth's crust, called a fault, causes an earthquake. The geographer Tom McKnight explained it this way:

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An earthquake is essentially a vibration in the crust that is produced by shock waves from a sudden displacement along a fault. The fault movement amounts to an abrupt release of energy from a long, slow accumulation of strain. . . . The faulting may take place right at the surface, but it usually originates at considerable depth, extending downward as much as 400 miles (640 km) beneath the surface. The pent-up energy that is released moves through the lithosphere in several kinds of waves from this center of motion (called the focus). These seismic waves are transmitted outward in widening circles, almost like ripples produced when a rock is thrown into a pond, gradually losing momentum with increasing distance from the focus. The strongest shocks and greatest crustal vibrations are usually felt directly above the focus on the surface, which is referred to as the epicenter of the earthquake. . . .

Earthquakes may occur anywhere, even in the middle of apparently very stable continental areas. Most, however, take place in association with the boundary zones of the great crustal plates, particularly along the midocean ridges and in the subduction areas of ocean margins. The greatest concentration of earthquake epicenters are found around the rim of the Pacific Ocean.

Despite our expanding understanding of the nature and causes of earthquakes and the increasing sophistication of quake detecting instruments, it is still quite impossible to predict a quake with any assurance. As one famous contemporary geophysicist states it, "At present we can't predict earthquakes any better than the ancients did" (McKnight 1993, page 411).

Why do earthquakes occur in Japan?

Three of Earth's tectonic plates meet near the Japanese islands. They are the Pacific Plate, the Eurasian Plate, and the Philippine Plate. Subduction zones are found near Japan (Figure 2 on page 11).

Subduction occurs when a plate with oceanic crust collides with a plate of continental crust. Oceanic crust is made of denser rock than continental crust, so it plunges beneath the less dense continental plate. Where subduction occurs, a deep ocean trench develops. Parallel to the trench, molten rock is forced up to form a chain of volcanic islands (known as island arcs). This is what formed most of the Japanese and Philippine islands.

Examine Figure 2 on page 11 again. It is a diagram of a subduction zone. East of the Japanese island of Hokkaido, the Pacific Plate slides below the Eurasian Plate at an angle of 45° toward Russia on the Asian mainland. This subduction passes underneath Hokkaido, causing earthquakes to occur along the zone to a depth of 600 km. Shallow earthquakes, which usually cause the greatest damage in Japan, occur in the overriding Eurasian Plate. Intermediate and deep earthquakes occur in the cooler interior of the descending lithosphere

this material is somewhat more complex. Have each group read the beginning of the lesson and then only the material for their group.

b. Provide each student with a copy of **Activity 3**. Students should read their group's information with others in their group, discuss what they've read in the Student DataBook, and explain in their own words what they've learned. Figure 2 on page 11 and Figure 3 on page 18 help illustrate some of the points discussed in the text. Remind students that important items in the readings are defined in the Glossary. (If possible, provide students in Expert Group 1 with several pieces of floor tile or other flexible material so they can demonstrate subduction in Jigsaw Activity B.)

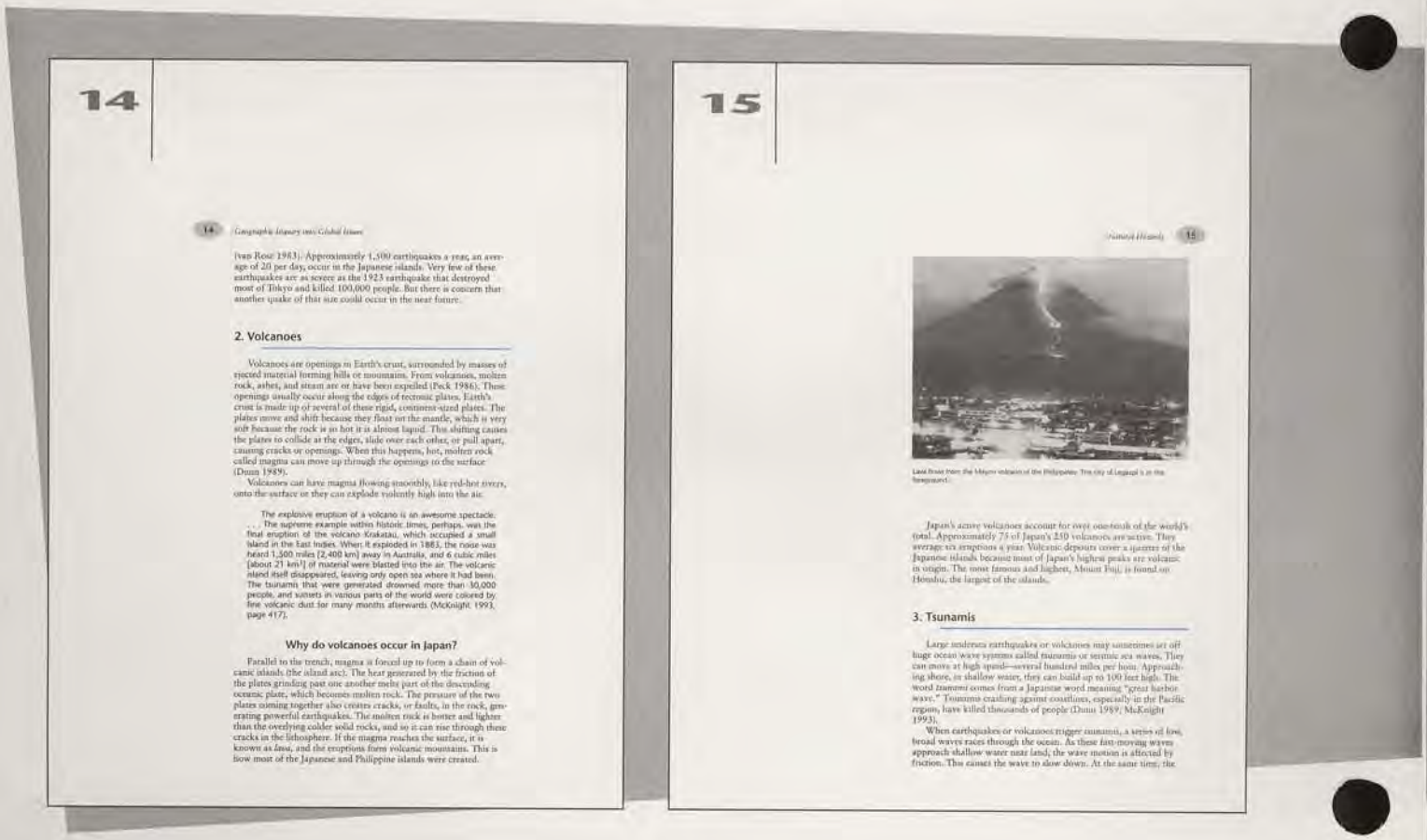
c. Allow time for the expert groups to complete the appropriate categories on their Hazard Charts (Activity 3).

d. Hand each member of each group a slip of paper with the number 1, 2, 3, or 4. Students will form new groups according to that number. If there are more than four students in a group, repeat the assignment of numbers.

B. Cooperative Learning Jigsaw Activity B: Teach Your Friends!

a. After Jigsaw Activity A, students with the same number will create four new groups. In the new groups there will be (at least) one "expert" from each of the original groups to report on an area of expertise—earthquakes, volcanoes, tsunamis, and typhoons.

b. Using the information presented by the "experts," each student will then fill in the missing parts of his or her Hazard Chart (Activity 3). See *Key for Activity 3*.



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(van Rose 1983). Approximately 1,500 earthquakes a year, an average of 20 per day, occur in the Japanese islands. Very few of these earthquakes are as severe as the 1923 earthquake that destroyed most of Tokyo and killed 100,000 people. But there is concern that another quake of that size could occur in the near future.

2. Volcanoes

Volcanoes are openings in Earth's crust, surrounded by masses of ejected material forming hills or mountains. From volcanoes, molten rock, ashes, and steam are or have been expelled (Peck 1986). These openings usually occur along the edges of tectonic plates. Earth's crust is made up of several of these rigid, continent-sized plates. The plates move and shift because they float on the mantle, which is very stiff because the rock is as hot it is almost liquid. This shifting causes the plates to collide at the edges, slide over each other, or pull apart, causing cracks or openings. When this happens, hot, molten rock called magma can move up through the openings to the surface (Dunn 1989).

Volcanoes can have magma flowing smoothly, like red-hot rivers, onto the surface or they can explode violently high into the air.

> The explosive eruption of a volcano is an awesome spectacle. . . . The supreme example within historic times, perhaps, was the final eruption of the volcano Krakatau, which occupied a small island in the East Indies. When it exploded in 1883, the noise was heard 1,500 miles [2,400 km] away in Australia, and 6 cubic miles [about 21 km³] of material were blasted into the air. The volcanic island itself disappeared, leaving only open sea where it had been. The tsunamis that were generated drowned more than 30,000 people, and sunsets in various parts of the world were colored by fine volcanic dust for many months afterwards (McKnight 1993, page 417).

Why do volcanoes occur in Japan?

Parallel to the trench, magma is forced up to form a chain of volcanic islands (the island arc). The heat generated by the friction of the plates grinding past one another melts part of the descending oceanic plate, which becomes molten rock. The pressure of the two plates coming together also creates cracks, or faults, in the rock, generating powerful earthquakes. The molten rock is hotter and lighter than the overlying colder solid rocks, and so it can rise through these cracks in the lithosphere. If the magma reaches the surface, it is known as *lava*, and the eruptions form volcanic mountains. This is how most of the Japanese and Philippine islands were created.

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Lava flows from the Mayon volcano of the Philippines. The city of Legaspi is in the foreground.

Japan's active volcanoes account for over one-tenth of the world's total. Approximately 75 of Japan's 250 volcanoes are active. They average six eruptions a year. Volcanic deposits cover a quarter of the Japanese islands because most of Japan's highest peaks are volcanic in origin. The most famous and highest, Mount Fuji, is found on Honshu, the largest of the islands.

3. Tsunamis

Large undersea earthquakes or volcanoes may sometimes set off huge ocean wave systems called tsunamis or seismic sea waves. They can move at high speed—several hundred miles per hour. Approaching shore, or shallow water, they can build up to 100 feet high. The word *tsunami* comes from a Japanese word meaning "great harbor wave." Tsunamis crashing against coastlines, especially in the Pacific region, have killed thousands of people (Dunn 1989; McKnight 1993).

When earthquakes or volcanoes trigger tsunamis, a series of low, broad waves races through the ocean. As these fast-moving waves approach shallow water near land, the wave motion is affected by friction. This causes the wave to slow down. At the same time, the

For Further Inquiry

Provide students with copies of **Activity 4.** Ask them to complete it as an assessment of their cooperative group experience in this lesson. You may want to use their replies in drafting future lesson plans.

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height of the wave increases as it strikes the land. Sometimes tsunamis are preceded by a sudden withdrawal of water from the shore, causing the sea surface to recede from shore. Then the massive wall of water surges ashore, reaching places far out of the reach of normal waves. This situation occurred in Hilo, Hawaii, in 1923, when a great tsunami was preceded by a sudden withdrawal of water. Many people ran onto the beach to pick up fish exposed on the land. They were then all washed away when the crest of the tsunami struck and engulfed the coast (Obrebunder and Moller 1987).

On March 27, 1964, the Great Alaskan Earthquake caused giant tsunamis that took lives and destroyed homes, businesses, and boats in coastal towns around the North Pacific, from California to Alaska to Japan. The damages caused by the huge waves were more serious than those caused by the earthquake that triggered the tsunamis.

> Kodiak, Alaska, was battered by an awesome 30-foot tsunami that lifted bodily a number of 50- to 100-foot king-crab boats, hurling them several blocks inland. At Seward, the big waves wrought widespread waterfront destruction. Five blocks simply disappeared—ceased to exist! Assorted warehouses and a halibut cannery were wiped out, and upward of 30 fishing boats and a similar number of pleasure crafts were destroyed or damaged beyond repair. The town of Chenega, on a small island near the quake epicenter under Prince William Sound, took the brunt of a 90-foot tsunami that wiped out one-third of the local population. In all, 92 percent of all fatalities claimed by this great upheaval were caused by rampaging seismic sea waves (Mooney 1980, page 131).

Why do tsunamis occur in Japan?

The Pacific coast of Japan is highly exposed to tsunamis, which are mainly caused by earthquakes occurring along the "Ring of Fire." Records of the following tsunamis provide examples of the damage and the hazards to people. (Refer to Figure 1 on page 5 for locations of the places mentioned.)

- June 15, 1896—At least 27,000 people were killed by three large tsunami waves. Practically every town and village along the Sanriku coast of northeastern Japan was destroyed.
- March 3, 1933—Approximately 2,986 people were killed and 5,000 houses were destroyed by a tsunami that was caused by earthquake activity in the ocean off the Sanriku coast of Japan.
- December 21, 1946—A severe earthquake in southwestern Japan generated a tsunami that invaded the coasts of Shikoku and the Kii Peninsula. Over 1,451 houses were swept away on the coast of Kochi prefecture.

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- May 24, 1960—180 people were killed and severe damage occurred in the districts of Tohoku and Hokkaido following an earthquake in Chile on May 22 (Murty 1977, pages 215–220).

Japan is especially vulnerable to tsunamis because of its location in an area where three tectonic plates converge. Earthquakes and landslides on the ocean floor are the primary causes of the approximately 150 tsunamis counted yearly in Japan. Efforts to gather data and develop more sophisticated warning systems have increased in Japan, as more human activities concentrate in the coastal areas.

4. Typhoons

Typhoon is one of the names given to a type of tropical cyclone storm. These rotating storms have winds of at least 75 mph. Such storms are called typhoons when they occur in the Indian Ocean, the South China Sea, and the western Pacific Ocean. They are identical to the hurricanes that form over the eastern Pacific, the Caribbean Sea, and the Atlantic Ocean.

> Typhoons originate out over the ocean as small cells of low pressure that develop into upward-spiraling wind patterns, fueled by the energy released by warm, moist, tropical sea air. The winds sometimes reach speeds up to 200 km/h (125 mph) and can cause enormous damage, destroying houses, bringing down power lines, flattening the ripening rice and downing tree crops. Heavy rain, often with over 300 mm (12 in) falling in 24 hours, causes flooding and landslides. Flooding in coastal areas is also caused by the huge waves that are whipped up by the wind, particularly when they are funneled into deep inlets and bays (Gregory 1990, page 233).

Why do typhoons occur in Japan?

Typhoons are a major natural hazard of the northwest Pacific. These rotating storms of the tropics bring very high winds and torrential rainfall. They strike principally between July and November and disrupt the normal seasonal weather pattern. The number in any one year varies between 3 and 30; they are more frequent in Japan than Korea. They occur more in the southern Japanese islands, because those islands are closer to warmer ocean waters.

> Typhoons reaching Japan curve first northwest and then northeast in front of prevailing winds, before dissipating their energy over colder sea or land [Figure 3 on page 18]. Typhoons

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originate over the warm waters of the southwest Pacific in unstable atmospheric conditions. They are moved to the west by the trade winds but curve to the right, following northwesterly and then northeasterly tracks before they die out over the land or the cooler waters of the north. The western and southern coasts of Kyushu suffer most typhoon damage (Gregory 1990, page 233).

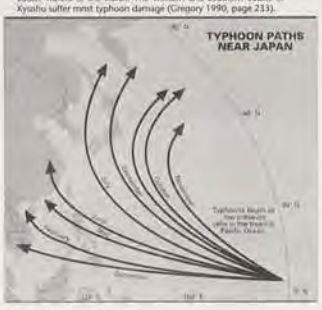

Figure 3 Typhoon paths near Japan.

Source: Gregory 1990.

Lesson 4

Are natural events more hazardous or less hazardous today than in the past?

Time Required

One 50-minute class period

Materials Needed

Copies of Activity 5 for all students

Glossary Words

density

natural disaster

Procedures

Are the Japanese people more vulnerable or less vulnerable to natural hazards today? (pages 19–23)

A. Divide students into groups of four and ask each group to choose a recorder and a reporter. Provide all students with copies of Activity 5.

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Lesson 4

Are natural events more hazardous or less hazardous today than in the past?

Objectives

In this lesson, you will

- Analyze data to decide whether natural events are more hazardous or less hazardous to the people of Japan today than in the past.
- Speculate whether the developments in Japan have global implications.

Glossary Words

density

natural disaster

Are the Japanese people more vulnerable or less vulnerable to natural hazards today?

Many people live and work in parts of the world where natural disasters occur. The global toll from natural disasters is on the rise, despite an extraordinary human effort to control the natural world. In the developing world, the loss of life is increasing. In developing countries, there is often little alternative to staying in areas known to be in danger. More developed nations, however, can afford to prepare for the consequences of natural hazards. The Japanese are leaders in the effort to predict and prepare for natural hazards.

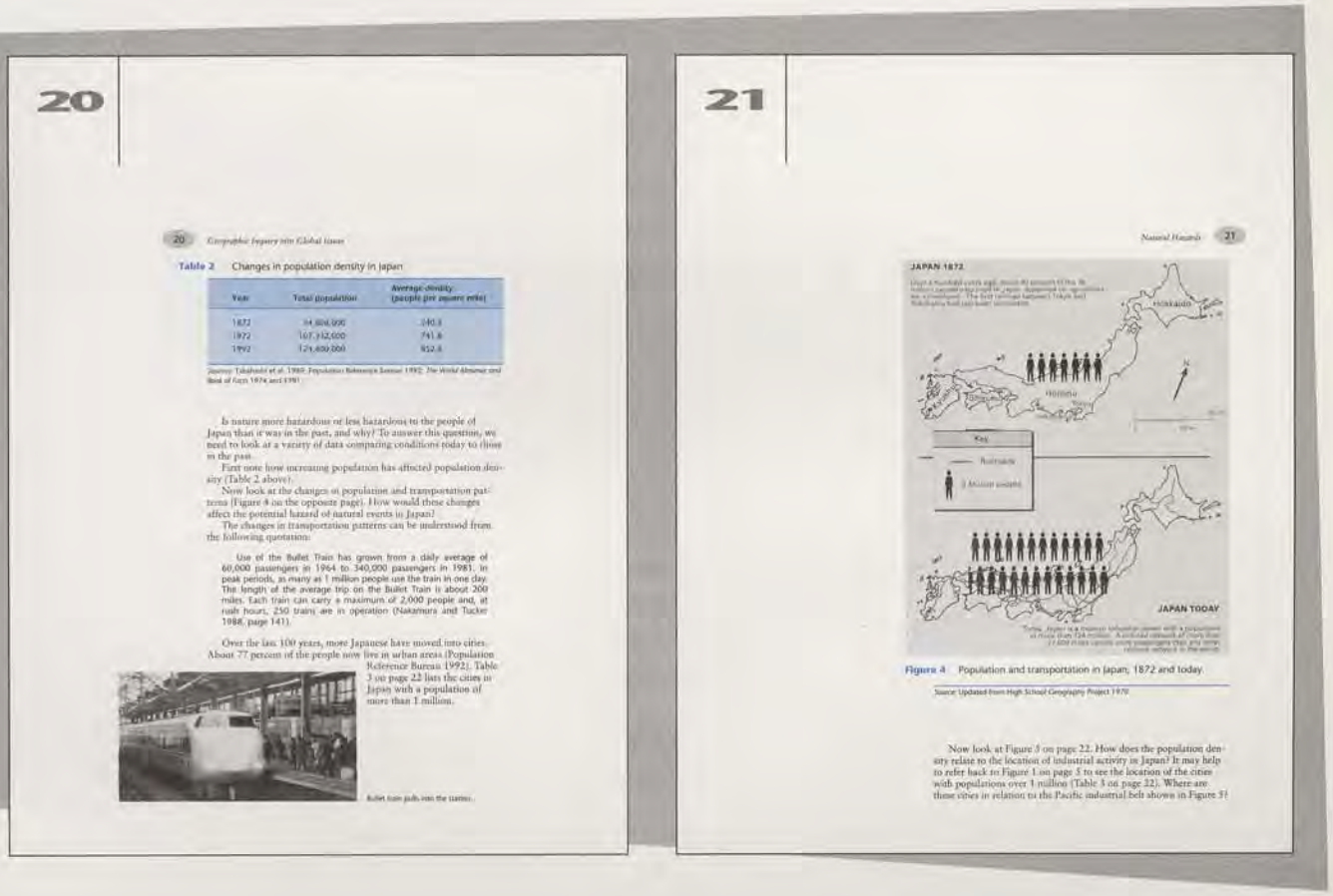
B. Ask students to use the data on Japan in the tables and figures in this lesson to identify reasons why Japan is more vulnerable or less vulnerable to natural hazards today than in the the past. Students can use Activity 5 for notes. Have students use Figure 1 on page 5 to find the cities listed in Table 3 on page 22, and to compare these locations to the main industrial zones on Figure 5 on page 22.

C. Instruct the recorders to compile their group's findings on the group copy of Activity 5. (See *Key for Activity 5* for possible responses. Students should note the correspondence among the locations of the largest cities, the expanding "Pacific Industrial Belt," and the zone of greatest risk from natural hazards.) *Note:* Recorders should keep completed Activity 5 for use in Lesson 5.

D. For the final part of this lesson, ask students to speculate on whether Japan's increased population (and therefore increased hazard risk) is representative of a trend for the rest of the world. Make sure they provide logical reasons.

For Further Inquiry

- You may want to assign an essay question in which students discuss why increases in population density, centralization in transportation patterns, and increased reliance on energy imports might prove problematic in the event of a natural disaster.
- Make sure students understand that the locations of Japan's largest cities, its principal industrial region, and its zone of highest hazard risk essentially overlap.



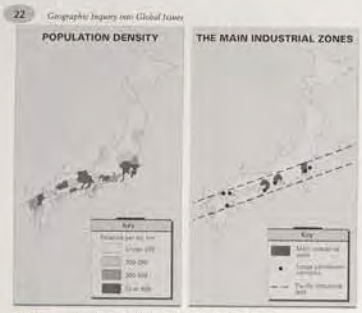


Figure 5 Population density in Japan and location of main industrial zones.

Source: Density map from Peck 1986; industrial zones map from Takahashi et al. 1989.

Table 3 Cities with populations over 1 million, 1987

Tokyo*	8,209,000	Kobe	1,413,000
Yokohama	3,072,000	Fukuoka	1,142,000
Osaka	2,546,000	Kawasaki	1,096,000
Nagoya	2,091,000	Kitakyushu	1,042,000
Sapporo	1,555,000	Hiroshima	1,034,000
Kyoto	1,469,000		

*Figure for Tokyo is the population for the 23 wards of Tokyo proper, not that of the Greater Metropolitan Tokyo administrative district, which covers a wide area embracing some sparsely populated places and even some offshore islands.

Source: Takahashi et al. 1989.

Table 4 shows some of the energy supplies needed to keep these industrial areas running. On which primary energy sources is Japan's economy becoming more reliant? On which sources is Japan becoming less reliant? How would the occurrence of a natural disaster affect the movements of these energy supplies into the cities?

Table 4 Sources of primary energy in Japan, 1960 and 1986 (10,000 billion kilocalories)

	1960	1986
Coal and lignite	49.5	76.4
Petroleum	35.4	220.6
Hydroelectricity	14.3	21.1
Nuclear electricity	—	41.2
Natural gas and liquefied natural gas	0.9	40.4
Firewood and charcoal	3.6	0.1
Total	93.7	399.8

Source: Takahashi et al. 1989.

Lesson 5

How do the people of Japan prepare for natural hazards?

Time Required

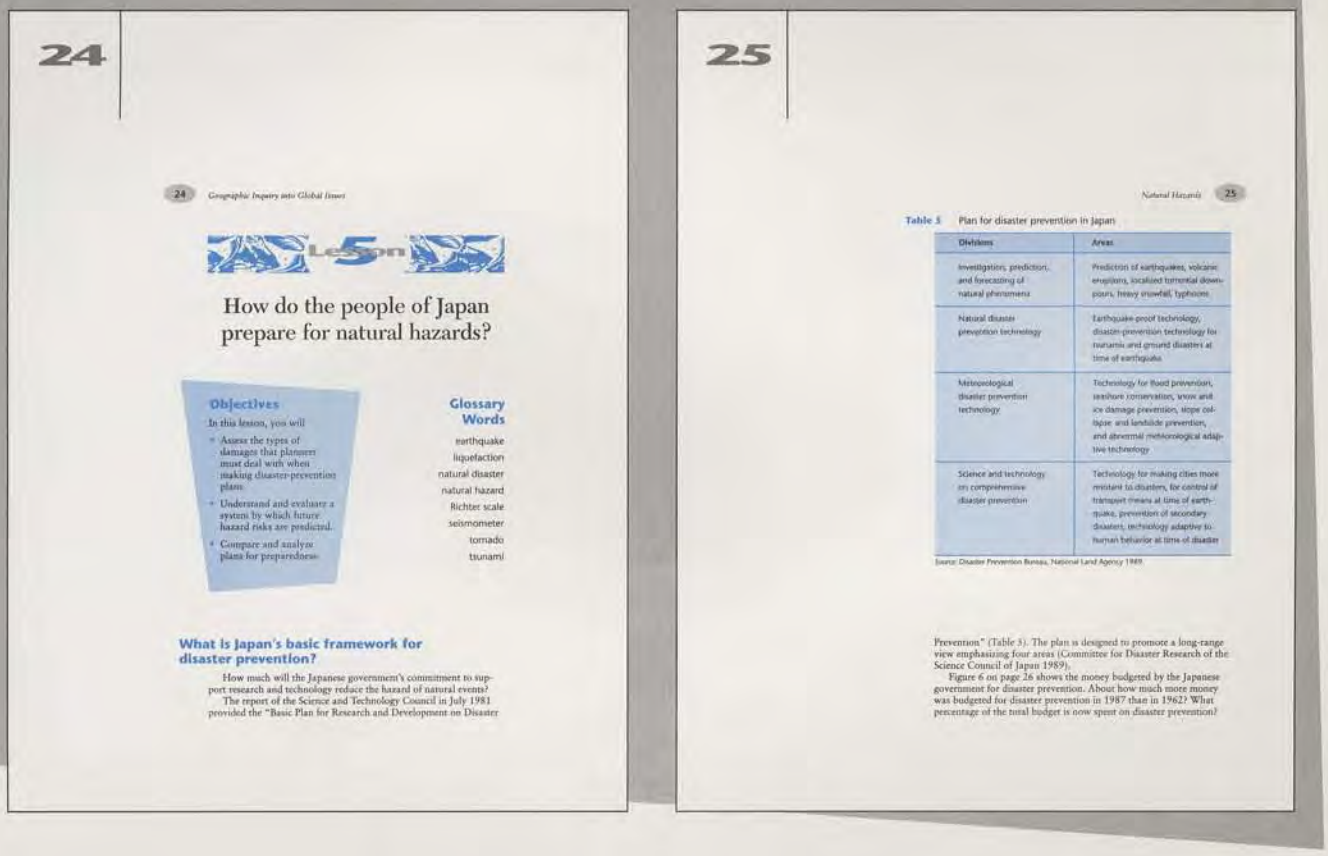
Two 50-minute class periods

Materials Needed

Handouts 1, 2, and 3 for each group of students
Completed Activity 5 from previous lesson

Glossary Words

earthquake
liquefaction
natural disaster
natural hazard
Richter scale
seismometer
tornado
tsunami



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Lesson 5

How do the people of Japan prepare for natural hazards?

Objectives

In this lesson, you will

- Assess the types of damages that planners must deal with when making disaster-prevention plans.
- Understand and evaluate a system by which future hazard risks are predicted.
- Compare and analyze plans for preparedness.

Glossary Words

earthquake
liquefaction
natural disaster
natural hazard
Richter scale
seismometer
tornado
tsunami

What is Japan's basic framework for disaster prevention?

How much will the Japanese government's commitment to support research and technology reduce the hazard of natural events?

The report of the Science and Technology Council in July 1981 provided the "Basic Plan for Research and Development on Disaster

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Natural Hazards 25

Table 5 Plan for disaster prevention in Japan

Divisions	Areas
Investigation, prediction, and forecasting of natural phenomena	Prediction of earthquakes, volcanic eruptions, localized torrential downpours, heavy snowfall, typhoons
Natural disaster prevention technology	Earthquake-proof technology, disaster-prevention technology for tsunamis and ground disasters at time of earthquake
Meteorological disaster prevention technology	Technology for flood prevention, seashore conservation, snow and ice damage prevention, slope collapse and landslide prevention, and abnormal meteorological adaptive technology
Science and technology on comprehensive disaster prevention	Technology for making cities more resistant to disasters, for control of transport means at time of earthquake, prevention of secondary disasters, technology adaptive to human behavior at time of disaster

Source: Disaster Prevention Bureau, National Land Agency 1989

Prevention" (Table 5). The plan is designed to promote a long-range view emphasizing four areas (Committee for Disaster Research of the Science Council of Japan 1989).

Figure 6 on page 26 shows the money budgeted by the Japanese government for disaster prevention. About how much more money was budgeted for disaster prevention in 1987 than in 1962? What percentage of the total budget is now spent on disaster prevention?

Getting Started

Ask students to think of different attitudes people might have regarding a potential hazard in their community. Examples might include:

a. *Denial* — "It won't happen here," or "It won't happen again."

b. *Fatalistic* — "There's nothing we can do about it. If it happens, it happens."

c. *Preventive action* — "The next time we'll be ready."

d. *Escape* — "Let's get out of here. This is a dangerous place to live."

Procedures

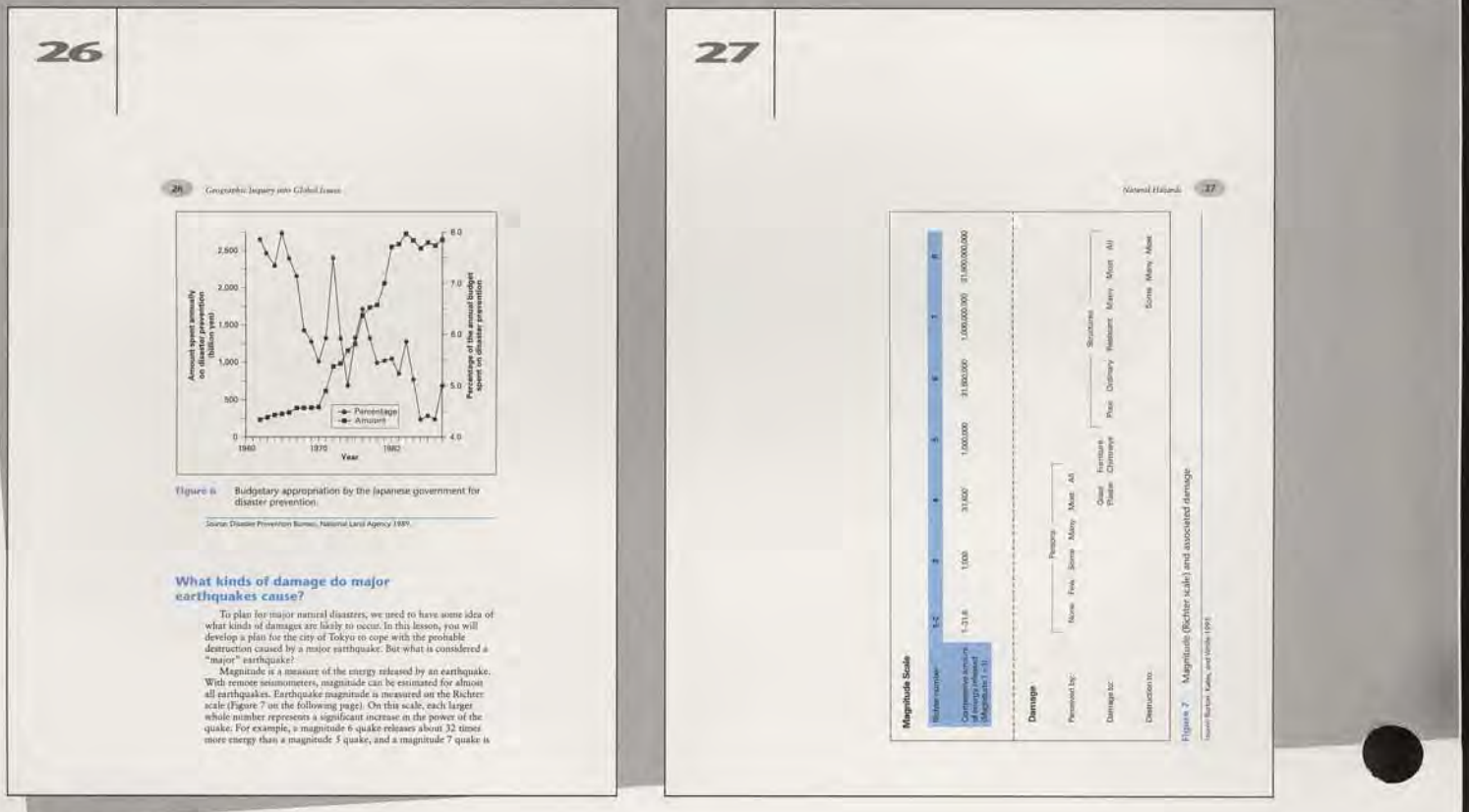
What is Japan's basic framework for disaster prevention? (pages 24–26)

A. Have students read this section as they work in the same groups from the previous lesson. Students should examine Table 5 on page 25 and Figure 6 on page 26. [Students should see that appropriations are about 2,000 billion more yen annually in 1987 than in 1962; this represents about 5 percent of the total budget.] After these data are examined, students can review **Activity 5** from the previous lesson and perhaps reconsider why they believe Japan is more hazardous or less hazardous today than it was in the past.

B. Remind students that there is no right or wrong answer to the title question of Activity 5. However, they should develop a sound rationale for their decisions based on the data. Have the reporter from each group present the group's final decision and summarize the reasons the group reached its conclusion. Tally all group decisions on the blackboard and invite discussion.

What kinds of damage do major earthquakes cause? (pages 26–30)

C. Read together with students the material about the earthquake magnitude scale and examine Figure 7 on page 27. Remind students that Tokyo is located in an area where the Pacific



and Philippine Plates subduct beneath the Eurasian Plate, causing earthquakes to occur. Students should see that occurrence of another earthquake of the size of the 1923 Great Kanto quake is a near certainty, and in fact, somewhat overdue.

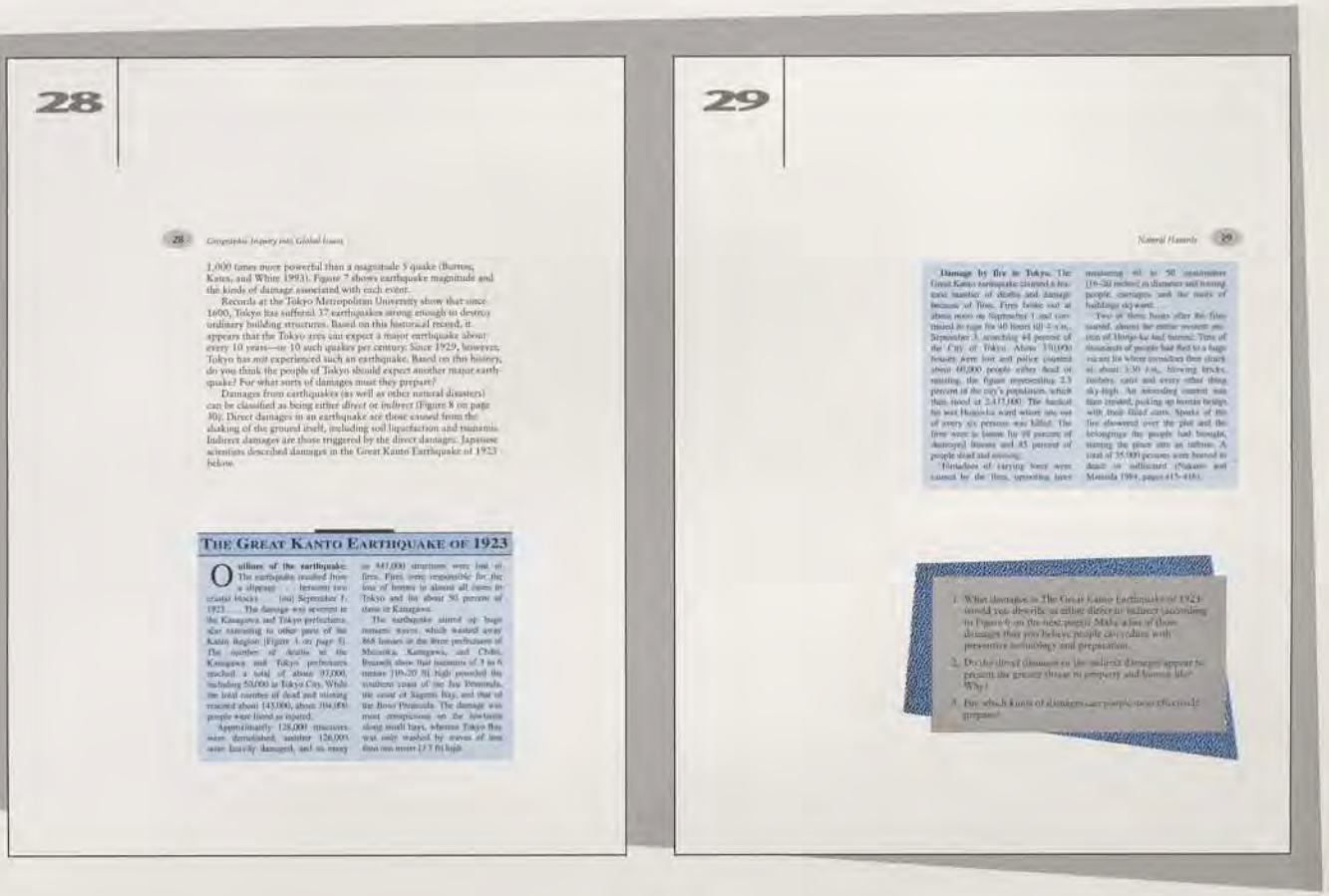
Read with students the definitions for direct and indirect damages on page 28 and discuss Figure 8 on page 30. According to the diagram, direct damages are caused by ground vibrations, tsunamis, and soil liquefaction (when soil liquefies under unusual pressure and stress). Indirect damages are caused by the direct damage. Some damages can be interpreted as resulting from both indirect and direct causes, such as injuries and deaths.

Ask students to read the account of the Great Kanto Earthquake on pages 28–29 and answer Questions 1–3 on page 29 following the reading. For homework, you might wish to ask students to imagine that an earthquake hit San Francisco and they were there to witness the event. They should study Figures 7 and 8 on pages 27 and 30 and write two or three paragraphs for a newspaper story. The quake was magnitude 8. They should report that everyone perceived the quake, most structures were damaged, and many were destroyed, according to Figure 7 for a magnitude 8 quake.

How should the people of Tokyo prepare for a major earthquake? (pages 30–31)

D. Before students read this section, explain that Tokyo is one of the world's largest cities, and it is the economic and industrial hub of Japan. Tokyo accounts for 25 percent of Japan's population and 30 percent of its gross national product. Therefore, it is important to develop countermeasures that will alleviate damages should another earthquake occur.

Divide students into six cooperative learning groups. Assign two groups to each of the three categories of countermeasures listed in the Student DataBook on pages 30–31: (1) prevention, (2) preparation and emergency relief, and (3) recovery. Ask the groups to draft a plan of action according to their assigned countermeasures.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1,000 times more powerful than a magnitude 5 quake (Burton, Kates, and White 1993). Figure 7 shows earthquake magnitude and the kinds of damage associated with each event.

Records at the Tokyo Metropolitan University show that since 1600, Tokyo has suffered 37 earthquakes strong enough to destroy ordinary building structures. Based on this historical record, it appears that the Tokyo area can expect a major earthquake about every 10 years—or 10 such quakes per century. Since 1929, however, Tokyo has *not* experienced such an earthquake. Based on this history, do you think the people of Tokyo should expect another major earthquake? For what sorts of damages must they prepare?

Damages from earthquakes (as well as other natural disasters) can be classified as being either *direct* or *indirect* (Figure 8 on page 30). Direct damages in an earthquake are those caused from the shaking of the ground itself, including soil liquefaction and tsunamis. Indirect damages are those triggered by the direct damages. Japanese scientists described damages in the Great Kanto Earthquake of 1923 below.

The Great Kanto Earthquake of 1923

Outlines of the earthquake: The earthquake resulted from a slippage . . . between two crustal blocks . . . [on] September 1, 1923. . . . The damage was severest in the Kanagawa and Tokyo prefectures, also extending to other parts of the Kanto Region (Figure 1 on page 5). The number of deaths in the Kanagawa and Tokyo prefectures reached a total of about 93,000, including 50,000 in Tokyo City. While the total number of dead and missing reached about 143,000, about 104,000 people were listed as injured.

Approximately 128,000 structures were demolished, another 126,000 were heavily damaged, and as many as 447,000 structures were lost to fires. Fires were responsible for the loss of homes in almost all cases in Tokyo and for about 50 percent of them in Kanagawa.

The earthquake stirred up huge tsunami waves, which washed away 868 houses in the three prefectures of Shizuoka, Kanagawa, and Chiba. Records show that tsunamis of 3 to 6 meters [10–20 ft] high pounded the southern coast of the Boso Peninsula, the coast of Sagami Bay, and that of the Izu Peninsula. The damage was most conspicuous on the lowlands along small bays, whereas Tokyo Bay was only washed by waves of less than one meter [3.3 ft] high.

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Natural Hazards 29

Damage by fire in Tokyo. The Great Kanto earthquake claimed a massive number of deaths and damage because of fires. Fires broke out at about noon on September 1 and continued to rage for 40 hours till 3 a.m., September 3, scorching 44 percent of the City of Tokyo. About 150,000 houses were lost and police counted about 60,000 people either dead or missing, the figure representing 2.3 percent of the city's population, which then stood at 2,477,000. The hardest hit was Honjo-ku ward where one out of every six persons was killed. The fires were to blame for 91 percent of destroyed houses and 85 percent of people dead and missing.

Tornadoes of varying force were caused by the fires, uprooting trees measuring 40 to 50 centimeters [16–20 inches] in diameter and tossing people, carriages, and the roofs of buildings sky-ward.

Two or three hours after the fires started, almost the entire western portion of Honjo-ku had burned. Tens of thousands of people had fled to a huge vacant lot where nowadays their clothes, at about 3:30 p.m., blowing, bricks, timbers, cans and every other thing sky-high. An unending current was then created, picking up human beings with their filled carts. Sparks of this fire showered over the plot and the belongings the people had brought, turning the place into an inferno. A total of 35,000 persons were burned to death or suffocated (Yokoami and Matsuda 1984, pages 415–416).

1. What damages in The Great Kanto Earthquake of 1923 would you describe as either direct or indirect (according to Figure 8 on the next page)? Make a list of those damages that you believe people can reduce with preventive technology and preparation.
2. Do the direct damages or the indirect damages appear to present the greater threat to property and human life? Why?
3. For which kinds of disasters are people most effectively prepared?

Questions and Answers for page 29

1. What damages in the Great Kanto Earthquake of 1923 would you describe as either direct or indirect (according to Figure 8)? Make a list of those damages that you believe people can reduce with preventive technology and preparation.
   - Direct: Structures demolished or damaged; losses of human life; tsunamis; damaged roads, etc.
   - Indirect: Fires; losses of life; explosions
   - Damages to be reduced could include structural damage with better, more quake-resistant construction, etc.

2. Do the direct damages or the indirect damages appear to present the greater threat to property and human life? Why?
   - In this case, the fires caused the greater damage (indirect) than that resulting from the quakes. The article states that fires were responsible for nearly all loss of property in Tokyo and about 50 percent in Kanagawa.

3. For which kinds of damages can people most effectively prepare?
   - This is an opinion question, partly to get students thinking about the next activity.

E. The summary of expected damages identified by the Tokyo Metropolitan Survey (Table 6 on page 31) will help groups focus on specific needs. Have the groups identify which damages listed in Table 6 are direct and which are indirect (see *Key for Table 6).*

F. Have each group post its plan.

G. Assign each group to critique another group's plan by comparing it to the official plans described in **Handouts 1, 2,** and **3.**

Key for Table 6

CALCULATED DAMAGE FROM A FUTURE EARTHQUAKE IN TOKYO

Totally collapsed wooden houses [Direct]
Collapsed walls and landslides [Direct]
Major bridges damaged [Direct]
Water supply pipes damaged, main pipes only [Direct]
City gas pipes damaged [Direct]
Houses burned by fires [Indirect]
Flood-damaged houses [Indirect]
Sufferers [Direct/Indirect]
Affected families [Direct/Indirect]
Injured [Direct/Indirect]
Dead [Direct/Indirect]

For Further Inquiry

- You may want to test for understanding by asking students to identify the following as Direct or Indirect:
  a. Vibration of Earth causes structures to collapse [Direct]
  b. Landslips or slides occur when soil liquefies [Direct]
  c. Gas lines rupture [Direct]
  d. Large areas are destroyed by fire storms [Indirect]
  e. Faulting in Earth causes a dam to crack [Direct]
  f. Floods from a damaged dam destroy everything in their path [Indirect]
  g. Sparks from electrical appliances ignite gases and set homes afire [Indirect]
  h. Houses flood when domestic water pipes break [Indirect]
- Will future earthquakes in Tokyo cause greater damage than what occurred in the Great Kanto Earthquake of 1923? Direct students to write several paragraphs that explain why they believe a future earthquake will cause more damage or less damage. Explain to students that there is no correct answer, but the reasons for their decisions should be clearly expressed. Make sure they use data to compare the two studies and support the position taken. The best essays may be read to the class or posted. If several students take opposite positions, ask them to debate the issue.

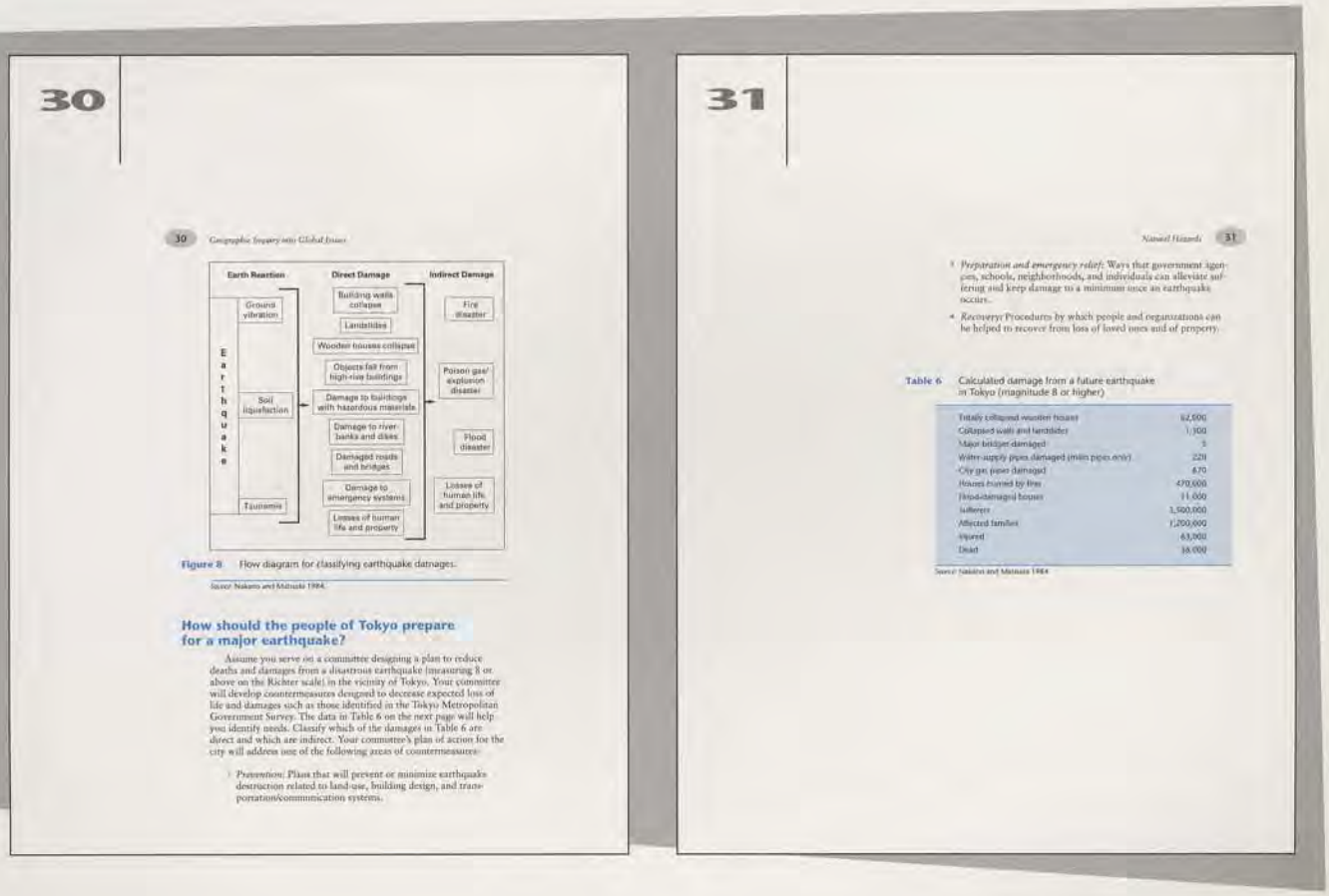
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Figure 8 Flow diagram for classifying earthquake damages.

Source: Nakano and Matsuki 1984.

How should the people of Tokyo prepare for a major earthquake?

Assume you serve on a committee designing a plan to reduce deaths and damages from a disastrous earthquake (measuring 8 or above on the Richter scale) in the vicinity of Tokyo. Your committee will develop countermeasures designed to decrease expected loss of life and damages such as those identified in the Tokyo Metropolitan Government Survey. The data in Table 6 on the next page will help you identify needs. Classify which of the damages in Table 6 are direct and which are indirect. Your committee's plan of action for the city will address one of the following areas of countermeasures:

1. *Prevention:* Plans that will prevent or minimize earthquake destruction related to land-use, building design, and transportation/communication systems.

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2. *Preparation and emergency relief:* Ways that government agencies, schools, neighborhoods, and individuals can alleviate suffering and keep damage to a minimum once an earthquake occurs.
3. *Recovery:* Procedures by which people and organizations can be helped to recover from loss of loved ones and of property.

Table 6 Calculated damage from a future earthquake in Tokyo (magnitude 8 or higher)

Totally collapsed wooden houses	82,000
Collapsed walls and landslides	1,300
Major bridges damaged	5
Water-supply pipes damaged (main pipes only)	220
City gas pipes damaged	670
Houses burned by fire	470,000
Flood-damaged houses	11,000
Sufferers	3,500,000
Affected families	1,200,000
Injured	63,000
Dead	30,000

Source: Nakano and Matsuki 1984

Lesson 6

How do people in the United States respond to earthquake hazards?

Time Required

Two 50-minute class periods

Materials Needed

Transparency of Overhead 2 from Lesson 2
Copies of Activity 6 for each group of students
Mini-Atlas maps 2 and 3

Glossary Words

earthquake

tectonic plates

Getting Started

Carry out the following activity before students read Lesson 6: Explain to students that one of the worst earthquakes in United States history occurred in San Francisco in 1906. As in the 1923 Tokyo earthquake, much of San Francisco was destroyed by fire. (Alternatively, ask if any students remember news coverage of the Los Angeles earthquake in January 1994.) Show students **Overhead 2** again and have them note that California is located on the boundary between the Pacific and North American plates (the well-known San Andreas Fault is this boundary). Thus, cities such as San Francisco and Los Angeles must live with the possibility that another great quake will occur. Remind the class about the following ideas: (1) Earthquakes can happen at any time of the day or night; and (2) Many people spend their vacations in places where earthquakes can occur. The following activity will help students think about some of the possible situations people might be in when a large earthquake strikes.

Divide the class into 10 groups. Give each member of the first group a copy of Situation 1 from **Activity 6,** the second group Situation 2, and so on. Students should follow these directions:

a. Read the situation assigned to your group.

b. Consider what your first reaction would be if you were the person in that situation. For some situations, you will need to think as if you are an adult.

c. Discuss several possibilities for preparedness actions that the person might take to survive the situation.

d. Decide on a recommendation from your group.

e. Designate a spokesperson to report the group's recommendations to the class.

Allow about 10 minutes for the groups to discuss their situations. Then have each group's spokesperson read aloud the group's situation and give a two- or three-minute report on the recommendations of the group.

Encourage further discussion about other possible situations and what students would do to prepare for them. When more than one group has reported on the same situation, ask them to discuss similarities and differences in their reports. The emphasis should *not* be on discovering a single "right" answer, but rather on the idea that there are many ways to prepare for and react to a specific situation.

Procedures

How do earthquake information guides for the United States and Japan compare? (pages 32–35)

A. Direct students to read this section. Then ask if they have ever thought about how to prepare at home for a natural hazard. Discuss whether the precautions listed in the excerpts would effectively reduce hazards in the home should an earthquake occur. Compare the U.S. and Japan Guides, using Questions 1–3 on page 33.

Where in the United States are earthquakes a hazard? (pages 35–38)

B. As students read through this section, use Figures 9 and 10 and Table 7 (pages 36–38) to help students understand that the United States, like Japan, has a hazardous environment. Students will need to see Overhead 2 (from Lesson 2 in this Teacher's Guide) to help them answer Question 4 on page 36. Questions 4–11 can be answered individually, in groups, or in class discussion. Encourage students to update the information to include earthquakes that have occurred since 1993.

Questions and Answers for page 33

1. What does each guide suggest for (a) self protection, (b) preventive measures, and (c) community support and emergency assistance?
   - Possible suggestions:
     (a) Both guides say to check for injuries; shut off electricity and gas; securely fasten heavy objects; protect self from falling objects; stay away from damaged areas; etc.

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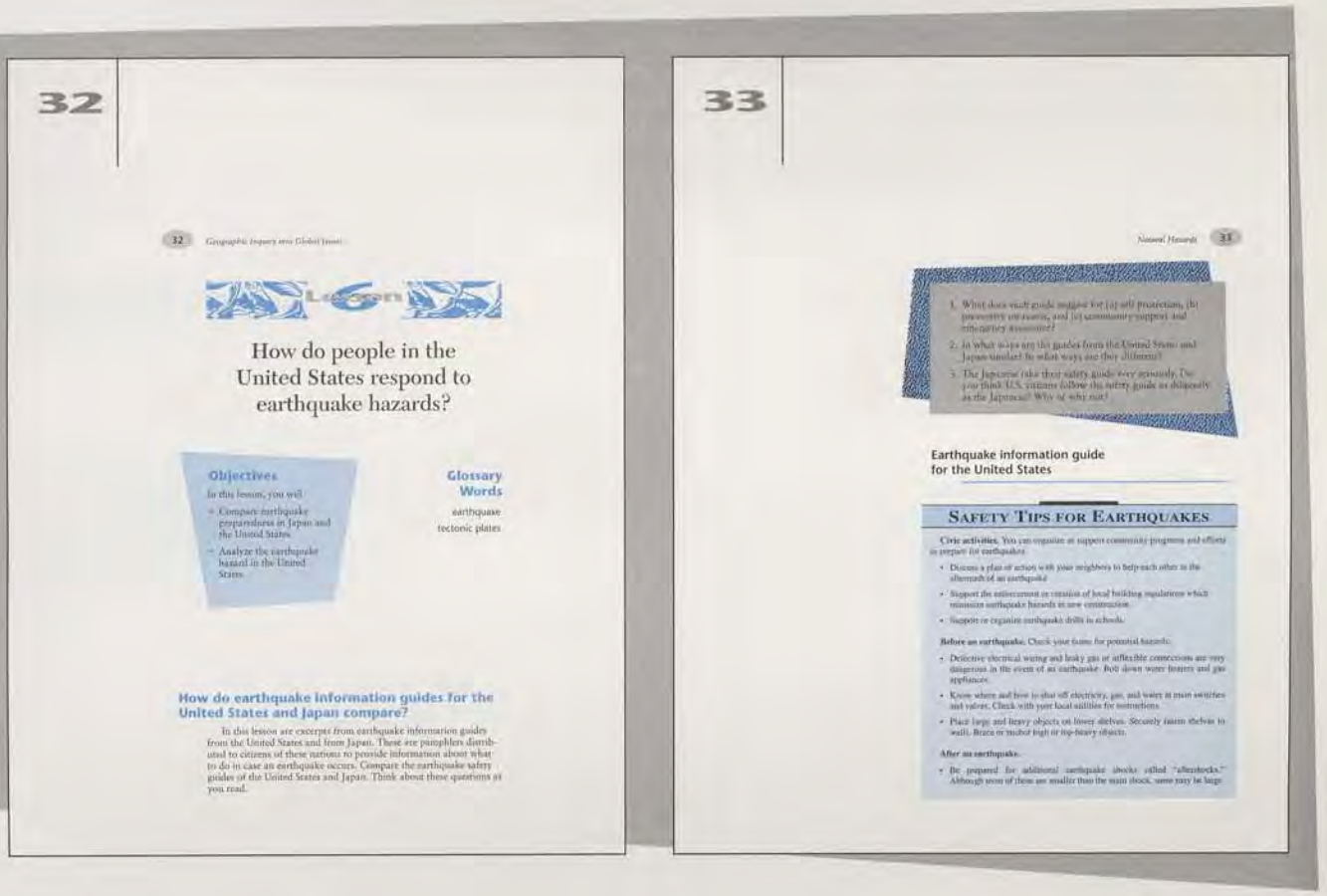


(b) Check wiring; check chimneys; secure heavy objects; etc.

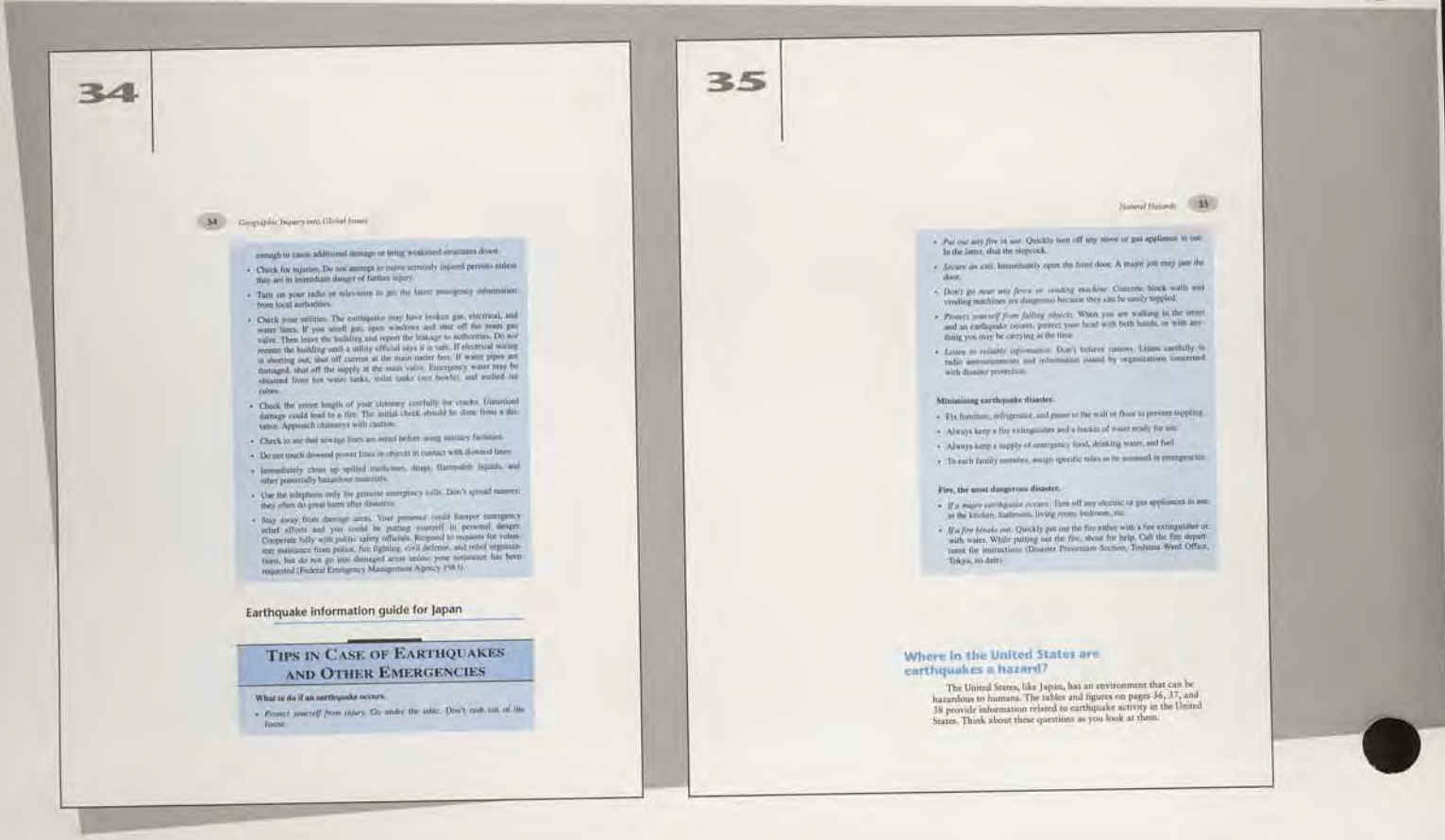
(c) Listen to radio information; organize drills; etc.

2. In what ways are the guides from the United States and Japan similar? In what ways are they different?

   - Both guides are organized in sections of what to do before, during, and after an earthquake. Both are written in short, clear sentences advising people of safety measures. The Japanese guide has a few more preventive measures and also emphasizes the danger from fire more than the United States guide. The Japanese guide also mentions assigning each family member an emergency role; the United States guide does not.

3. The Japanese take their safety guide very seriously. Do you think U.S. citizens follow their safety guide as diligently as the Japanese? Why or why not?

   - Answers will vary, but Japan probably has a larger percentage of people who take preparation for natural hazards seriously. Japan is a small country and most of the people have experienced a natural hazard first-hand or have relatives who have shared their experiences. The people are also more homogeneous in culture and values than in the United States, which enables them to agree more readily on what is of vital importance to their safety and welfare. Explain that all students in Japan receive training in school on how to deal with natural hazards.



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enough to cause additional damage or bring weakened structures down.

- Check for injuries. Do not attempt to move seriously injured persons unless they are in immediate danger of further injury.
- Turn on your radio or television to get the latest emergency information from local authorities.
- Check your utilities. The earthquake may have broken gas, electrical, and water lines. If you smell gas, open windows and shut off the main gas valve. Then leave the building and report the leakage to authorities. Do not reenter the building until a utility official says it is safe. If electrical wiring is shorting out, shut off current at the main meter box. If water pipes are damaged, shut off the supply at the main valve. Emergency water may be obtained from hot water tanks, toilet tanks (not bowls), and melted ice cubes.
- Check the entire length of your chimney carefully for cracks. Unnoticed damage could lead to a fire. The initial check should be done from a distance. Approach chimneys with caution.
- Check to see that sewage lines are intact before using sanitary facilities.
- Do not touch downed power lines or objects in contact with downed lines.
- Immediately clean up spilled medicines, drugs, flammable liquids, and other potentially hazardous materials.
- Use the telephone only for genuine emergency calls. Don't spread rumors; they often do great harm after disasters.
- Stay away from damage areas. Your presence could hamper emergency relief efforts and you could be putting yourself in personal danger. Cooperate fully with public safety officials. Respond to requests for volunteer assistance from police, fire fighting, civil defense, and relief organizations, but do not go into damaged areas unless your assistance has been requested (Federal Emergency Management Agency 1983).

Earthquake information guide for Japan

TIPS IN CASE OF EARTHQUAKES AND OTHER EMERGENCIES

What to do if an earthquake occurs.

- *Protect yourself from injury.* Go under the table. Don't rush out of the house.

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- *Put out any fire in use.* Quickly turn off any stove or gas appliance in use. In the latter, shut the stopcock.
- *Secure an exit.* Immediately open the front door. A major jolt may jam the door.
- *Don't go near any fence or vending machine.* Concrete block walls and vending machines are dangerous because they can be easily toppled.
- *Protect yourself from falling objects.* When you are walking in the street and an earthquake occurs, protect your head with both hands, or with anything you may be carrying at the time.
- *Listen to reliable information.* Don't believe rumors. Listen carefully to radio announcements and information issued by organizations concerned with disaster protection.

Minimizing earthquake disaster.

- Fix furniture, refrigerator, and piano to the wall or floor to prevent toppling.
- Always keep a fire extinguisher and a bucket of water ready for use.
- Always keep a supply of emergency food, drinking water, and fuel.
- To each family member, assign specific roles to be assumed in emergencies.

Fire, the most dangerous disaster.

- *If a major earthquake occurs:* Turn off any electric or gas appliances in use, as the kitchen, bathroom, living room, bedroom, etc.
- *If a fire breaks out.* Quickly put out the fire either with a fire extinguisher or with water. While putting out the fire, shout for help. Call the fire department for instructions (Disaster Prevention Section, Toshima Ward Office, Tokyo, no date).

Where in the United States are earthquakes a hazard?

The United States, like Japan, has an environment that can be hazardous to humans. The tables and figures on pages 36, 37, and 38 provide information related to earthquake activity in the United States. Think about these questions as you look at them.

Questions and Answers for page 36

4. Compare the locations of earthquakes in the United States (Figure 9) to the positions of the tectonic plates you saw in Overhead 2. What is the relationship of plate movement to the location of the earthquakes?

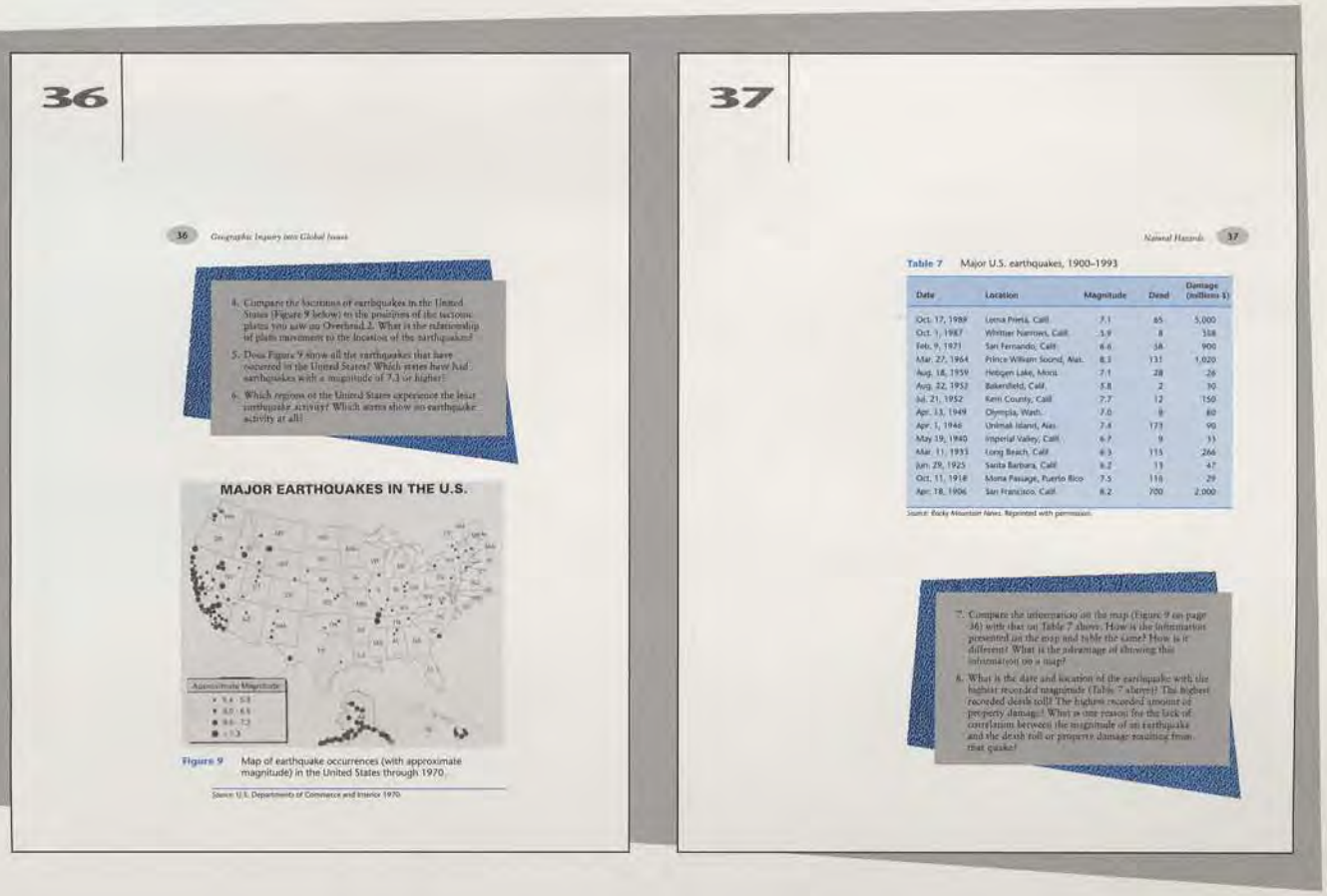
   - Most areas with earthquake activity are in zones where the tectonic plates meet, causing stress to build. The release of the stored energy results in faults and earthquakes.

5. Does Figure 9 show all the earthquakes that have occurred in the United States? Which states have had earthquakes with a magnitude of 7.3 or higher?

   - Figure 9 shows only those earthquakes with a magnitude of 5.4 and above, and in California, only those of 7.3 and above. Only quakes that occurred before 1970 are shown. States that have experienced a magnitude of 7.3 or higher are Alaska, Hawaii, Nevada, California, Missouri, and Montana, and the area north of Maine.

6. Which regions of the United States experience the least earthquake activity? Which states show no earthquake activity at all?

   - Regions experiencing the least quake activity are the Upper Midwest, Great Plains, and Gulf Coast states. North Dakota has not had any earthquake activity.



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4. Compare the locations of earthquakes in the United States (Figure 9 below) to the positions of the tectonic plates you saw on Overhead 2. What is the relationship of plate movement to the location of the earthquakes?
5. Does Figure 9 show all the earthquakes that have occurred in the United States? Which states have had earthquakes with a magnitude of 7.3 or higher?
6. Which regions of the United States experience the least earthquake activity? Which states show no earthquake activity at all?

MAJOR EARTHQUAKES IN THE U.S.

Approximate Magnitude

Figure 9 Map of earthquake occurrences (with approximate magnitude) in the United States through 1970.

Source: U.S. Departments of Commerce and Interior 1970.

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Table 7 Major U.S. earthquakes, 1900–1993

Date	Location	Magnitude	Dead	Damage (millions $)
Oct. 17, 1989	Loma Prieta, Calif.	7.1	65	5,000
Oct. 1, 1987	Whittier Narrows, Calif.	5.9	8	358
Feb. 9, 1971	San Fernando, Calif.	6.6	58	900
Mar. 27, 1964	Prince William Sound, Alas.	8.3	131	1,020
Aug. 18, 1959	Hebgen Lake, Mont.	7.1	28	26
Aug. 22, 1952	Bakersfield, Calif.	5.8	2	30
Jul. 21, 1952	Kern County, Calif.	7.7	12	150
Apr. 13, 1949	Olympia, Wash.	7.0	9	80
Apr. 1, 1946	Unimak Island, Alas.	7.4	173	95
May 19, 1940	Imperial Valley, Calif.	6.7	9	33
Mar. 11, 1933	Long Beach, Calif.	6.3	115	266
Jun. 29, 1925	Santa Barbara, Calif.	6.2	13	47
Oct. 11, 1918	Mona Passage, Puerto Rico	7.5	116	29
Apr. 18, 1906	San Francisco, Calif.	8.2	700	2,000

Source: Rocky Mountain News. Reprinted with permission.

7. Compare the information on the map (Figure 9 on page 36) with that on Table 7 above. How is the information presented on the map and table the same? How is it different? What is the advantage of showing this information on a map?
8. What is the date and location of the earthquake with the highest recorded magnitude (Table 7 above)? The highest recorded death toll? The highest recorded amount of property damage? What is one reason for the lack of correlation between the magnitude of an earthquake and the death toll or property damage resulting from that quake?

Questions and Answers for page 37

7. Compare the information on the map (Figure 9) with that on Table 7. How is the information presented on the map and table the same? How is it different? What is the advantage of showing this information on a map?

   - Both the map and the table indicate location and degree of damage. The map shows magnitude (destructive effects of the earthquakes on people and property) while the table also provides specific dates, and death tolls. Showing the data on the map allows for easier identification of regional patterns.

8. What is the date and location of the earthquake with the highest recorded magnitude (Table 7)? The highest recorded death toll? The highest recorded amount of property damage? What is one reason for the lack of correlation between the magnitude of an earthquake and the death toll or property damage resulting from that quake?

   - The earthquake with the highest recorded magnitude in Table 7 occurred March 27, 1964, in Prince William Sound, Alaska. The most deaths occurred in San Francisco in 1906. More property damage occurred in the 1989 Loma Prieta quake. The magnitude and death toll of a given earthquake won't necessarily match because earthquakes of great magnitude may occur in an area of sparse population or the people affected may have a high degree of preparedness. The cost of the damage tends to increase over time because more is invested in structures and other property.

Questions and Answers for page 38

9. Compare Figure 9 to Figure 10. Are there states with high-magnitude earthquakes that do not require earthquake education? Do you believe those states should require earthquake education? Why or why not?

   - There are many states with high-magnitude earthquakes that do not require earthquake awareness and safety education, including Nevada and Missouri, to name two. As to whether those states should require earthquake awareness education, students may consider earthquake frequency, cost, crowded curriculum, time taken from other academic instruction, and the value of awareness and preparation in saving lives.

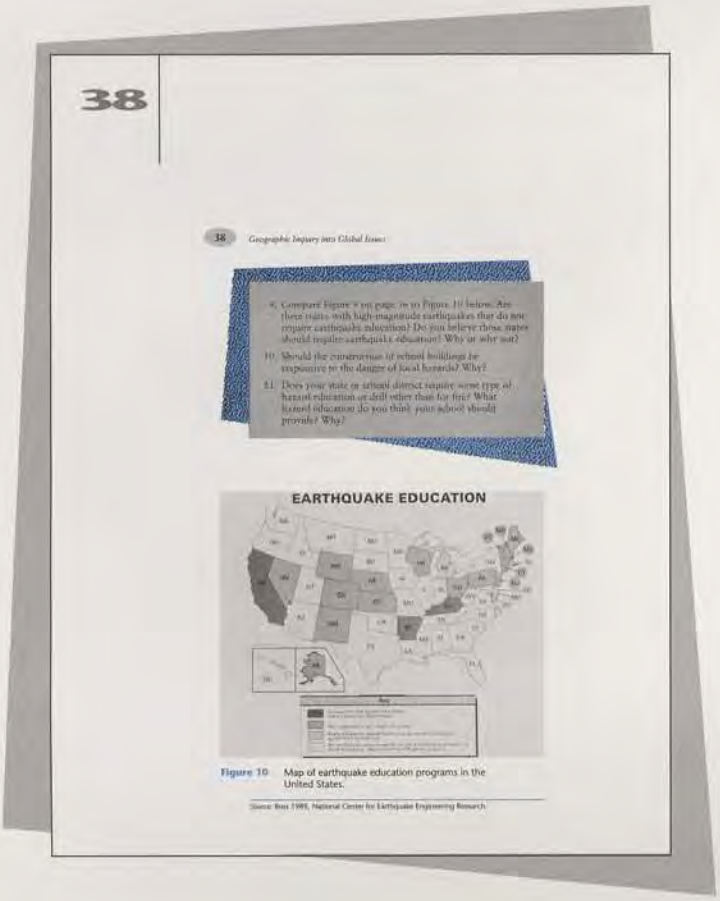
10. Should the construction of school buildings be responsive to the danger of local hazards? Why?

    - Discussion may focus on the idea that new buildings can be designed and located with local hazards in mind, but what about old buildings? Can school districts with small budgets afford to renovate the old buildings or change location because the land is unstable?

continued

11. Does your state or school district require some type of hazard education or drill other than for fire? What hazard education do you think your school should provide? Why?
    - This exercise should help students think about specific preparedness needs for hazards in their own community. Students will return to this topic at the end of Lesson 7.

C. Distribute **Mini-Atlas maps 2 and 3** to each group of three or four students. Ask groups to use these maps, along with Figure 9 (page 36) showing earthquake distribution in the United States, to consider whether *any* part of the United States is "safe" from natural hazards. [Mini-Atlas map 3 shows rivers (sites of floods), mountains (avalanches), and tornadoes. Thinking of this information together with earthquake distribution and hurricane distribution (shown on Figure 9 and Mini-Atlas map 2), it is apparent that nearly *every* region in the United States is prone to some kind of natural hazard. Students can also speculate about what areas are subject to extreme cold or hot weather spells, too, and plot those on Mini-Atlas map 3. Discuss with the class what steps each place should take to lessen hazard dangers. You may wish to have the class prepare a disaster plan for the school.]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9. Compare Figure 9 on page 36 to Figure 10 below. Are there states with high-magnitude earthquakes that do not require earthquake education? Do you believe those states should require earthquake education? Why or why not?

10. Should the construction of school buildings be responsive to the danger of local hazards? Why?

11. Does your state or school district require some type of hazard education or drill other than for fire? What hazard education do you think your school should provide? Why?

EARTHQUAKE EDUCATION

Figure 10 Map of earthquake education programs in the United States.

Source: Ross 1989, National Center for Earthquake Engineering Research

Lesson 7

How does preparedness affect the consequences of natural hazards from place to place?

Time Required

Two 50-minute class periods

Materials Needed

Copies of Activity 7 for all students
Mini-Atlas map 4
Copy of Activity 1 from Lesson 1
Transparency of Overhead 1 from Lesson 1

Glossary Words

cyclone

deltaic

hurricane

natural disaster

natural hazard

typhoon

Getting Started

Conduct the following oral quiz, *What's Your Weather IQ? Just for Fun!* Discuss the answers with students and write the grade scale on the blackboard.

Questions and Key for Oral Quiz

WHAT'S YOUR WEATHER IQ? JUST FOR FUN!

1. The greatest number of thunderstorms occurs in the midlatitudes. [False]
2. The highest winds on Earth have been recorded in hurricanes. [True]
3. Which of the following kills more people in the United States: tornadoes, lightning, hail, or hurricanes? [Lightning]
4. Hurricanes are named only after women. [False]
5. In which of the following months do most tornadoes occur in the Northern Hemisphere: May, June, July, August, October, January, March? [May]
6. Sixty percent of all tornadoes occur in which of the following time slots: (a) noon to 6 P.M., (b) 6 P.M. to midnight, (c) midnight to 6 A.M., (d) 6 A.M. to noon? [Noon to 6 P.M.]
7. Name one of the two U.S. states that experiences the most violent thunderstorms in the country and the world. [Florida and Colorado]
8. Two countries in the world lead in the number and intensity of tornadoes—one is the United States. What English-speaking country is the other? [Australia]
9. Warm air holds more moisture than cold air does. [True]

10. Most systems of high pressure are found in equatorial areas. [False]

Grade Scale:

0–4 correct	Under no circumstances should you ever venture outside.
5–7 correct	You are probably smarter than 90 percent of television weather forecasters.
8–10 correct	Consider a career in meteorology.

Procedures

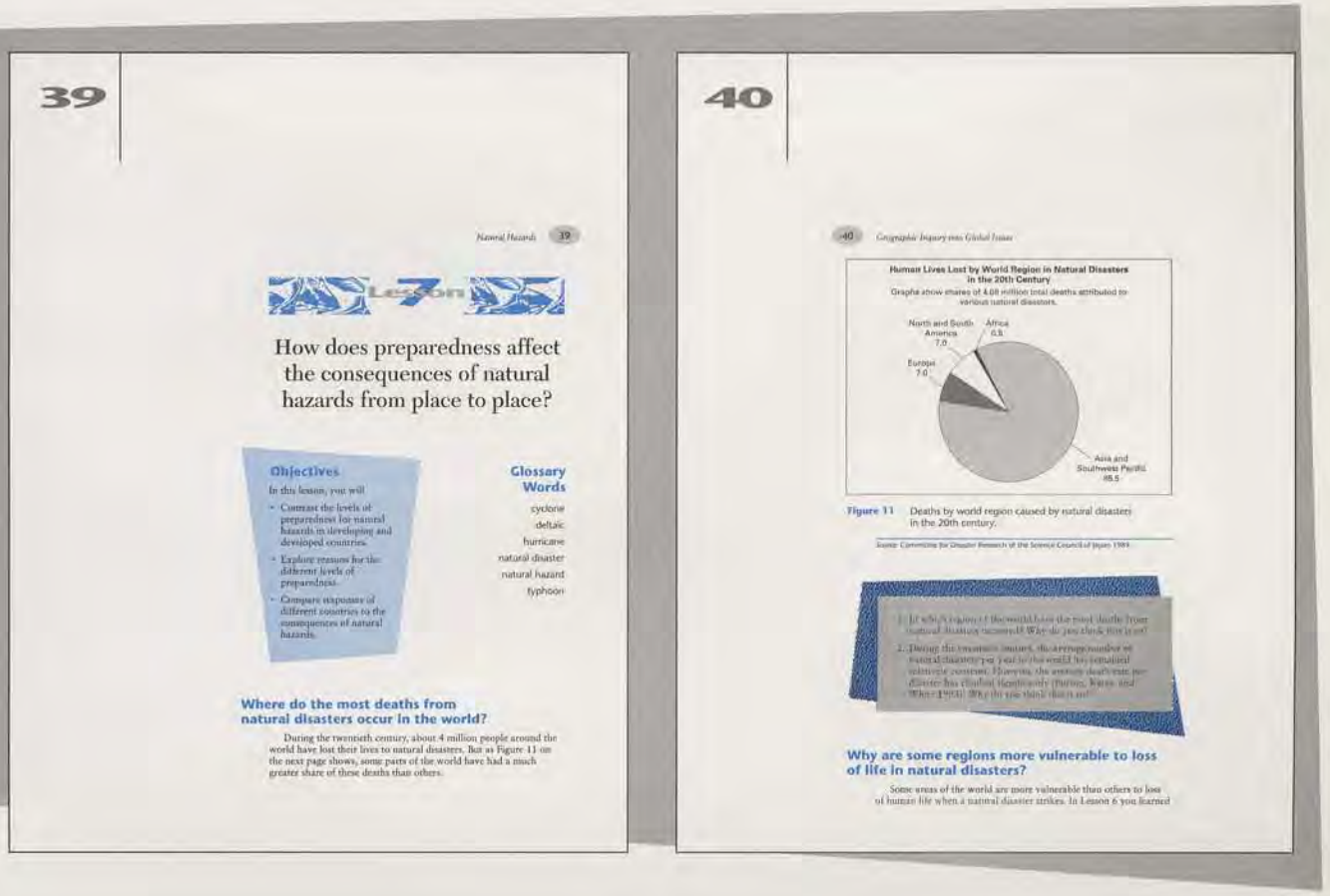
Where do the most deaths from natural disasters occur in the world? (pages 39–40)

A. Direct students' attention to Figure 11 on page 40 to answer Questions 1 and 2.

Why are some regions more vulnerable to loss of life in natural disasters? (pages 40–47)

B. Have students read the text about destructive storms and study Table 8 on page 41. Discuss Questions 3–5 following the table.

C. Divide students into four groups and assign each group one of the four articles about the 1991 typhoon. Have students gather information about the causes for large death tolls in Bangladeshi typhoons. Data should be classified according to the seven categories given in the Student DataBook on page 42. Have students locate Chittagong, Dhaka, Cox's Bazar, and the offshore islands affected by the 1991 typhoon on the map of Bangladesh (Figure 12 on page 44). On the map, students should observe that most of the landscape in Bangladesh is covered by rivers. Ask students what they think east-west travel in the southern part of the country is like. [Very difficult on account of the numerous rivers] Distribute **Mini-Atlas map 4** to the groups. Ask them to consider which areas of that country are likely to be at risk from flood hazards. Have students



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Lesson 6

How does preparedness affect the consequences of natural hazards from place to place?

Objectives

In this lesson, you will

- Contrast the levels of preparedness for natural hazards in developing and developed countries.
- Explore reasons for the different levels of preparedness.
- Compare responses of different countries to the consequences of natural hazards.

Glossary Words

cyclone
deltaic
hurricane
natural disaster
natural hazard
typhoon

Where do the most deaths from natural disasters occur in the world?

During the twentieth century, about 4 million people around the world have lost their lives to natural disasters. But as Figure 11 on the next page shows, some parts of the world have had a much greater share of these deaths than others.

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Human Lives Lost by World Region in Natural Disasters in the 20th Century

Graphs show shares of 4.08 million total deaths attributed to various natural disasters.

North and South America 7.0
Africa 6.8
Europe 7.0
Asia and Southwest Pacific 65.5

Figure 11 Deaths by world region caused by natural disasters in the 20th century.

Source: Committee for Disaster Research of the Science Council of Japan 1994

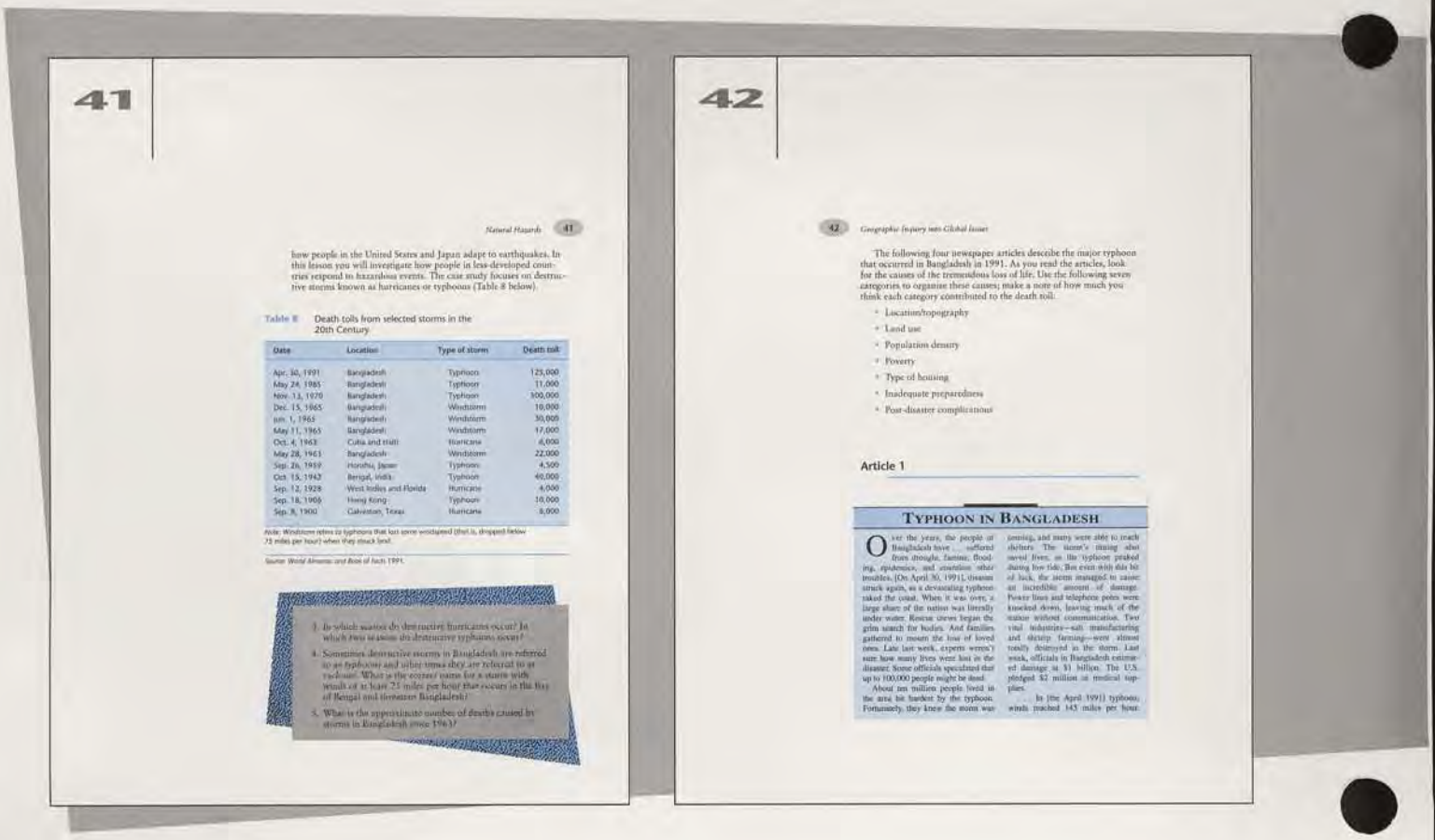
Why are some regions more vulnerable to loss of life in natural disasters?

Some areas of the world are more vulnerable than others to loss of human life when a natural disaster strikes. In Lesson 6 you learned

Questions and Answers for page 40

1. In which region of the world have the most deaths from natural disasters occurred? Why do you think this is so?
   - Most deaths from natural disasters occur in Asia and the Southwest Pacific. Encourage students to identify reasons why the most deaths from natural disasters occur in these regions. Possible answers include that this is an area of earthquakes and volcanoes, including the Ring of Fire, typhoons, floods, and also of underdeveloped nations with rapid population growth, poverty, and lack of hazard preparedness.

2. During the twentieth century, the average number of natural disasters per year in the world has remained relatively constant. However, the average death rate per disaster has climbed significantly (Burton, Kates, and White 1993). Why do you think this is so?
   - Possible reasons include the increase in population and density, the growth of cities, more development in hazardous areas, and more accurate accounts of disaster casualties. Refer students to their Hazard Chart (Activity 3 in Lesson 3) if they have difficulty answering this question.



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how people in the United States and Japan adapt to earthquakes. In this lesson you will investigate how people in less-developed countries respond to hazardous events. The case study focuses on destructive storms known as hurricanes or typhoons (Table 8 below).

Table 8 Death tolls from selected storms in the 20th Century

Date	Location	Type of storm	Death toll
Apr. 30, 1991	Bangladesh	Typhoon	125,000
May 24, 1985	Bangladesh	Typhoon	11,000
Nov. 13, 1970	Bangladesh	Typhoon	300,000
Dec. 15, 1965	Bangladesh	Windstorm	10,000
Jun. 1, 1965	Bangladesh	Windstorm	30,000
May 11, 1965	Bangladesh	Windstorm	17,000
Oct. 4, 1963	Cuba and Haiti	Hurricane	6,000
May 28, 1963	Bangladesh	Windstorm	22,000
Sep. 26, 1959	Honshu, Japan	Typhoon	4,500
Oct. 15, 1942	Bengal, India	Typhoon	40,000
Sep. 12, 1928	West Indies and Florida	Hurricane	4,000
Sep. 18, 1906	Hong Kong	Typhoon	10,000
Sep. 8, 1900	Galveston, Texas	Hurricane	8,000

Note: Windstorm refers to typhoons that lost some windspeed (that is, dropped below 75 miles per hour) when they struck land.

Source: World Almanac and Book of Facts 1991.

3. In which seasons do destructive hurricanes occur? In which two seasons do destructive typhoons occur?

4. Sometimes destructive storms in Bangladesh are referred to as typhoons and other times they are referred to as cyclones. What is the correct name for a storm with winds of at least 75 miles per hour that occurs in the Bay of Bengal and threatens Bangladesh?

5. What is the approximate number of deaths caused by storms in Bangladesh since 1963?

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The following four newspaper articles describe the major typhoon that occurred in Bangladesh in 1991. As you read the articles, look for the causes of the tremendous loss of life. Use the following seven categories to organize these causes; make a note of how much you think each category contributed to the death toll:

- Location/topography
- Land use
- Population density
- Poverty
- Type of housing
- Inadequate preparedness
- Post-disaster complications

Article 1

Typhoon in Bangladesh

Over the years, the people of Bangladesh have . . . suffered from drought, famine, flooding, epidemics, and countless other troubles. [On April 30, 1991], disaster struck again, as a devastating typhoon raked the coast. When it was over, a large share of the nation was literally under water. Rescue crews began the grim search for bodies. And families gathered to mourn the loss of loved ones. Late last week, experts weren't sure how many lives were lost in the disaster. Some officials speculated that up to 100,000 people might be dead.

About ten million people lived in the area hit hardest by the typhoon. Fortunately, they knew the storm was coming, and many were able to reach shelters. The storm's timing also saved lives, as the typhoon peaked during low tide. But even with this bit of luck, the storm managed to cause an incredible amount of damage. Power lines and telephone poles were knocked down, leaving much of the nation without communication. Two vital industries—salt manufacturing and shrimp farming—were almost totally destroyed in the storm. Last week, officials in Bangladesh estimated damage at $1 billion. The U.S. pledged $2 million in medical supplies.

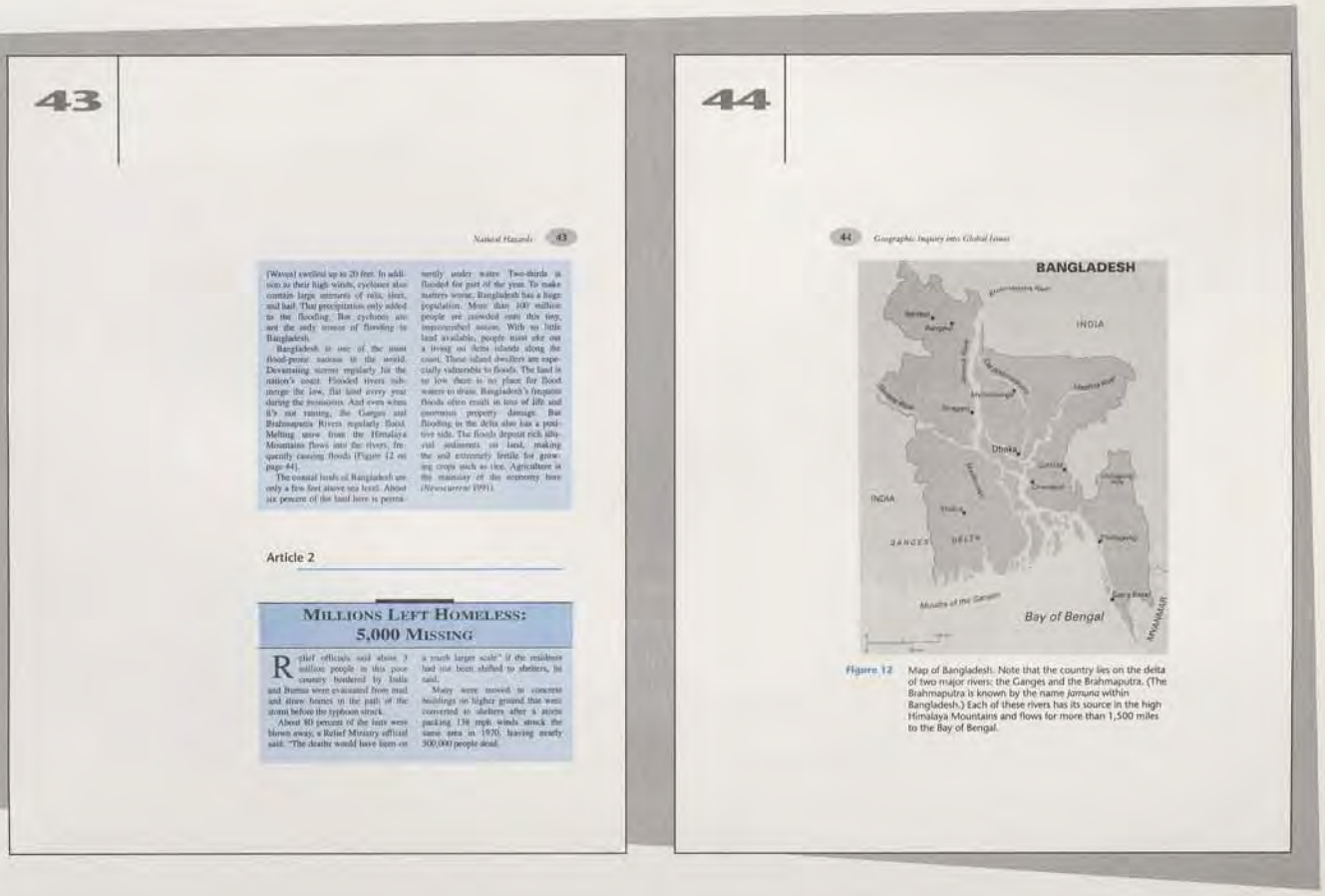
. . . In [the April 1991] typhoon, winds reached 145 miles per hour.

Questions and Answers for page 41

3. In which season do destructive hurricanes occur? In which two seasons do destructive typhoons occur?
   - Hurricanes occur in autumn; typhoons occur in spring and autumn.

4. Sometimes destructive storms in Bangladesh are referred to as *typhoons* and other times they are referred to as *cyclones*. What is the *correct* name for a storm with winds of at least 75 miles per hour that occurs in the Bay of Bengal and threatens Bangladesh?
   - Hurricanes and typhoons are types of cyclonic storms; that is, they involve intense winds swirling about a strong low-pressure center. Typhoons occur in the Eastern Hemisphere, hurricanes in the Western Hemisphere. The correct name for one of these storms near Bangladesh is *typhoon* if windspeed is over 75 mph.

5. What is the approximate number of deaths caused by storms in Bangladesh since 1963?
   - Approximately 715,000 Bangladeshis have been killed in typhoons since 1963.



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(Waves) swelling up to 20 feet. In addition to their high winds, cyclones also contain large amounts of rain, sleet, and hail. That precipitation only added to the flooding. But cyclones are not the only source of flooding in Bangladesh.

Bangladesh is one of the most flood-prone nations in the world. Devastating storms regularly hit the nation's coast. Flooded rivers submerge the low, flat land every year during the monsoons. And even when it's not raining, the Ganges and Brahmaputra Rivers regularly flood. Melting snow from the Himalaya Mountains flows into the rivers, frequently causing floods (Figure 12 on page 44).

The coastal lands of Bangladesh are only a few feet above sea level. About six percent of the land here is permanently under water. Two-thirds is flooded for part of the year. To make matters worse, Bangladesh has a huge population. More than 100 million people are crowded onto this tiny, impoverished nation. With so little land available, people must eke out a living on delta islands along the coast. These island dwellers are especially vulnerable to floods. The land is so low there is no place for flood waters to drain. Bangladesh's frequent floods often result in loss of life and enormous property damage. But flooding in the delta also has a positive side. The floods deposit rich alluvial sediments on land, making the soil extremely fertile for growing crops such as rice. Agriculture is the mainstay of the economy here (*Newsweek* 1991).

Article 2

MILLIONS LEFT HOMELESS: 5,000 MISSING

Relief officials said about 3 million people in this poor country bordered by India and Burma were evacuated from mud and straw homes in the path of the storm before the typhoon struck.

About 80 percent of the huts were blown away, a Relief Ministry official said. "The deaths would have been on a much larger scale" if the residents had not been shifted to shelters, he said.

Many were moved to concrete buildings on higher ground that were converted to shelters after a storm packing 138 mph winds struck the same area in 1970, leaving nearly 300,000 people dead.

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Figure 12 Map of Bangladesh. Note that the country lies on the delta of two major rivers: the Ganges and the Brahmaputra. (The Brahmaputra is known by the name *Jamuna* within Bangladesh.) Each of these rivers has its source in the high Himalaya Mountains and flows for more than 1,500 miles to the Bay of Bengal.

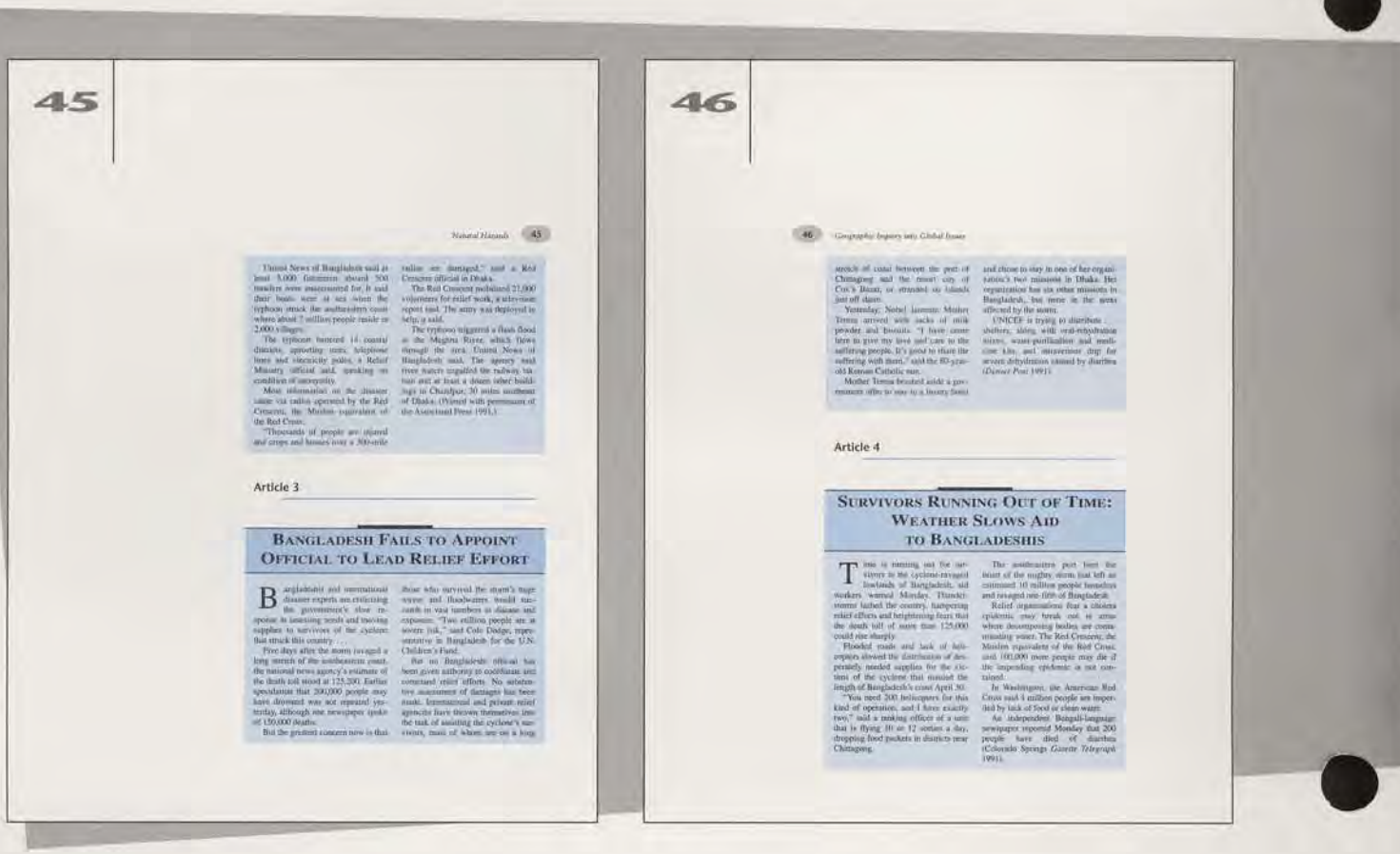
shade in these areas on Mini-Atlas map 4. [By studying the locations of rivers (Figure 12 on page 44) and reading Article 1 (pages 42 and 43) students can note that nearly all of this very flat country is at risk from floods. Students may also note that the densest populations (shown on Mini-Atlas map 4) are also found in the flattest, most flood-prone areas.]

The information obtained from the articles should be recorded on a separate sheet of paper under the appropriate categories (see *Answer Key 1* on the following page).

D. Ask students to share their findings in their groups and record them on the blackboard or on butcher paper. Results should be similar to *Answer Key 1*. Have students (working either individually or in groups) score each of the seven categories from 1 to 5 in terms of its contribution to the loss of life. Consider 1 as low, signifying a minor contribution to loss of life, and 5 as high, signifying a major reason for deaths. [Answers will vary.] Provide each student with a copy of **Activity 7**. The purpose here is to have students create a graphic presentation of the information they have gathered for the seven categories. Explain to the class that there are a variety of ways to present their findings from the articles. A common system, such as the bar graph they will make on Graph 1 on Activity 7, will allow their responses to be compared. Note that students will complete Graph 2 on page 2 of Activity 7 later in this lesson. No keys are given for Activity 7 graphs because no correct answers are identifiable. The graphs should show *relative* differences rather than exact differences.

How do Bangladesh and the United States compare in terms of disaster preparedness? (pages 47–53)

E. Have students read this section that begins on page 47. Then explain that they will investigate and compare two countries—the United States, which is highly developed, and Bangladesh, which is very poor—with respect to their preparedness for destructive storms (hurricanes, typhoons) using the five measures listed in Table 9 on page 47. Discuss the five measures to ensure understanding. Then discuss the six effectiveness factors on page 48 (wealth, technology, government action, public education, cultural beliefs, economic develop-



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United News of Bangladesh said at least 5,000 fishermen aboard 500 trawlers were unaccounted for. It said their boats were at sea when the typhoon struck the southeastern coast, where about 7 million people reside in 2,600 villages.

The typhoon battered 14 coastal districts, uprooting trees, telephone lines and electricity poles, a Relief Ministry official said, speaking on condition of anonymity.

More information on the disaster came via radios operated by the Red Crescent, the Muslim equivalent of the Red Cross.

"Thousands of people are injured and crops and houses over a 300-mile radius are damaged," said a Red Crescent official in Dhaka.

The Red Crescent mobilized 27,000 volunteers for relief work, a television report said. The army was deployed to help, it said.

The typhoon triggered a flash flood in the Meghna River, which flows through the area, United News of Bangladesh said. The agency said river waters engulfed the railway station and at least a dozen other buildings in Chandpur, 30 miles southeast of Dhaka. (Printed with permission of the Associated Press 1991.)

Article 3

Bangladesh Fails to Appoint Official to Lead Relief Effort

Bangladeshi and international disaster experts are criticizing the government's slow response in assessing needs and moving supplies to survivors of the cyclone that struck this country . . .

Five days after the storm ravaged a long stretch of the southeastern coast, the national news agency's estimate of the death toll stood at 125,200. Earlier speculation that 200,000 people may have drowned was not repeated yesterday, although one newspaper spoke of 150,000 deaths.

But the greatest concern now is that those who survived the storm's rampage and floodwaters would succumb in vast numbers to disease and exposure. "Two million people are at severe risk," said Cole Dodge, representative in Bangladesh for the U.N. Children's Fund.

But no Bangladeshi official has been given authority to coordinate and command relief efforts. No substantive assessment of damages has been made. International and private relief agencies have thrown themselves into the task of assisting the cyclone's survivors, many of whom are on a long

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stretch of coast between the port of Chittagong and the resort city of Cox's Bazar, or stranded on islands just off shore.

Yesterday, Nobel laureate Mother Teresa arrived with sacks of milk powder and biscuits. "I have come here to give my love and care to the suffering people. It's good to share the suffering with them," said the 80-year-old Roman Catholic nun.

Mother Teresa headed aside a government offer to use to a luxury hotel and chose to stay in one of her organization's two missions in Dhaka. Her organization has six other missions in Bangladesh, but none in the areas affected by the storm.

UNICEF is trying to distribute shelters, along with oral-rehydration mixes, water-purification and medicine kits, and intravenous drip for severe dehydration caused by diarrhea (*Denver Post* 1991).

Article 4

Survivors Running Out of Time: Weather Slows Aid to Bangladeshis

Time is running out for survivors in the cyclone-ravaged lowlands of Bangladesh, aid workers warned Monday. Thundershower lashed the country, hampering relief efforts and heightening fears that the death toll of more than 125,000 could rise sharply.

Flooded roads and lack of helicopters slowed the distribution of desperately needed supplies for the victims of the cyclone that mauled the length of Bangladesh's coast April 30.

"You need 200 helicopters for this kind of operation, and I have exactly two," said a ranking officer of a unit that is flying 10 or 12 sorties a day, dropping food packets in districts near Chittagong.

The southeastern port bore the brunt of the mighty storm that left an estimated 10 million people homeless and ravaged one-fifth of Bangladesh.

Relief organizations fear a cholera epidemic may break out as areas where decomposing bodies are contaminating water. The Red Crescent, the Muslim equivalent of the Red Cross, said 100,000 more people may die if the impending epidemic is not contained.

In Washington, the American Red Cross said 1 million people are imperiled by lack of food or clean water.

An independent Bengali-language newspaper reported Monday that 200 people have died of diarrhea (Colorado Springs *Gazette Telegraph* 1991).

Answer Key 1

REASONS FOR LOSS OF LIFE IN BANGLADESH TYPHOONS

Location/topography: Flat land; delta near to sea level; large rivers flood easily; location in area prone to hazards of typhoons and floods; poor transport network due to many rivers.

Land use: Farms are on fertile delta and coastal islands because land is scarce; same locations are good for fishing.

Population density: 2000+ per sq. mile; 10 million located in area affected by typhoon.

Poverty: Four out of five are poverty stricken; 60 percent are landless.

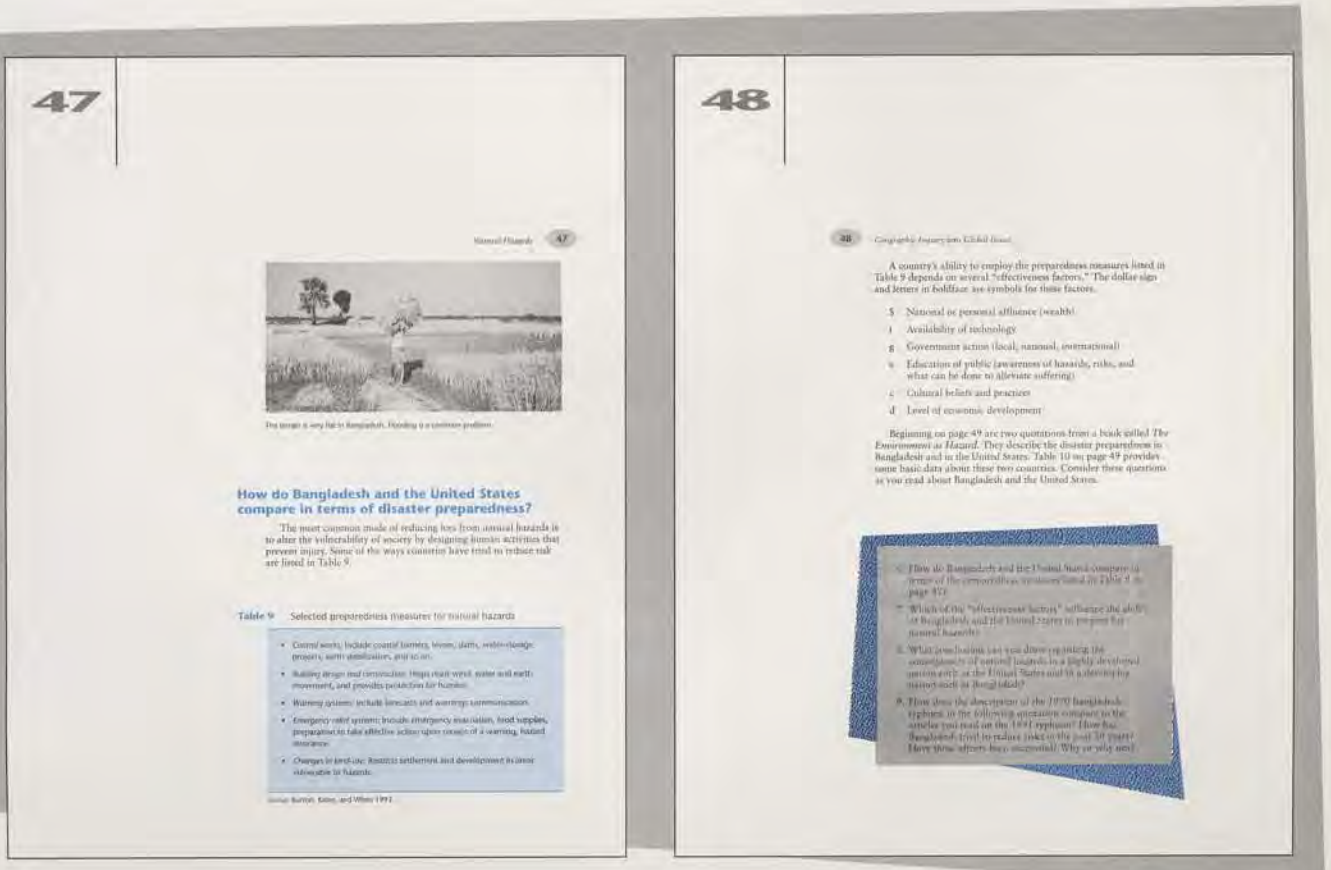
Type of housing: Huts are made from palm leaves, straw, and bamboo.

Inadequate preparedness: Some people got to shelters established by government, but most could not; preventive measures, warnings, and communication systems were inadequate.

Post-disaster complications: Destruction of crops; lack of food, drinking water, and sanitation = disease; telephone poles and power lines down = poor communication; salt and shrimp industries destroyed; damage at over $1 billion.

ment). Explain that students will use these six factors to evaluate each country's effectiveness in developing preparedness measures against destructive storms. Tell students they will use the symbols to represent the six factors as they make the second bar graph on Activity 7.

F. Place students in groups of four. Ask groups first to compare the area, population, population density, and per capita incomes of the United States and Bangladesh as displayed in Table 10 on page 49. Then divide each group into two pairs. Ask one pair in each group to read the information on Bangladesh and the other pair to read about the United States. Encourage those reading about Bangladesh to use the data collected from the articles about



Questions and Answers for page 48

6. How do Bangladesh and the United States compare in terms of the preparedness measures listed in Table 9?

   - See *Answer Key 2* on page 34 in this Teacher's Guide.

7. Which of the "effectiveness factors" influence the ability of Bangladesh and the United States to prepare for natural disasters?

   - See *Answer Key 2* on page 34 in this Teacher's Guide.

8. What conclusions can you draw regarding the consequences of natural hazards in a highly developed nation such as the United States and in a developing nation such as Bangladesh?

   - More developed nations have greater resources to cope with hazards, greater ability to take preventive measures, and greater ability to pay for any recovery from damages.

continued

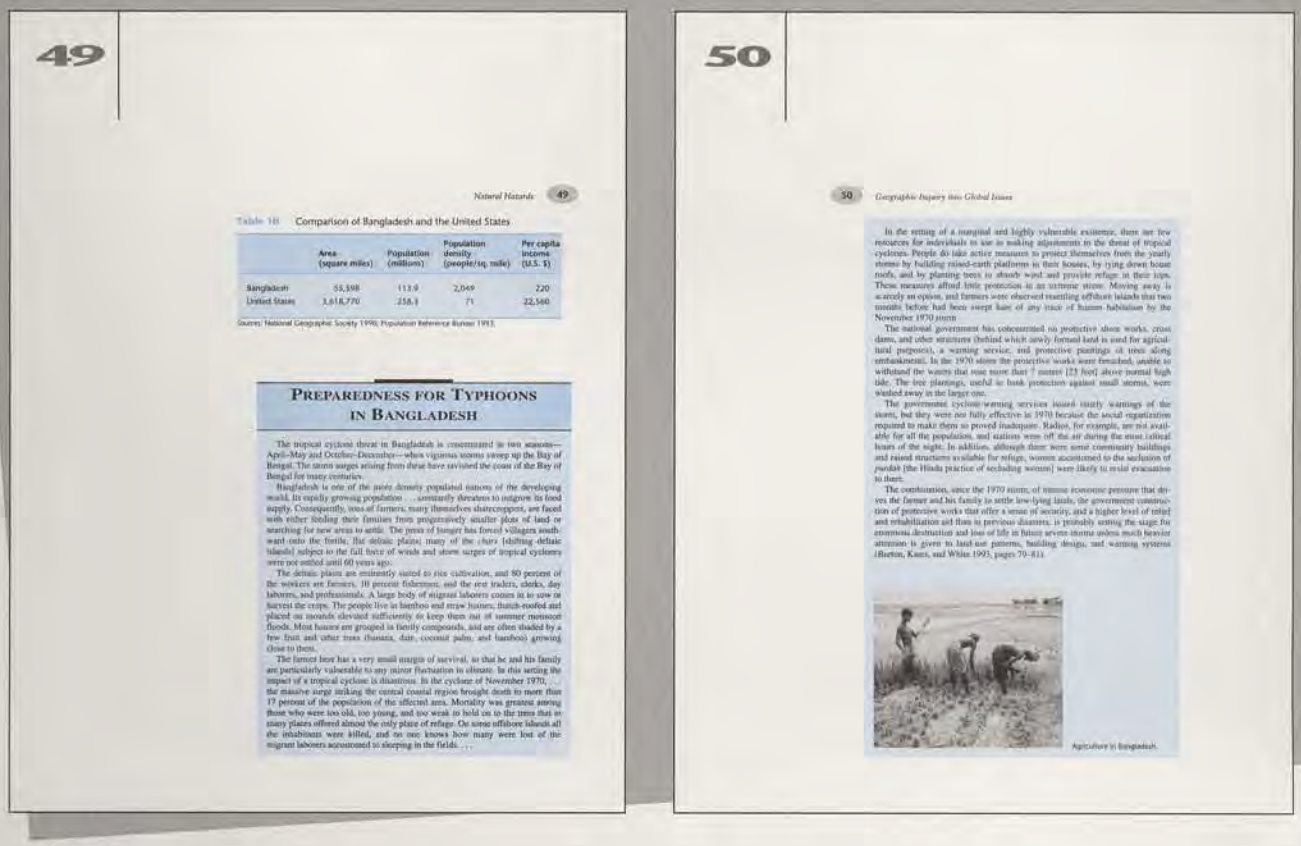


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Table 10 Comparison of Bangladesh and the United States

	Area (square miles)	Population (millions)	Population density (people/sq. mile)	Per capita income (U.S. $)
Bangladesh	55,598	113.0	2,049	220
United States	3,618,770	258.3	71	22,560

Sources: National Geographic Society 1990; Population Reference Bureau 1993.

Preparedness for Typhoons in Bangladesh

The tropical cyclone threat in Bangladesh is concentrated in two seasons—April–May and October–December—when vigorous storms sweep up the Bay of Bengal. The storm surges arising from these have ravished the coast of the Bay of Bengal for many centuries.

Bangladesh is one of the more densely populated nations of the developing world. Its rapidly growing population . . . constantly threatens to outgrow its food supply. Consequently, tens of farmers, many themselves sharecroppers, are faced with either feeding their families from progressively smaller plots of land or searching for new areas to settle. The press of hunger has forced villagers southward onto the fertile, flat deltaic plains; many of the *chars* [shifting deltaic islands] subject to the full force of winds and storm surges of tropical cyclones were not settled until 60 years ago.

The deltaic plains are eminently suited to rice cultivation, and 80 percent of the workers are farmers, 10 percent fishermen, and the rest traders, clerks, day laborers, and professionals. A large body of migrant laborers comes in to sow or harvest the crops. The people live in bamboo and straw homes; thatch-roofed and placed on mounds elevated sufficiently to keep them out of summer monsoon floods. Most homes are grouped in family compounds, and are often shaded by a few fruit and other trees (banana, date, coconut palm, and bamboo) growing close to them.

The farmer here has a very small margin of survival, so that he and his family are particularly vulnerable to any minor fluctuation in climate. In this setting the impact of a tropical cyclone is disastrous. In the cyclone of November 1970, . . . the massive surge striking the central coastal region brought death to more than 17 percent of the population of the affected area. Mortality was greatest among those who were too old, too young, and too weak to hold on to the trees that in many places offered almost the only place of refuge. On some offshore islands all the inhabitants were killed, and no one knows how many were lost of the migrant laborers accustomed to sleeping in the fields. . . .

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In the setting of a marginal and highly vulnerable existence, there are few resources for individuals to use in making adjustments to the threat of tropical cyclones. People do take active measures to protect themselves from the yearly storms by building raised-earth platforms in their houses, by tying down house roofs, and by planting trees to absorb wind and provide refuge in their tops. These measures afford little protection in an extreme storm. Moving away is scarcely an option, and farmers were observed resettling offshore islands that two months before had been swept bare of any trace of human habitation by the November 1970 storm.

The national government has concentrated on protective shore works, cross dams, and other structures (behind which newly formed land is used for agricultural purposes), a warning service, and protective plantings of trees along embankments. In the 1970 storm the protective works were breached, unable to withstand the waters that rose more than 7 meters [23 feet] above normal high tide. The tree plantings, useful in bank protection against small storms, were washed away in the larger one.

The government cyclone-warning services issued timely warnings of the storm, but they were not fully effective in 1970 because the social organization required to make them so proved inadequate. Radios, for example, are not available for all the population, and stations were off the air during the most critical hours of the night. In addition, although there were some community buildings and raised structures available for refuge, women accustomed to the seclusion of *purdah* [the Hindu practice of secluding women] were likely to resist evacuation to them.

The combination, since the 1970 storm, of intense economic pressure that drives the farmer and his family to settle low-lying lands, the government construction of protective works that offer a sense of security, and a higher level of relief and rehabilitation aid than in previous disasters, is probably setting the stage for enormous destruction and loss of life in future severe storms unless much heavier attention is given to land-use patterns, building design, and warning systems (Burton, Kates, and White 1993, pages 70–81).

Agriculture in Bangladesh.

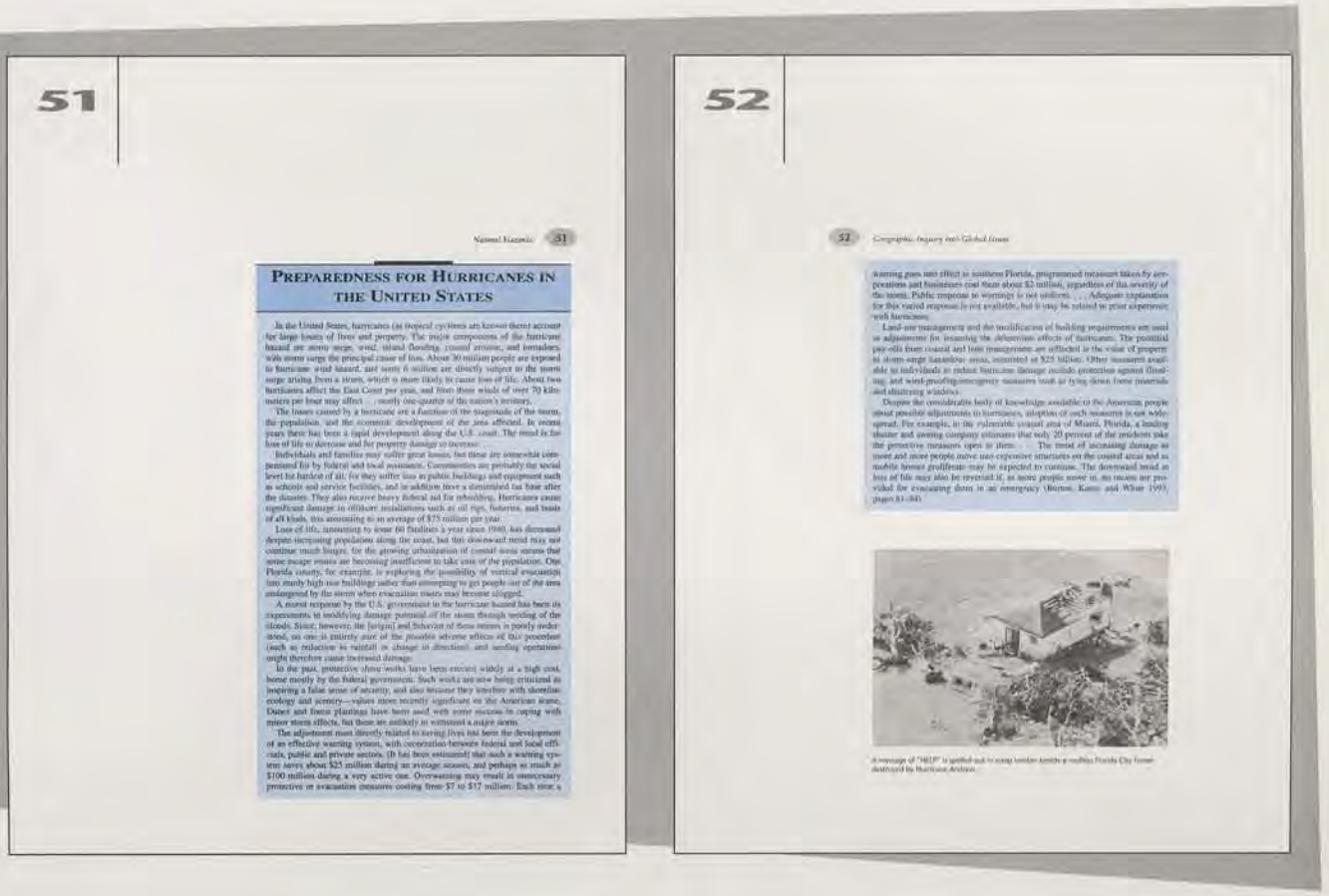
9. How does the description of the 1970 Bangladesh typhoon in the quotation (on pages 49–50 of the Student DataBook) compare to the articles you read on the 1991 typhoon? How has Bangladesh tried to reduce risks in the past 20 years? Have those efforts been successful? Why or why not?

   - The two disasters were very similar. Government efforts, including building control structures and using radio warnings, were not entirely successful. One reason is because so many poor people continue to live on very hazardous islands prone to flooding.

the 1991 typhoon to analyze how effective the country's preparedness for a major typhoon actually is. Have students answer Questions 6–9 on page 48.

G. Then have the student pairs develop a bar graph using Graph 2 in Activity 7 for the country to which they were assigned. Again, students should score from 1 (low) to 5 (high) the contribution of each of the five measures from Table 9 toward their assigned country's preparedness levels. After the graphs are completed, each pair should explain to the others in their group how and why they ranked the measures as they did. Based on their shared information, all students in the group can complete the bar graph for both countries and then decide which of the six effectiveness factors influence the preparedness measures of each country. Students should write the symbols for each effectiveness factor on the bar graph (see *Answer Key* 2).

H. Finally, members of each group may share and explain their group's graph to the class. Involve the class in developing conclusions regarding the vulnerability to or preparedness for hurricanes/typhoons in a highly developed country such as the United States and in a developing country such as Bangladesh. Ask: How has the availability of technology influenced each country's ability to prepare? Help



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PREPAREDNESS FOR HURRICANES IN THE UNITED STATES

In the United States, hurricanes (as tropical cyclones are known there) account for large losses of lives and property. The major components of the hurricane hazard are storm surge, wind, inland flooding, coastal erosion, and tornadoes, with storm surge the principal cause of loss. About 30 million people are exposed to hurricane wind hazard, and some 6 million are directly subject to the storm surge arising from a storm, which is most likely to cause loss of life. About two hurricanes affect the East Coast per year, and those winds of over 70 kilometers per hour may affect . . . nearly one-quarter of the nation's territory.

The losses caused by a hurricane are a function of the magnitude of the storm, the population, and the economic development of the area affected. In recent years there has been a rapid development along the U.S. coast. The trend is for loss of life to decrease and for property damage to increase: . . .

Individuals and families may suffer great losses, but these are somewhat compensated for by federal and local assistance. Communities are probably the social level hit hardest of all, for they suffer loss in public buildings and equipment such as schools and service facilities, and in addition have a diminished tax base after the disaster. They also receive heavy federal aid for rebuilding. Hurricanes cause significant damage to offshore installations such as oil rigs, fisheries, and boats of all kinds, this amounting to an average of $75 million per year.

Loss of life, amounting to some 60 fatalities a year since 1940, has decreased despite increasing populations along the coast, but this downward trend may not continue much longer, for the growing urbanization of coastal areas means that some escape routes are becoming insufficient to take care of the population. One Florida county, for example, is exploring the possibility of vertical evacuation into sturdy high rise buildings rather than attempting to get people out of the area endangered by the storm when evacuation routes may become clogged.

A recent response by the U.S. government to the hurricane hazard has been its experiments in modifying damage potential of the storm through seeding of the clouds. Since, however, the [origin] and behavior of these storms is poorly understood, no one is entirely sure of the possible adverse effects of this procedure (such as reduction in rainfall or change in direction), and seeding operations might therefore cause increased damage.

In the past, protective dune works have been erected widely at a high cost, borne mostly by the federal government. Such works are now being criticized as fostering a false sense of security, and also because they interfere with shoreline ecology and scenery—values more recently significant on the American scene. Dunes and forest plantings have been used with some success in coping with minor storm effects, but these are unlikely to withstand a major storm.

The adjustment most directly related to saving lives has been the development of an effective warning system, with cooperation between federal and local officials, public and private sectors. (It has been estimated) that such a warning system saves about $25 million during an average season, and perhaps as much as $100 million during a very active one. Overwarning may result in unnecessary protective or evacuation measures costing from $7 to $17 million. Each time a

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warning goes into effect in southern Florida, programmed measures taken by corporations and businesses cost them about $2 million, regardless of the severity of the storm. Public response to warnings is not uniform. . . . Adequate explanation for this varied response is not available, but it may be related to prior experience with hurricanes.

Land-use management and the modification of building requirements are used as adjustments for lessening the deleterious effects of hurricanes. The potential pay-offs from coastal and land management are reflected in the value of property in storm-surge hazardous areas, estimated at $25 billion. Other measures available to individuals to reduce hurricane damage include protection against flooding and wind-proofing-emergency measures such as tying down home materials and shuttering windows.

Despite the considerable body of knowledge available to the American people about possible adjustments to hurricanes, adoption of such measures is not widespread. For example, in the vulnerable coastal area of Miami, Florida, a leading disaster and zoning company estimates that only 20 percent of the residents take the protective measures open to them. . . . The trend of increasing damage as more and more people move into expensive structures on the coastal areas and as mobile homes proliferate may be expected to continue. The downward trend in loss of life may also be reversed if, as more people move in, no means are provided for evacuating them in an emergency (Burton, Kates, and White 1993, pages 81–84).

A message of "HELP" is spelled out in scrap lumber beside a mobile home destroyed by Hurricane Andrew.

Answer Key 2

Comparing Preparedness for Destructive Storms in Bangladesh and the United States (effectiveness factors are symbolized in bold)

Control works: The effort to establish control works has been much greater in the United States than in Bangladesh, but in the event of a large storm, neither country is well prepared, as evidenced in Bangladesh. The lack of **$**, **t**, and **g** contribute to the great loss of life in a poor country, whereas the damages to property are usually greater in developed nations. The dunes, forests, and control works constructed along the Florida coast provide false security because, although effective for small storms, they are unlikely to hold up under a powerful hurricane. U.S. experiments with cloud seeding have met with little success.

Building design and construction: Some coastal areas of the United States require building design and construction to include storm proofing, but the stability of the structures under stress is unknown. In Bangladesh, houses continue to be built out of bamboo and straw because the people are poor and more durable materials are generally unavailable. The government is also poor and has not made storm protection a priority. **$**, **t**, **g**, **c**, and **d** are factors that influence building design and construction.

Warning systems: Both the United States and Bangladesh have warning systems, but the United States has more sophisticated technology and is better organized to communicate the information. In fact, the costs of "unnecessary" evacuation due to incorrect predictions can be costly to U.S. coastal communities. In Bangladesh, many people do not have access to radios, and in 1970 the storm came at night when stations were off the air. **$**, **t**, **g**, **e**, and **d** are factors influencing the effectiveness of warning systems.

Emergency relief systems: Emergency relief is highly inadequate in Bangladesh because, although there are some safe structures to which the people can evacuate, they are few and the people are sometimes unable to reach them. Cultural practices, such as the seclusion of women, also contribute to the difficulty of evacuating people to common shelters. The transient nature of many of the people in the delta and island areas makes hazard education difficult if it is attempted. Although people build raised-earth platforms in their houses and tie down house roofs, the measures do not protect them in a large storm. In the United States, escape routes in the Florida Keys, for example, are insufficient because there is only one major highway and the population is dense. "Vertical" evacuation into strong high-rise buildings is planned. In the United States, public and private agencies are quick to respond with emergency relief, but in Bangladesh, the people rely to a great extent on international help, which is not adequate and does not occur in a timely manner. **$**, **t**, **g**, **e**, **c**, and **d** are all effectiveness factors in the degree of emergency relief.

Changes in land use: Government regulation is required for changes in land use. In Bangladesh there are no laws restricting settlement on the low deltas and chars because the population has increased, the people are poor, and they rely on farming and fishing for their livelihood. In the United States there are zoning laws and building requirements that control building patterns in coastal areas. Like Bangladesh, the hazardous coastal areas are often highly populated, but for different reasons, such as a pleasant climate, an enjoyable life style, and leisure activities. The economic value of these activities, however, makes enactment of highly restrictive land use plans less popular. **$**, **h**, **c**, and **d** are factors that influence land-use planning.

students understand that both countries have problems dealing with hazards, but the problems differ, in part owing to the abilities of each country to cope with the hazard. In Bangladesh, the primary concern is with saving lives, while in the United States, preparedness measures are usually sufficient to avert major loss of human life, but property damage remains high.

Questions and Answers for page 53

10. Based on what you have read in this lesson, what kinds of knowledge and expertise can more-developed countries provide to less-developed countries to help them reduce their losses from natural disasters?

    - Opinion question. Ideas can be taken from the excerpt on United States disaster preparedness, including techniques to minimize damage to buildings or instituting effective early-warning systems.

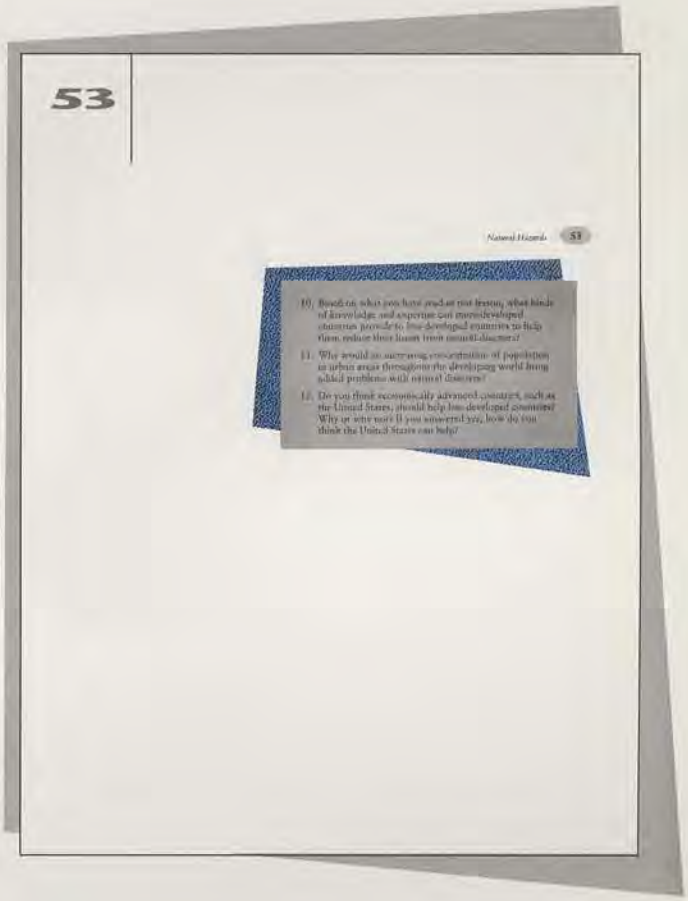
11. Why would an increasing concentration of population in urban areas throughout the developing world bring added problems with natural disasters?

    - This would put a greater number of people at risk by concentrating more people in a smaller area.

12. Do you think economically advanced countries, such as the United States, should help less-developed countries? Why or why not? If you answered *yes*, how do you think the United States can help?

    - This is an opinion question. Encourage students to defend their answers and explain their opinions.

I. To bring closure to this lesson and the whole module, have students discuss their ideas about Questions 10–12 on page 53. Display and discuss **Overhead 1** from Lesson 1 again as a way to reinforce all of the concepts covered in the module.



For Further Inquiry

- You may want to set aside time for students' long-term reports based on **Activity 1,** assigned in Lesson 1. To evaluate Activity 1, consider the following:
  a. validity of the hazard and its history,
  b. extent of the students' data-gathering and the number of people contacted,
  c. extent to which conclusions are supported with data,
  d. use of maps, graphs, and tables.
- An extended related assignment could include a preparedness guide for a hazard in your own community.
- Invite a speaker from your city government to discuss and answer questions regarding local preparedness for natural hazards.

Extension Activities and Resources

1. **Related GIGI Modules**
   - If you are looking for additional materials about the areas examined in *Natural Hazards,* you will find another major case study of Japan in *Global Economy;* Japan is also the focus of a short comparison case study in *Waste Management.* The major case study in *Population and Resources* is on Bangladesh, and Bangladesh is also the subject of a comparison case study in *Global Climate Change.*
   - Materials supporting the issue of *Natural Hazards* may be found in *Environmental Pollution.* In that module, students learn that severe environmental degradation can increase risks of natural hazards or even trigger them. In *Global Climate Change,* the possibilities of global warming are linked with storm hazards from sea level rise, increased risks from dangerous heat waves, and other issues. The *Hunger* module looks at drought as one of several causes of regional hunger in Africa.

2. **Britannica Global Geography System (BGGS)**

   BGGS provides myriad extension activities to enhance each GIGI module. For a complete description of the BGGS CD-ROM and videodiscs and how they work with the GIGI print modules, please read the BGGS Overview in the tabbed section at the beginning of this Teacher's Guide.

3. **Related Videos**
   - The following videos examining natural hazards are available from EBEC: "Tokyo: Capital of Japan"; "Warning: Earthquake!"; "Earthquakes: Lesson of a Disaster"; "The San Andreas Fault"; "Earthquakes: Exploring Earth's Restless Crust"; "Continental Drift: The Theory of Plate Tectonics"; "Fire Mountain"; "Volcanoes: Exploring the Restless Earth"; "Heartbeat of a Volcano"; "Volcano: The Birth of a Mountain"; and "Flood Forecasting."

     For information, or to place an order, call toll-free, 1-800-554-9862.

- Other related videos include: "Fire on the Rim" (PBS); "Plate Tectonics: Volcanoes and Earthquakes" (*Nova* series, PBS); "Restless Rocks" (*Spaceship Earth* series, PBS); "Ring of Fire" (IMAX); "Born of Fire" (National Geographic Society); and "Europe: How Do People Deal with Natural Hazards?" (*Global Geography* series, Agency for Instructional Technology).
- A free video on disaster prevention (Videocassette Series: Disaster Prevention Tape 4) is available from

  Japan Information Center
  Consulate General of Japan
  50 Fremont St. Suite 2200
  San Francisco, California 94105

4. Slides

Sets of slides showing earthquake damage and volcanoes are available from

National Geophysical Data Center
NOAA, EIGCI
325 Broadway
Boulder, Colorado 80303
Phone: (303) 497-6277

5. Related Literature

Read *The Big Wave* by Pearl S. Buck. Segments of this short story could be read orally each day if class sets are not available. Ask students to explain the philosophy expressed in the story that helped the Japanese people deal personally and as a community with disaster. [The beliefs that time heals, that one must remember those who died, that people must carry on and live life fully without dwelling on past and potential disasters.]

Alternatively, read the following short excerpt:

> To live in the midst of danger is to know how good life is. . . . To live in the presence of death makes us brave and strong," Kino's father replied. "That is why our people never fear death. We see it too often and we do not fear it. To die a little later or a little sooner does not matter. But to live bravely, to love life, to see how beautiful the trees are and the mountains, yes, and even the sea, to enjoy work because it produces food for life—in these things we Japanese are a fortunate people. We love life because we live in danger. We do not fear death because we understand that life and death are necessary to each other (Buck 1948).

Note that this book was written in the late 1940s. Ask students to compare the response of the story's characters to a natural hazard to that of today's Japanese people, such as those living on Miyake Island.

6. **Additional Activities**
   - These hands-on experiences are highly appropriate for middle-school children who may not yet have been exposed to the concepts of plate tectonics. Help students do additional research and create a diorama or model of the natural event to
     a. demonstrate tectonic plate activity with tiles and compare the effects of an earthquake upon different foundations (gravel and rock versus mud, for example), and buildings of varied styles and heights (using wooden blocks);
     b. show different volcanic types;
     c. demonstrate how variations in coastal topography affect incoming tsunamis;
     d. explain typhoon (hurricane) development with a model showing low pressure center (eye of storm), air rotation, and rising air masses, using a fan with varying velocity to show different levels of destruction on the diorama;
     e. create diagrams for the overhead projector to show Earth's interior, continental drift, typhoon patterns in the southwest Pacific, and so on.
   - Provide students with the following information on the International Decade for Natural Disaster Reduction (IDNDR). *Note:* This activity on international cooperation is recommended for high school students, but it may be a bit tedious for middle-school children.

How can increased international cooperation reduce the threat from natural hazards?

There is a movement to use international experience as a guide to what can and should be done to minimize the threat to life and property from natural hazards. In 1989, the United Nations declared the decade from 1990 to 2000 as the "International Decade for Natural Disaster Reduction" (IDNDR). The basic objectives of IDNDR are to increase global awareness of and preventive measures against natural disasters and to pool and disseminate disaster-prevention techniques.

The basic objective of the IDNDR is to prevent or reduce the impact of natural disasters by gathering and sharing human and material resources in order that humanity can enjoy a safe and comfortable twenty-first century. . . . The most important mission of the IDNDR is the dissemination of knowledge and expertise on disaster science from economically advanced countries to developing countries. In the twenty-first century, the populations of many nations are expected to be concentrated in megalopolises. Such societies will be less resilient in terms of natural disasters. Bearing this in mind, we must be prepared to anticipate new types of vulnerability by launching new basic research programs during this century (Committee for Disaster Research of the Science Council of Japan 1989).

In discussion, elicit student responses to the introductory question. Help students understand that although humans cannot control the occurrence of many natural events, more international cooperation, as suggested by the IDNDR, could help people to be better warned and prepared for hazards. The issue of technology transfer is central here. Discuss with the class how more-developed countries could assist less-developed countries in the prevention of, emergency preparation for, and recovery from natural disasters. Increasing concentrations of people into congested urban areas in the Third World increases problems of education and evacuation. Problems that might arise when implementing the proposals are funding (who pays?), location (where should the effort be made?), and control (how to enact the measures?). This activity can be greatly extended if you wish.

7. **Writing**

   Ask interested students to present a report on a recent major disaster in the United States (for example, the 1989 or 1994 California earthquakes, Hurricanes Hugo and Andrew in the Southeast, or the floods in Texas in 1991 and the Midwest in 1993). Reports should include data on casualties and property damage and a description of the measures taken to recover from the disaster.

8. **Outside Experts**

   Invite representatives from international disaster-relief agencies, such as the Red Cross, to speak to students about how their organizations respond to assist communities that have suffered natural disasters.

✎Name _____

Independent Study Project

How Prepared Is Your Community for a Natural Hazard?

Investigate a natural hazard in your own community or region. Use the following questions and other questions you think of to help focus your report. The data you collect should be used to support conclusions in the report. Make maps, graphs, and tables to illustrate your report.

1. What is the nature of the hazard?

   _____

2. Where is it located?

   _____

3. What are the dates of occurrences (time line)?

   _____

4. How did people prepare for the hazard? Question parents, relatives, other students (not in the geography class), community members, etc. Questions might deal with the following:
   - awareness of hazards,
   - awareness of risks to people,
   - adequacy of natural hazard education in grades K–12 of the local schools,
   - awareness of what can be done by the public and by emergency authorities,
   - how to assist authorities, and
   - using science and technology to reduce disaster loss.

   _____

   _____

   _____

   _____

   _____

5. Was there an official warning for the hazard?

   _____

6. Could the hazard or its damages have been prevented? If so, how?

   _____

   _____

7. How do/did people cope with the hazard and its aftermath?

8. How did the geography/topography change as a result of the hazard?

9. What were individual and community responses to the event?

10. What preventive measures are in place or can be developed to lessen the devastating results of the hazard if it were to recur?

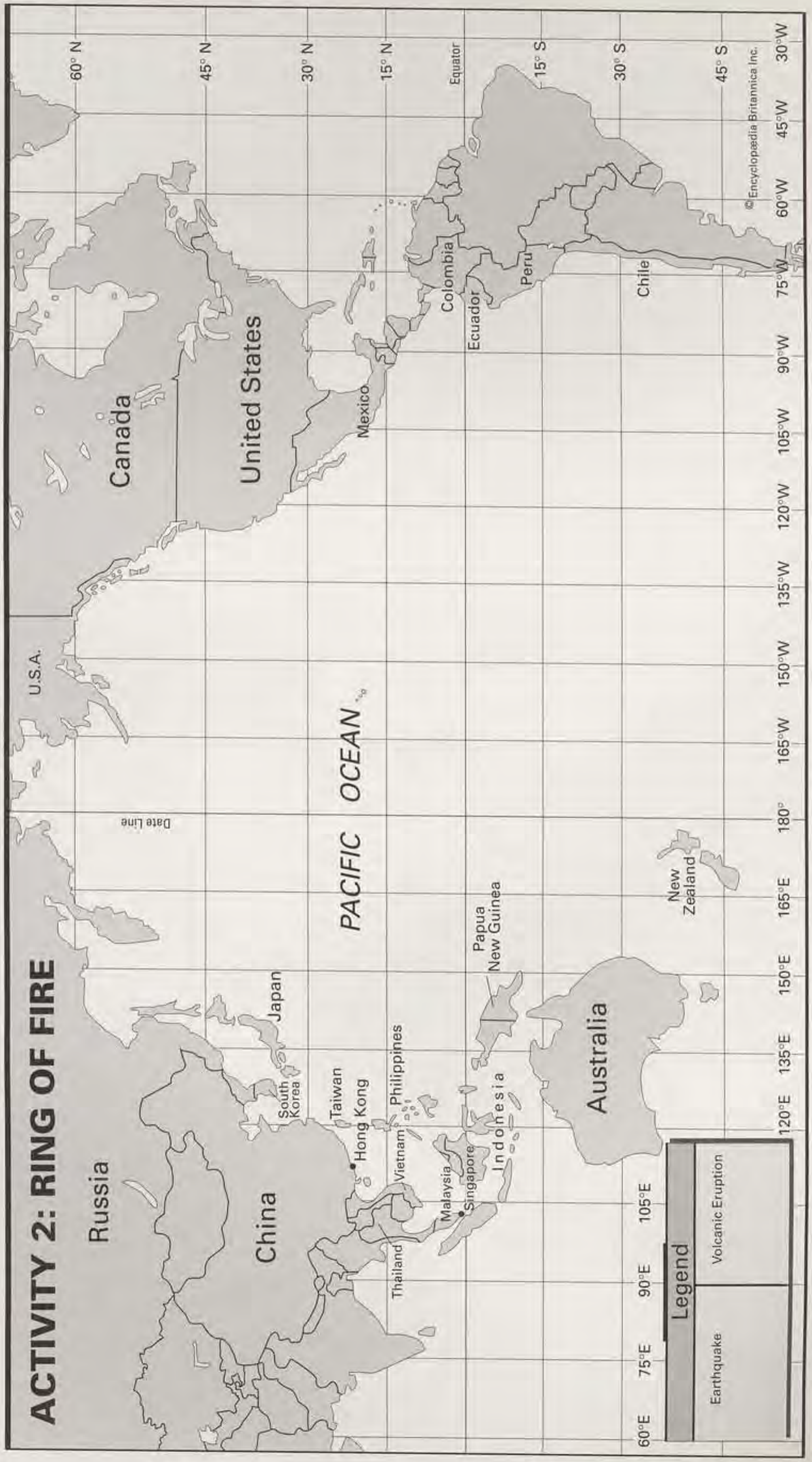
11. Are there any beneficial results of the hazard? If so, what are they? How and why would they be considered beneficial?

12. Why have people settled in this region? Why do they continue to live in this area?

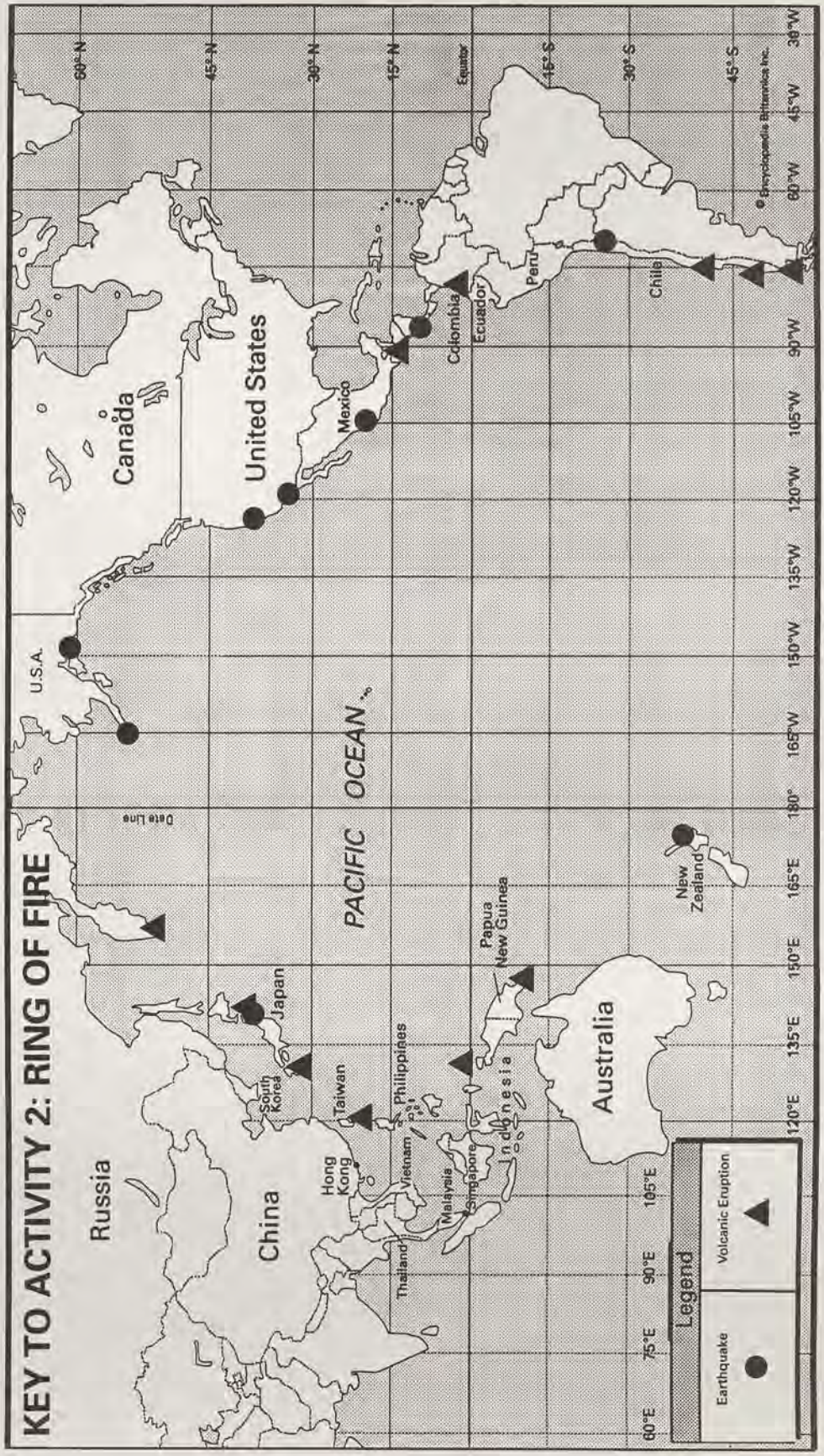
Name ______________________

Discovering the Ring of Fire

Directions: Design a symbol for an earthquake and another one for a volcanic eruption. Put them in the legend box. Then plot the location of these events from Table 1 onto the map below.



Discovering the Ring of Fire



Name _____

Become an Expert and Teach Your Friends

Your teacher will ask you to become an expert on one kind of natural event that occurs in Japan. Read about that event in your Student DataBook, and prepare to share your knowledge with other members of the class. Complete the Hazard Chart by using information provided by other class experts.

Hazard Chart

	Hazard Definition	Causes	Frequency in Japan
Earthquakes			
Volcanoes			
Tsunamis			
Typhoons			

Become an Expert and Teach Your Friends

Hazard Chart

	Hazard Definition	Causes	Frequency in Japan
Earthquakes	Shaking of Earth caused by release of energy as rock breaks or shifts under stress	Shifting of rocks along plate boundaries below surface of Earth	Approximately 1,500 per year or 20 per day; most so small that people don't notice
Volcanoes	Opening in Earth's crust from which molten rock, ash, and steam are expelled	Movement of Earth's plates causing cracks in crust that allow magma to reach surface	Approximately 75 active volcanoes, averaging over six eruptions per year
Tsunamis	Ocean waves triggered by movement of ocean floor during strong earthquakes	Strong earthquakes, landslides, or volcanic eruptions near ocean	Approximately 150 per year
Typhoons	Rotating tropical storm with winds of at least 75 mph	Warm ocean temperatures and unstable atmospheric conditions	Varies from 3 to 30 per year; heaviest in southern islands

✎Name _____

Self-assessment for Lesson 3 Jigsaw Groups (Hazard Chart)

1. In which group were you?

   Expert groups (circle the appropriate group below):

   1. Earthquakes 2. Volcanoes 3. Tsunamis 4. Typhoons

   Teach-a-friend groups (circle the appropriate group below):

   Group A Group B Group C Group D

2. Was this the first jigsaw cooperative learning in which you participated?

   Yes No

3. Did you enjoy it? Explain.

   _____

   _____

4. What did you learn that you did not know before?

   _____

   _____

5. If you were going to do a jigsaw activity again, how would you make it different?

   _____

   _____

   _____

   _____

Name _____

Is Nature More Hazardous or Less Hazardous for the Japanese People Today?

Present Conditions	Conditions in the Past

Conclusion

_____

_____

Explanation

_____

_____

Is Nature More Hazardous or Less Hazardous for the Japanese People Today?

Present Conditions	Conditions in the Past
• Increase in population and in population density; 11 cities have grown to over 1 million people • Most people depend on a centralized energy system as opposed to use of coal and kerosene to heat and light homes • Better education for children and adults regarding hazards • Countermeasures developed by government authorities • Improved technology and warning systems • Government appropriation for disaster research, prediction, and prevention	• Low population and population density • Railroad and subway almost nonexistent • Energy use is spread out so there is little dependence on a single source of energy • Few cities and industrial areas along coasts or on steep slopes where hazard risk is great • Little or no advance warning systems • Little or no government appropriation for disaster research, prediction, and prevention

Situations for Earthquake Scenarios

1. You are staying on the eighteenth floor of a hotel in San Francisco. A large earthquake strikes, causing major damage to the city. Streets are blocked, and the elevator in your hotel is not working. Your parents went shopping and left you in charge of your younger sister, who has been injured by a falling object and is cut badly. What do you do?

2. A large earthquake hits while you are visiting your cousins in a remote, hilly area outside Reno, Nevada. It is a rainy, gloomy night. A portion of the house is damaged by a landslide, the utilities are not working, and there is always the possibility of aftershocks. What do you do?

3. A large earthquake hits while you are home in Anchorage, Alaska, with your family. Your house is not extensively damaged, but a railroad car on a nearby track has been derailed and is leaking chlorine gas. You must evacuate. If you had to leave within 20 minutes, what would you do? If you had two hours to evacuate, what would you do?

4. You are in Los Angeles the day after Thanksgiving doing your holiday shopping. A moderate earthquake strikes, shutting down the public transportation system and the utilities. It is 6:30 P.M., your arms are full of packages, and your family expects you home by now. What do you do?

5. You and your spouse are on a weekend trip to Reno, Nevada. A major earthquake hits the San Francisco Bay area where you live. Roads, electricity, and phones are out. Your children are at home with a relative who is visiting from Wisconsin. What do you do?

6. You are disabled and get around quite well in a motorized wheelchair. You live in Memphis, Tennessee, on the third floor in a five-story apartment building with an elevator. An earthquake hits, putting the elevator out of commission. You are concerned about the threat of fire. What do you do?

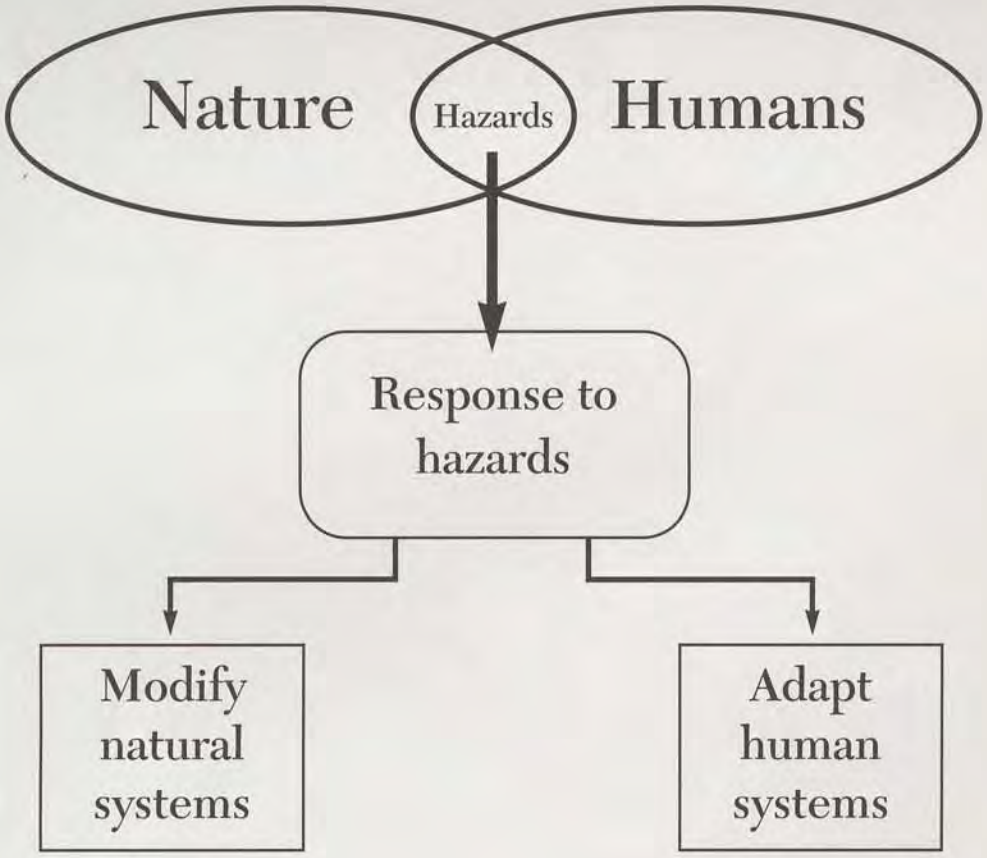
7. You are at home in San Francisco with your six-week-old baby when an earthquake hits, knocking many objects off shelves and tearing the chimney off the house. A fire starts in the house next door. Your spouse is at work. What do you do?

8. You live in a senior citizens' apartment building in Los Angeles. A moderate earthquake hits, shaking many objects off shelves. You are struck by some flying glass, and the cut starts to bleed profusely. What do you do?

9. You are at work in Oakland when a large earthquake strikes. You drove to work from Walnut Creek, a city east of Oakland, through a tunnel. The tunnel is now impassable, and several people in your office are injured. You have first-aid training and could help. Your children (ages six and nine) attend school in Walnut Creek. The phone lines are tied up. You are concerned about the kids. It is 11:00 A.M. What do you do?

10. You and your family are home in Honolulu, Hawaii, when a large earthquake strikes. A big tree falls onto your house, destroying the kitchen. It starts to rain. You think you smell gas. What do you do?

Natural Hazards Occur from Interactions Between Nature and Humans



The interaction of natural and human systems creates hazards for humans. Responding to these hazards, societies may seek to modify the natural events system (the atmosphere, hydrosphere, and lithosphere) and/or the human use system (people, economies, and social organizations).

Source: Burton, Kates, and White 1993, page 32.

The World's Deadliest Natural Disasters

A 25-year sample provided details of the frequency of intensive natural hazards and their effects.

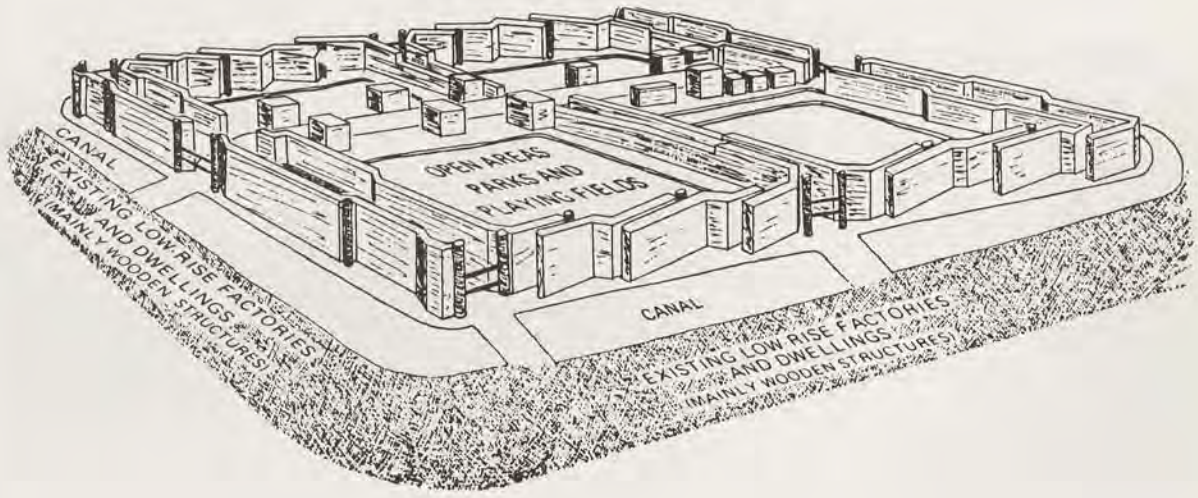
Type of disaster	Index of frequency	Percentage of deaths
Floods	100	39
Typhoons, hurricanes	73	36
Earthquakes	41	13
Tornadoes	32	1
Gales, thunderstorms	15	5
Snowstorms	13	1
Heat waves	8	1
Cold waves	6	1
Volcanic eruptions	6	2
Landslides	6	1

Source: Gregory 1990, page 37.

Japan: Examples of Preventive Measures

The main countermeasures projected by Tokyo Metropolitan Government are for fires which may occur simultaneously in many independent sites. They include development of open spaces to be used for disaster prevention, laying down water tanks along the roads to the open spaces in order to ensure evacuation routes, land use management, [and] planning for evacuation from fire. . . . [Nakano and Matsuda 1984, page 418.]

Designation of open spaces for emergency evacuation and construction of fire-resistant high-rise buildings



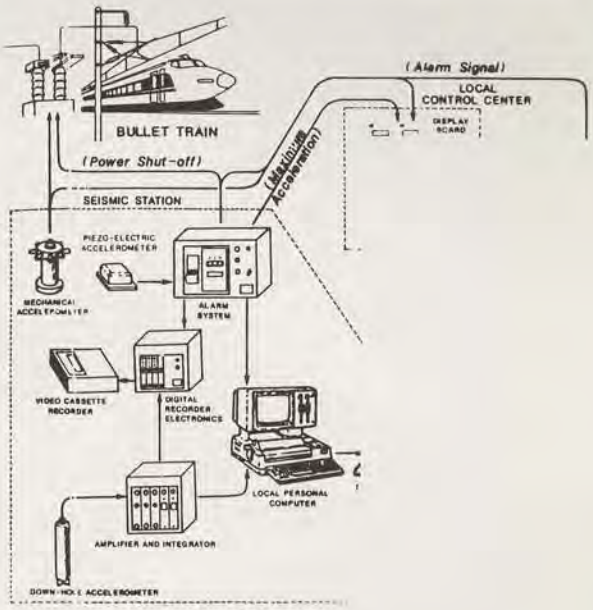
Disaster Refuge Planned for Tokyo Metropolitan Area

In anticipation of a major earthquake sometime after 1978, redevelopment is planned for the Koto area of Tokyo, an especially vulnerable area below sea level (due to land subsidence) and crowded with flammable factories and residences. The planned redevelopment seems to draw inspiration from the classic walled cities or castles. Open spaces used normally for public parks or athletic fields are surrounded by high-rise fire-resistant buildings, separated by canals from the older existing areas. Such open spaces are intended as havens of refuge for evacuation in the face of fire and inundation from the sea. . . . Building these open spaces will require more than 10 years of effort and about one-third of the total annual Tokyo metropolitan budget—an allocation of funds deemed desirable by the city officials. [Burton, Kates, and White 1993, page 141.]

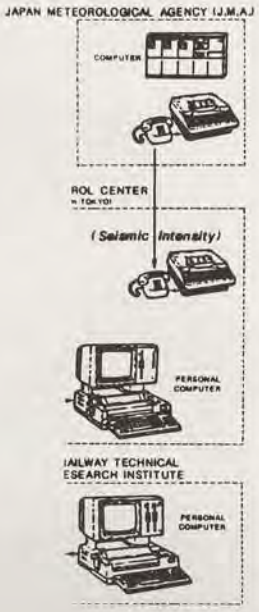
Earthquake Warning System

In 1965, one-half year after the Bullet Train started operation, a magnitude 6.0 earthquake near Shizuoka damaged the train track. While there was no human injury or damage to the train itself, the danger of earthquakes to the train was realized, and, consequently, construction of an earthquake warning system was recommended. . . .

This earthquake warning system today is a product of 20 years of complex evolution of seismology, technology, and needs.



Alarm system [illegible] *Line of Shinkansen*



". . . since the detectors are spaced every 20 km, the chances are good that the train will not traverse a damaged portion of track, or, if it does, it will do so at a reduced speed. The primary goal of the earthquake warning system is to prevent the train from crossing damaged track at high speed."

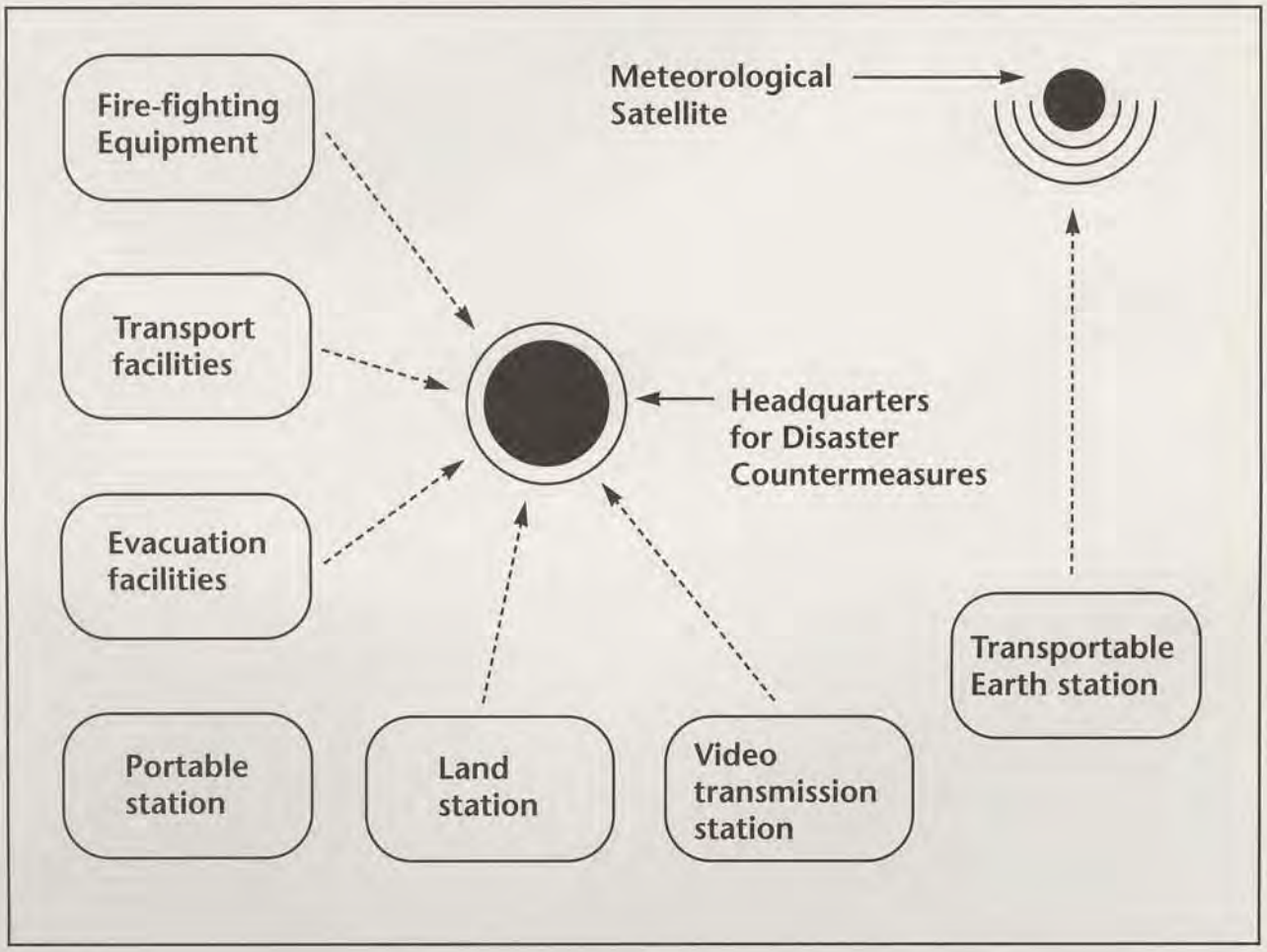
Source: Nakamura and Tucker 1988, pages 142–143, 146.

Development and Improvement of Disaster Prevention Facilities and Equipment

In order for the disaster prevention activities to be smoothly carried out, observation equipment including meteorological satellites, meteorological radar and seismometers; provisions, machines and materials required for disaster emergency activities; broadcasting and communication facilities serviceable at the time of a disaster; transport facilities; fire-fighting equipment; and evacuation facilities are provided and installed.

Also, efforts are made to promote such projects as making buildings less flammable, developing evacuation sites and routes, remodeling urban areas, and securing open space. In the event of a disaster, the municipality of the area responds first and takes emergency measures with headquarters for disaster countermeasures established as required. Further, depending on the condition of the disaster, the prefectural government establishes the headquarters for disaster countermeasures and promotes countermeasures.

Central Disaster Prevention Radio Communications Network



Making Cities More Disaster Resistant

The following measures are taken against earthquake disasters in the cities:

- Securing and improvement of evacuation sites and routes.
- Upgrading standards for buildings, extension of public facilities, and improvement for earthquake resistance of lifeline facilities.
- Promoting fire-resistant construction of buildings and improving fire-fighting facilities.

Sources: Disaster Prevention Bureau, National Land Agency, 1991; Disaster Prevention Section, Toshima Ward Office, Tokyo; Japan Information Center, no date, *Special Series—Japan in Slides.*

Japan: Examples of Preparation and Emergency Relief

Establishment of an Emergency Relief System

". . . the Tokyo Metropolitan Fire Board has been making vigorous efforts to train skillful fire fighters and to strengthen and improve an emergency rescue system in order to cope swiftly with various types of disasters. . . . In order to make individual citizens more aware of disaster prevention and to educate them about disaster preventive behavior, **Disaster Prevention Day** has been established. Also, volunteer groups are organized for disaster prevention and relief purposes, and programs such as first-aid training are offered at various places."

Schoolchildren participate in fire-fighting exercises in order to protect their own neighborhoods from fires.

Earthquakes hit Japan frequently. Every year citizens participate in a full-scale evacuation and disaster relief exercise on Disaster Prevention Day.

Disaster Prevention Exercise

When a natural disaster occurs or seems likely to occur, the organizations concerned with disaster prevention, local inhabitants and local organizations, carry out exercises for transmission of alarms and warnings, evacuation, fire fighting, and rescue in cooperation with one another. On September 1, Disaster Prevention Day, a "comprehensive exercise for disaster prevention" is carried out by the government in cooperation with the organizations concerned.

Source: Japan Information Center, no date. "Disaster Prevention in Tokyo." *Special Series—Japan in Slides.*

Japan: Disaster Recovery Measures

Disaster Recovery Project

Recovery of damaged public engineering facilities, educational facilities, welfare facilities, and agricultural, forestry, and fishery facilities is made directly by the government or by local governments with subsidies granted by the government.

Disaster Loans

Persons engaged in agriculture, forestry, and fisheries, and in smaller enterprises, and persons of lower income who incurred damage will have various loans allowed under more generous conditions than usual.

Disaster Compensation and Casualty Insurance

Damaged enterprises or persons engaged in agriculture, forestry, and fisheries are compensated for loss. Earthquake insurance is reinsured by the government.

Tax Reduction or Exemption

For the affected persons, measures are taken for reducing, exempting, or allowing respite for collection of income and inhabitant taxes.

Tax Allocation to Local Governments and Local Bonds

For the affected local governments, measures such as delivery of special tax allocations and permission of local bonds are taken.

Source: Disaster Prevention Bureau, National Land Agency, 1991.

✎Name ________________

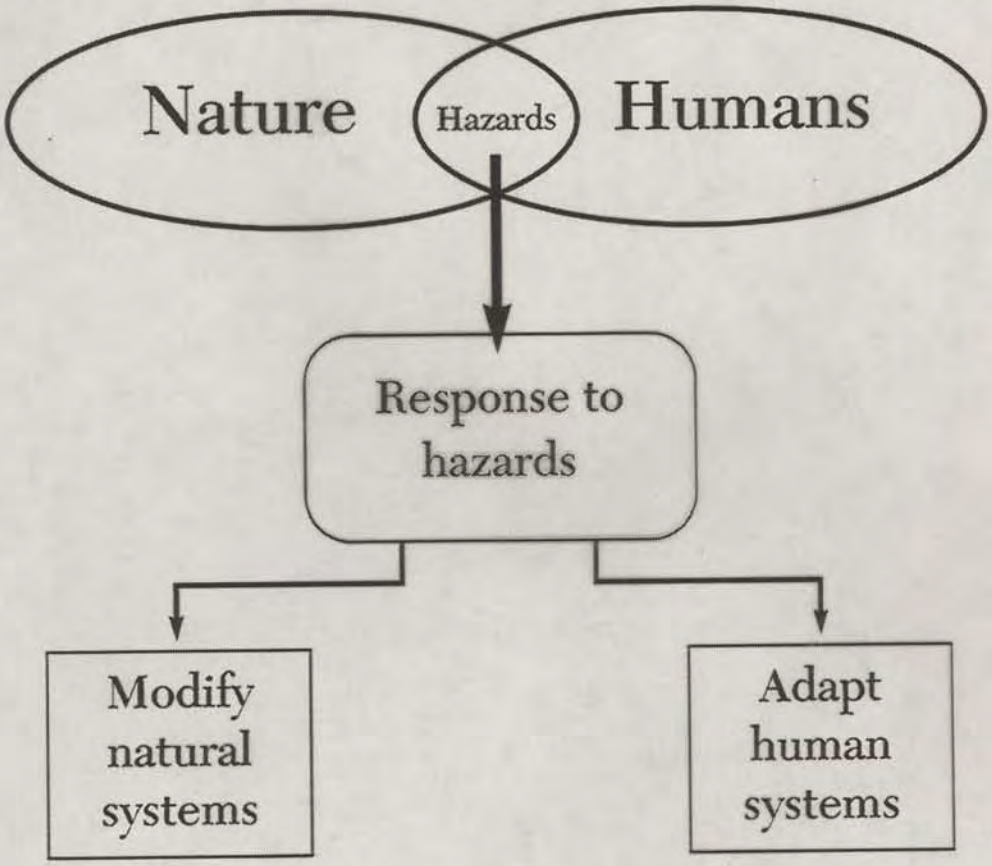
Graphing Natural Disasters

Graph 1—Reasons for Loss of Life in Bangladesh Typhoons

How might Bangladesh be able to reduce the devastating effects of typhoons and floods?

Graph 2—Comparing Preparedness for Destructive Storms in Bangladesh and the United States

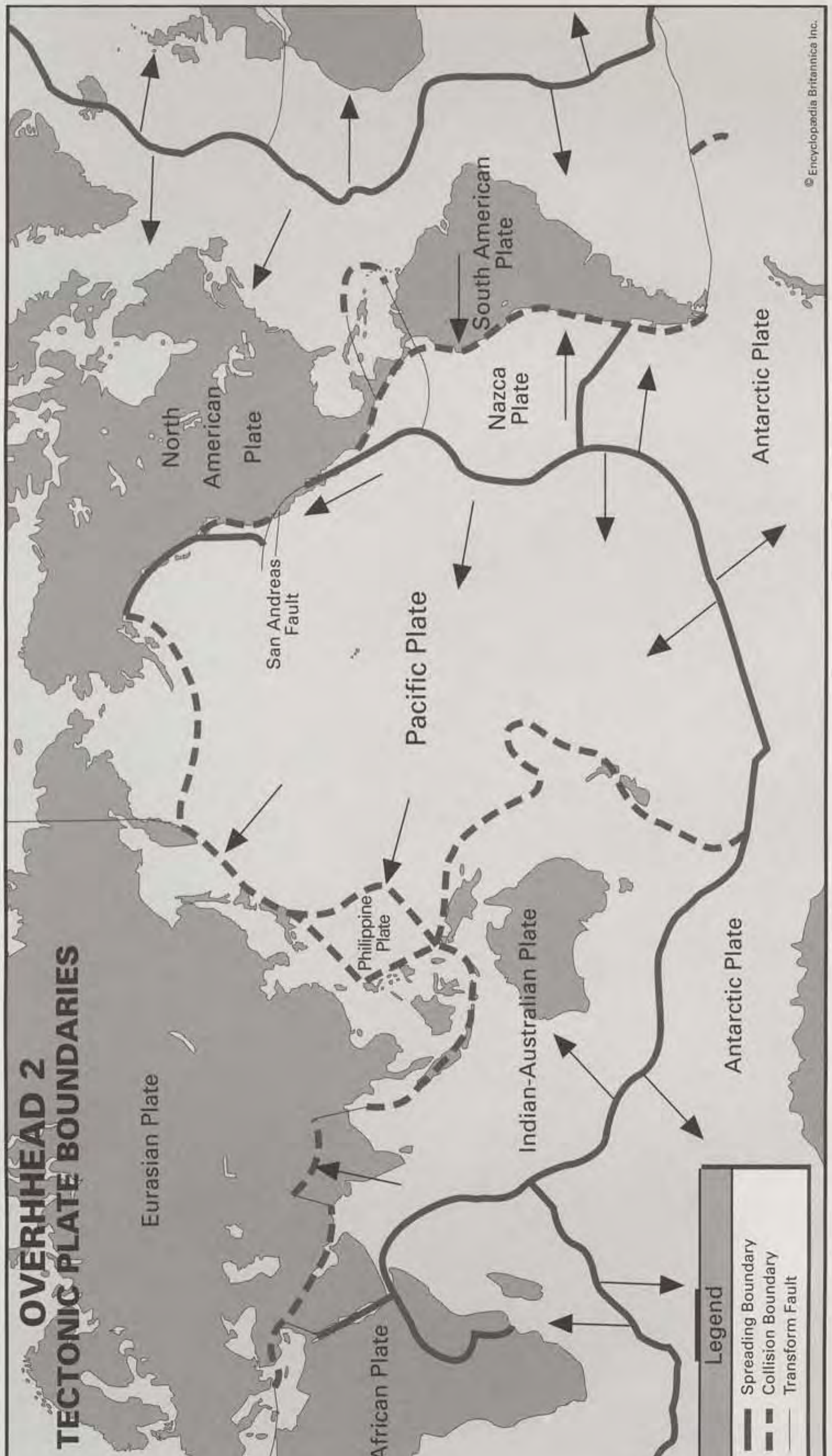
Natural Hazards Occur from Interactions Between Nature and Humans



The interaction of natural and human systems creates hazards for humans. Responding to these hazards, societies may seek to modify the natural events system (the atmosphere, hydrosphere, and lithosphere) and/or the human use system (people, economies, and social organizations).

Source: Burton, Kates, and White 1993, page 32.

Boundaries of Earth's Tectonic Plates, Showing Plate Movement



Source: Adopted from B. A. Bolt. 1988. *Earthquakes.* New York: W. H. Freeman & Co.

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Source: Gregory 1990, page 37.

BRITANNICA GLOBAL GEOGRAPHY SYSTEM

GIGI

Geographic Inquiry into Global Issues

Natural Hazards

Program Developers
A. David Hill, James M. Dunn, and Phil Klein

Regional Case Study
Japan

Britannica
ENCYCLOPAEDIA BRITANNICA EDUCATIONAL CORPORATION
310 South Michigan Avenue Chicago, Illinois 60604

Geographic Inquiry into Global Issues (GIGI)
The Center for Geography Education
Department of Geography, Box 260
University of Colorado at Boulder
Boulder, CO 80309-0260

GIGI Project Staff
A. David Hill, Director
James M. Dunn
Phil Klein

Project Consultants
Alan Backler
Michael Hartoonian
Robert Richburg
Joseph P. Stoltman

Natural Hazards
First draft written by Kathryn Lapp and Corine O'Donnell
Reviewed by William Riebsame and staff of Natural Hazards Research and Applications Information Center, Boulder, Colorado

EBEC Production Staff and Associates
Project Manager: Emily Clott
Director, Educational Product Development: Martha Hopkins
Design, Editorial, Production: Proof Positive/Farrowlyne Associates, Inc.
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Logo and Package Design: Richard Laurent

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Contents

GIGI National Field Trial Locations

Anchorage, AK
Juneau, AK
Birmingham, AL
Grove Hill, AL
Ventura, CA
Arvada, CO
Boulder, CO
Colorado Springs, CO
Lakewood, CO
Westminster, CO
Wilmington, DE
Nokomis, FL
Lithonia, GA
Marietta, GA
Beckemeyer, IL
Red Bud, IL
Lafayette, IN
La Porte, IN
Merrillville, IN
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Eldorado, KS
Morgantown, KY
Lowell, MA
South Hamilton, MA
Westborough, MA
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Pasadena, MD
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Memo to the Student from the GIGI Staff

GIGI stands for *Geographic Inquiry into Global Issues,* which is the name of a series of modules. Each module inquires into a different world issue. We wrote this memo to explain that GIGI is different from most textbooks you have used.

With GIGI, you can have fun learning if you think like a scientist or detective. The main business of both scientists and detectives is puzzle-solving. They use information ("data" to the scientist and "evidence" to the detective) to test their solutions to puzzles. This is what you do with GIGI. GIGI poses many puzzles about important global issues: Each module centers around a major question, each lesson title is a question, and there are many other questions within each lesson. GIGI gives you real data about the world to use in solving these puzzles.

To enjoy and learn from GIGI, you have to take chances by posing questions and answers. Just as scientists and detectives cannot always be sure they have the right answers, you will sometimes be uncertain with GIGI. But that's OK! What's important is that you try hard to come up with answers, even when you're not sure. Many of GIGI's questions don't have clear-cut, correct answers. Instead, they ask for your interpretations or opinions. (Scientists and detectives are expected to do this, too.) You also need to ask your own questions. If you ask a good question in class, that can sometimes be more helpful to you and your classmates than giving an answer.

The data you will examine come in many forms: maps, graphs, tables, photos, cartoons, and written text (including quotations). Many of these come from other sources. Unlike most textbooks, but typical of articles in scientific journals, GIGI gives its sources of data with in-text references and full reference lists. Where an idea or piece of information appears in GIGI, its author and year of publication are given in parentheses, for example: (Gregory 1990). If the material used is quoted directly, page numbers are also included, for example: (Gregory 1990, pages 3–5). At the end of the module you'll find a list of references, alphabetized by authors' last names, with complete publication information for the sources used.

To help you understand the problems, GIGI uses "case studies." These are examples of the global issue that are found in real places. "Major case studies" detail the issue in a selected world region. You will also find one or two shorter case studies that show variations of the issue in other regions.

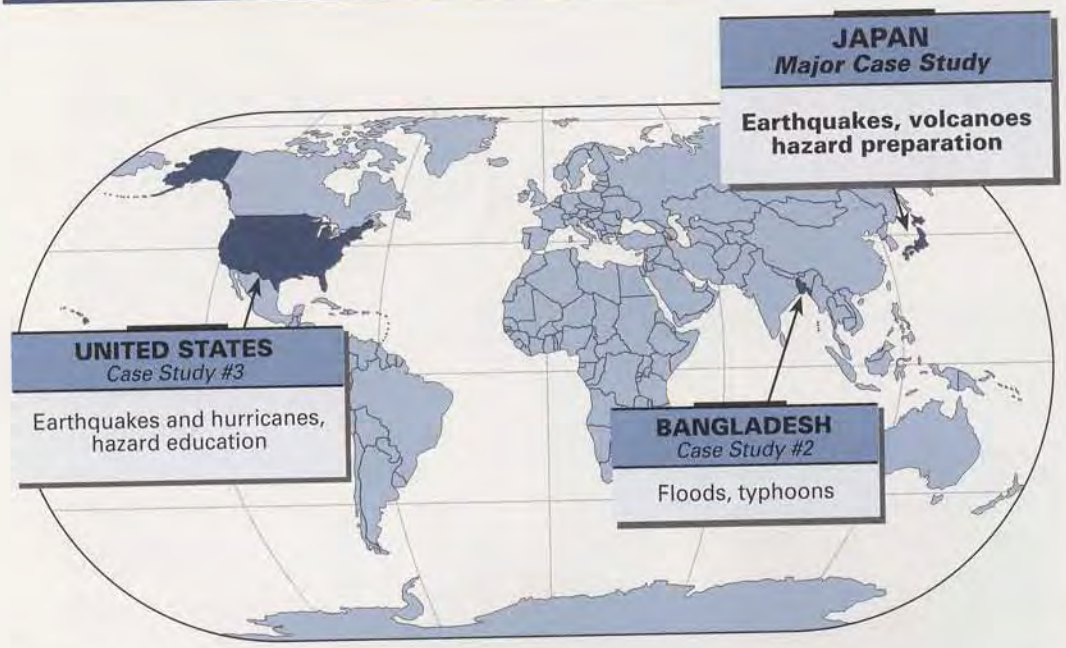
We hope your geographic inquiries are fun and worthwhile!

Natural Hazards

Why do the effects of natural hazards vary from place to place?

- What is it like to live through an earthquake or flood?
- What happens to people in a tornado or hurricane?
- What would you do if your home was buried under 10 feet of snow?
- What do people experience when a volcano erupts?

In this module, you will study natural events and why they can become hazardous to people. Natural hazards pose a great threat to human life and property. Geographers want to know why some places are more prepared for natural hazards than others. This module shows you how three countries cope with these risks.



Questions You Will Consider in This Module

- Why do events such as earthquakes and volcanoes occur where they do?
- When does a natural *event* become a natural *hazard*?
- How do natural hazards affect the way people live?
- How do people reduce the danger from hazardous natural events?
- Are natural events more hazardous or less hazardous today than they were in the past? Why?
- Why do abilities to prepare for hazards vary among different countries?

How do natural hazards affect the lives of people in Japan?

Objectives

In this lesson, you will

- Investigate an example of a hazardous event in Japan.
- Analyze how the event affected the people's quality of life.

Glossary Words

earthquake
magma
natural hazard
seismometer
volcano

"The Fire Below" is an article that appeared in a Japanese magazine. It describes a volcanic eruption in 1983 on Miyake Island, Japan (Figure 1 on the opposite page). Consider these questions as you read the article.

1. How did the volcano affect the land, economy, and life of the people on Miyake Island?
2. Explain how people were prepared for and warned about the eruption.
3. Did the people move from the area to avoid another disaster? Why or why not?
4. Would *you* stay on Miyake Island in the face of this continuing hazard? Why or why not?

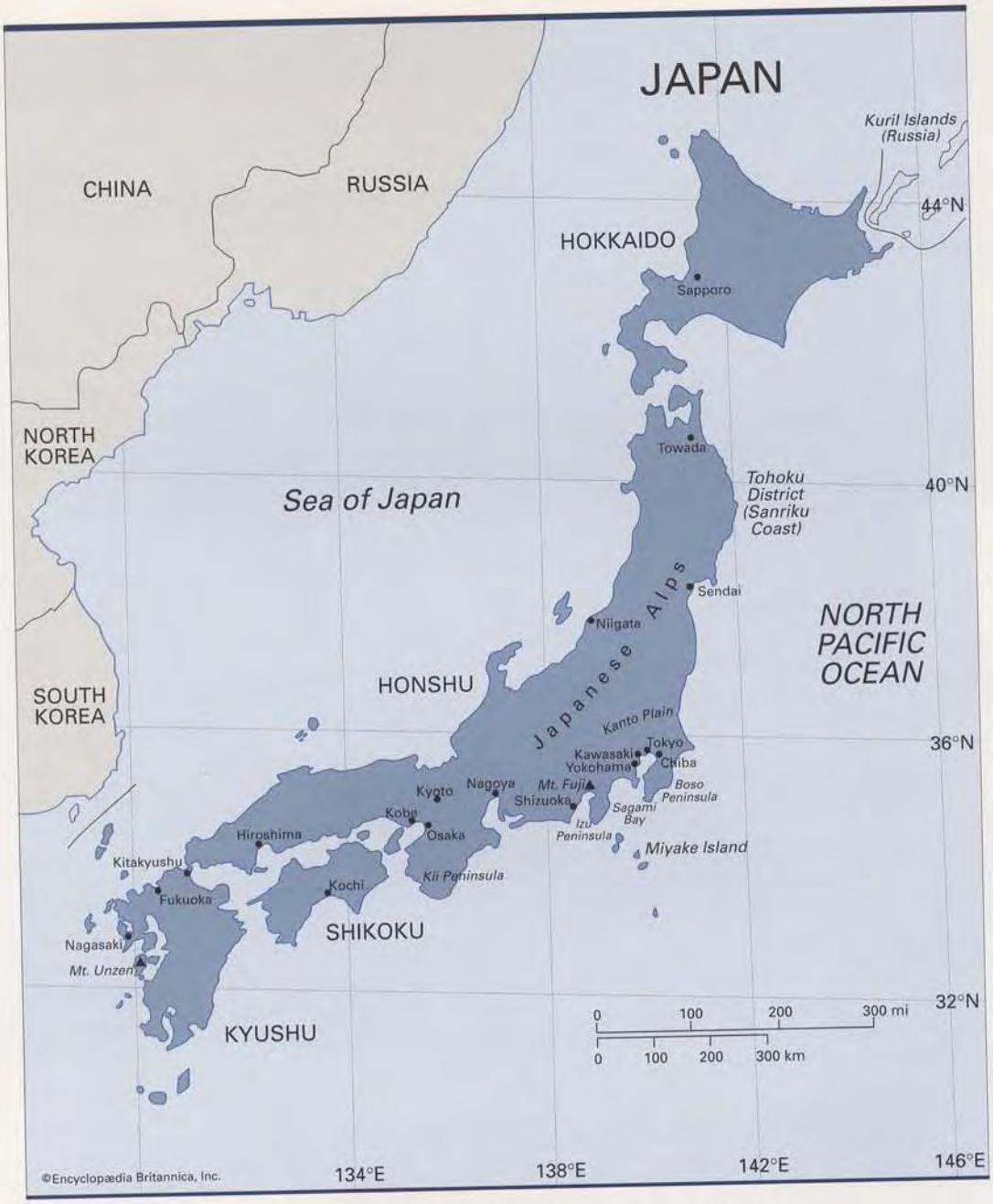


Figure 1 Map of Japan, showing the four main islands.

THE FIRE BELOW

The volcanic explosion was sure to come—but when?

The earth shook. Fountains of fire and ash blossomed from the side of the mountain. It looked and felt and sounded and smelled like the end of the world. The people of Miyake Island, an overnight boat ride south of Tokyo, knew it was coming. Somewhere deep in their hearts, they'd always known. But not now, when things are going so well, when there are crops to harvest, fish to catch, the good life to live.

But at 3:35 P.M., October 3, 1983, a chain of gaping vents burst on the mountainside, one after another. A strafing zig-zag of craters. An unceasing, rhythmic bombardment of noise. In moments, the southwest ridge was aflame. Rockets of sparks shot high into the air—awesome, beautiful, horrible. Thick cables of smoke twisted upward—as high, it was said, as the island is long. Glowing magma gushed from the vents, the blood of the mountain, a glacier of fire. It oozed downward, faster and faster, across the island's only highway, ever downward toward the village. It had come.

Something was wrong, somehow strange, long before the eruption. Not everyone felt it, but one who did was fisherman Akira Negishi, 63. For a month, he'd been telling people, "The ocean's too hot, close to 30°C. This time of year, it should be about six degrees lower." Animals sensed it, too. Jack Moyer, an American marine biologist residing on the island for some 30 years, was on the beach near his home the morning of the eruption. "Weasels—dozens of them. They were headed for the sea in droves. The big waves didn't bother them, they just kept going." It was about 10 A.M.

By 1 P.M., the signs were even stronger. A series of slight but unmistakable tremors jiggled the windows, rippled the surface of tea in the cups, raised the hairs on the backs of necks. After an hour or so of this, tourism worker Tanaka, 43, picked up his phone and dialed the island's meteorological station. "Volcano or just an earthquake?" he asked. The station's seismometers were monitoring the

Fountains of fire and ash blossomed from the side of the mountain.

Villagers push a cart carrying their belongings as they flee a volcanic eruption.

tremors, they said. So far, nothing was definite, one way or the other. But the tremors continued, strengthening by the minute. In a sweet-potato field near her house in Ako Village, a housewife was taking her 3 o'clock break, sitting on the ground with some friends. "I felt 'zoom, zoom, zoom,' a tingling, as if my bottom were going to sleep." In the back of her mind was a drill the villagers had practiced back in August, a drill most of the children had thought was silly, something about what to do in case of an earthquake . . . or an eruption.

Silly? Older folks didn't think so. Twice in their lifetimes the mountain had trembled, twice before it had vomited fire. The 1940 eruption ripped out the side of a mountain called Sanschichi and smothered the fields below with a crust of lava that even today is as brittle and black-red as firebrick. The 1962 burst was worse, devastating even more of the same eastern sector of the island, cratering and gushing its way clear down to the surf line and hissing out into the sea.

Ako Village, on the west coast of the tiny island, had been spared in those latest eruptions, and in most of the others—some 16 in all since 1085. . . .

About half of the island's 4,467 full-time residents live in the clustered subvillages of their ancestors, in old wooden houses with swept dirt yards and flowers and trees behind chest-high walls of cement blocks or rocks. The people tend to be clannish, and social life is rather limited. Young people notice this, and complain that on Miyake, if you stand up too quickly, you bump into your neighbor looking over your shoulder. Quite a number of children leave as soon as they are old enough, seeking jobs in the more liberal cities on the main islands. But city air doesn't taste of pines and salt, and many of them eventually return. . . .

Some minutes past 4 P.M., about a half-hour after the eruptions on the ridge had been confirmed, an official in Ako flicked a switch and said into a microphone, "Evacuate, evacuate!" Thanks to the warning, no lives were

Aftermath of a volcanic eruption.

lost in the Miyake disaster. But as people boarded buses for an Evacuation Center, in a school gym in the northern part of the island, they carried almost nothing with them. "I expected to be back soon. I just couldn't believe my home was in danger," cried a woman at the center. "This is all I brought—just look." She held up a baby bottle in one hand and a half-empty pack of cigarettes in the other. Strapped to her back was a sleeping infant. She had remembered to bring him, too.

In the gym, safely 15 or 20 kilometers away, she joined the hundreds of evacuees crowded before a color TV and watched silently as cameras in helicopters recorded the scene. About 6 P.M., the river of lava crossed the highway above deserted Ako Village. By morning, 12 hours later, the TV screen showed little more than steaming lava. Eight out of [every] 10 of Ako's 521 houses had vanished.

More than 500 residents fled the island on the following day, heading for Tokyo on the very same ships that had earlier delivered emergency supplies of food, blankets, and water. Those who remained said they would try to resettle in the Ako area, even if this meant living in the flimsy temporary huts that already were being set up by the authorities.

When telephone service had been established, among the flood of calls was one from the daughter of a 59-year-old Ako woman. "She wants me to come and live with her in Tokyo," said the woman. "But the graves of my ancestors are here. And even though the lava buried my house, the land underneath it is still mine. I'm staying."

Her feelings were echoed by many. A 71-year-old farmer's wife: "Live in Tokyo? No, the air hurts my eyes." An 11-year-old schoolboy, his eyes puffy from lack of sleep and from crying, but his voice as steady as a rock: "Of course there'll be another eruption someday. So what? I'm staying, too." And a 49-year-old construction worker with a tanned and leathery face: "Are we weasels, running into the sea at the first sign of danger? This is my land, my Miyake. Born here, live here, die here. That's what I believe" (*Japan Pictorial* 1984, pages 29–33).

Why does Japan have so many earthquakes and volcanoes?

Objectives

In this lesson, you will

- Identify the locational patterns of earthquakes and volcanoes.
- Understand the relationship of plate tectonics to earthquakes and volcanoes.

Glossary Words

asthenosphere
crust
earthquake
island arc
lithosphere
magma
plate tectonics
subduction
tectonic plates
volcano

Where are earthquakes and volcanoes concentrated in the Pacific Ocean region?

Table 1 on the following page reports the latitude and longitude of several earthquakes and volcanic eruptions in the Pacific region. You can plot these locations on a map to see a pattern over a large area.

Table 1 Latitude and longitude of selected earthquakes and volcanic eruptions in the Pacific region

Earthquakes	Volcanic eruptions
60°N x 148°W	50°N x 155°E
55°N x 167°W	38°N x 140°E
38°N x 122°W	30°N x 130°E
35°N x 140°E	20°N x 122°E
33°N x 118°W	15°N x 90°W
19°N x 103°W	5°N x 78°W
10°N x 86°W	1°N x 128°E
25°S x 70°W	10°S x 148°E
39°S x 177°E	40°S x 73°W
	48°S x 75°W
	53°S x 74°W

Sources: Information Please Almanac 1992; *Goode's World Atlas,* 18th Edition 1990.

Why are the islands of Japan threatened by recurring volcanoes and earthquakes?

Earth's thin crust is made up of several separate, rigid slabs called tectonic plates. According to the theory of plate tectonics, the movements of tectonic plates explain the occurrence of earthquakes and volcanoes. Two plates can either move apart from one another or move toward one another. Boundaries where plates move apart from each other are called *spreading ridges*. Boundaries where two plates come together are called *subduction* or *collision* zones (Figure 2 on the following page).

Most of the world's powerful earthquakes and destructive volcanic eruptions occur where two plates come together. When friction becomes too great and the plates are no longer able to move, tremendous pressures build up. When that energy is released, earthquakes occur. Molten rock (magma) from the asthenosphere moves up through cracks in the rigid lithosphere created by all the pressures. Volcanoes occur when the magma erupts onto the surface.

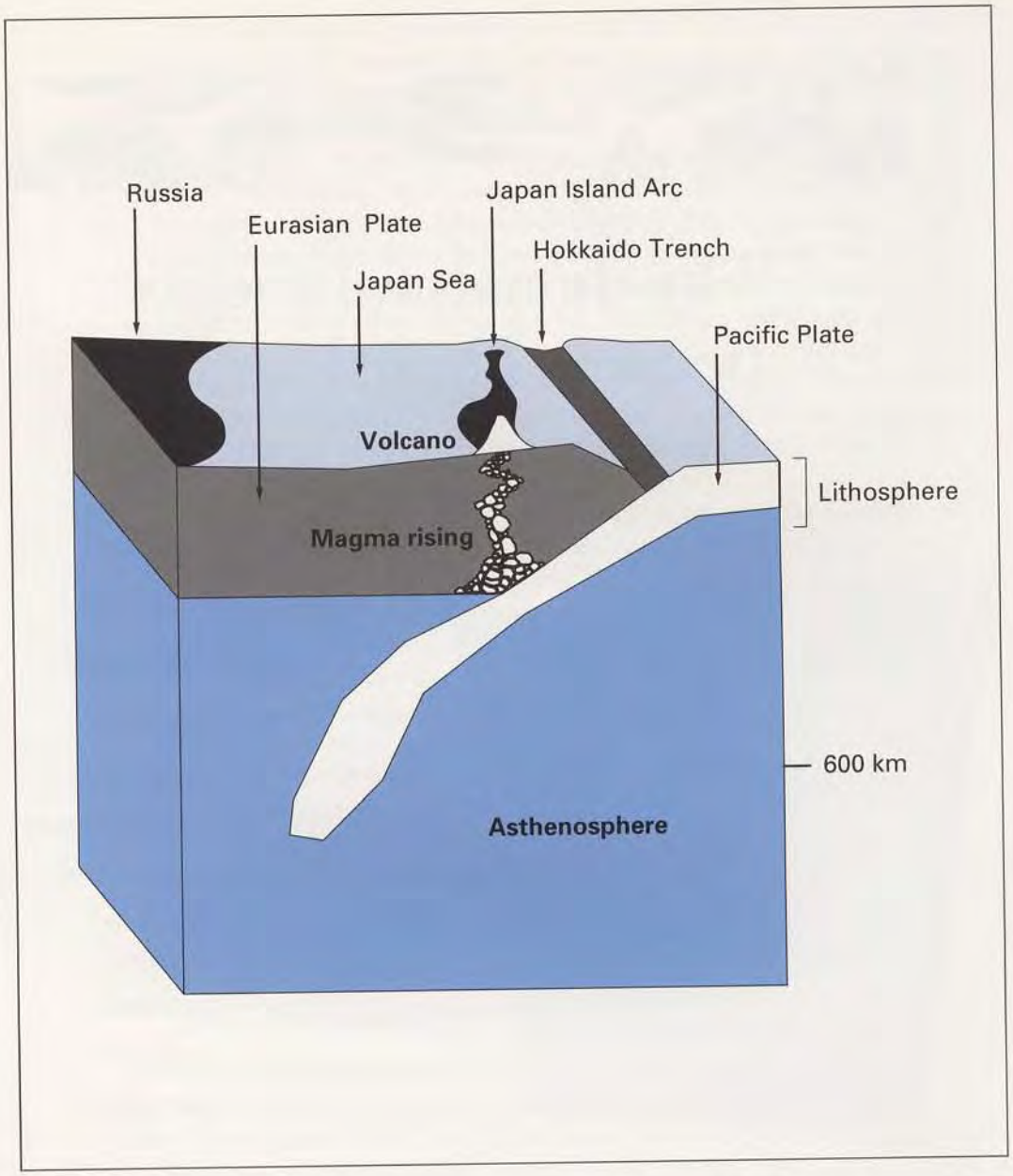


Figure 2 Diagram of a subduction zone. East of the island of Hokkaido, Japan, the Pacific Plate slides below the Eurasian Plate at an angle of 45° and extends toward the Asian mainland. This subduction passes underneath Hokkaido, causing earthquakes to occur along the zone to a depth of 600 km. Shallow earthquakes, which usually cause the greatest damage, occur in the overriding Eurasian Plate.

Source: van Rose 1983.

Why do natural events become hazardous to the people of Japan?

Objectives

In this lesson, you will

- Learn the causes of some natural events that are hazardous to the people of Japan.
- Explain why earthquakes, volcanoes, tsunamis, and typhoons occur in the Japanese islands.

Glossary Words

crust
cyclone
earthquake
epicenter
fault
hurricane
island arc
lithosphere
magma
mantle
prefecture
seismic waves
subduction
tectonic plates
tsunami
typhoon
volcano

What causes the natural hazards threatening the islands of Japan?

1. Earthquakes

Earthquakes, at least the big ones, can create havoc because they happen without warning. A sudden movement along a crack in Earth's crust, called a fault, causes an earthquake. The geographer Tom McKnight explained it this way:

An earthquake is essentially a vibration in the crust that is produced by shock waves from a sudden displacement along a fault. The fault movement amounts to an abrupt release of energy from a long, slow accumulation of strain. . . . The faulting may take place right at the surface, but it usually originates at considerable depth, extending downward as much as 400 miles (640 km) beneath the surface. The pent-up energy that is released moves through the lithosphere in several kinds of waves from the center of motion (called the focus). These seismic waves are transmitted outward in widening circles, almost like ripples produced when a rock is thrown into a pond, gradually losing momentum with increasing distance from the focus. The strongest shocks and greatest crustal vibrations are usually felt directly above the focus on the surface, which is referred to as the epicenter of the earthquake. . . .

Earthquakes may occur anywhere, even in the middle of apparently very stable continental areas. Most, however, take place in association with the boundary zones of the great crustal plates, particularly along the midocean ridges and in the subduction areas of ocean margins. The greatest concentration of earthquake epicenters are found around the rim of the Pacific Ocean.

Despite our expanding understanding of the nature and causes of earthquakes and the increasing sophistication of quake detecting instruments, it is still quite impossible to predict a quake with any assurance. As one famous contemporary geophysicist states it, "At present we can't predict earthquakes any better than the ancients did" (McKnight 1993, page 413).

Why do earthquakes occur in Japan?

Three of Earth's tectonic plates meet near the Japanese islands. They are the Pacific Plate, the Eurasian Plate, and the Philippine Plate. Subduction zones are found near Japan (Figure 2 on page 11).

Subduction occurs when a plate with oceanic crust collides with a plate of continental crust. Oceanic crust is made of denser rock than continental crust, so it plunges beneath the less dense continental plate. Where subduction occurs, a deep ocean trench develops. Parallel to the trench, molten rock is forced up to form a chain of volcanic islands (known as island arcs). This is what formed most of the Japanese and Philippine islands.

Examine Figure 2 on page 11 again. It is a diagram of a subduction zone. East of the Japanese island of Hokkaido, the Pacific Plate slides below the Eurasian Plate at an angle of 45° toward Russia on the Asian mainland. This subduction passes underneath Hokkaido, causing earthquakes to occur along the zone to a depth of 600 km. Shallow earthquakes, which usually cause the greatest damage in Japan, occur in the overriding Eurasian Plate. Intermediate and deep earthquakes occur in the cooler interior of the descending lithosphere

(van Rose 1983). Approximately 1,500 earthquakes a year, an average of 20 per day, occur in the Japanese islands. Very few of these earthquakes are as severe as the 1923 earthquake that destroyed most of Tokyo and killed 100,000 people. But there is concern that another quake of that size could occur in the near future.

2. Volcanoes

Volcanoes are openings in Earth's crust, surrounded by masses of ejected material forming hills or mountains. From volcanoes, molten rock, ashes, and steam are or have been expelled (Peck 1986). These openings usually occur along the edges of tectonic plates. Earth's crust is made up of several of these rigid, continent-sized plates. The plates move and shift because they float on the mantle, which is very soft because the rock is so hot it is almost liquid. This shifting causes the plates to collide at the edges, slide over each other, or pull apart, causing cracks or openings. When this happens, hot, molten rock called magma can move up through the openings to the surface (Dunn 1989).

Volcanoes can have magma flowing smoothly, like red-hot rivers, onto the surface or they can explode violently high into the air.

> The explosive eruption of a volcano is an awesome spectacle. . . . The supreme example within historic times, perhaps, was the final eruption of the volcano Krakatau, which occupied a small island in the East Indies. When it exploded in 1883, the noise was heard 1,500 miles [2,400 km] away in Australia, and 6 cubic miles [about 21 km^3] of material were blasted into the air. The volcanic island itself disappeared, leaving only open sea where it had been. The tsunamis that were generated drowned more than 30,000 people, and sunsets in various parts of the world were colored by fine volcanic dust for many months afterwards (McKnight 1993, page 417).

Why do volcanoes occur in Japan?

Parallel to the trench, magma is forced up to form a chain of volcanic islands (the island arc). The heat generated by the friction of the plates grinding past one another melts part of the descending oceanic plate, which becomes molten rock. The pressure of the two plates coming together also creates cracks, or faults, in the rock, generating powerful earthquakes. The molten rock is hotter and lighter than the overlying colder solid rocks, and so it can rise through these cracks in the lithosphere. If the magma reaches the surface, it is known as *lava*, and the eruptions form volcanic mountains. This is how most of the Japanese and Philippine islands were created.

Lava flows from the Mayon volcano of the Philippines. The city of Legazpi is in the foreground.

Japan's active volcanoes account for over one-tenth of the world's total. Approximately 75 of Japan's 250 volcanoes are active. They average six eruptions a year. Volcanic deposits cover a quarter of the Japanese islands because most of Japan's highest peaks are volcanic in origin. The most famous and highest, Mount Fuji, is found on Honshu, the largest of the islands.

3. Tsunamis

Large undersea earthquakes or volcanoes may sometimes set off huge ocean wave systems called tsunamis or seismic sea waves. They can move at high speed—several hundred miles per hour. Approaching shore, in shallow water, they can build up to 100 feet high. The word *tsunami* comes from a Japanese word meaning "great harbor wave." Tsunamis crashing against coastlines, especially in the Pacific region, have killed thousands of people (Dunn 1989; McKnight 1993).

When earthquakes or volcanoes trigger tsunamis, a series of low, broad waves races through the ocean. As these fast-moving waves approach shallow water near land, the wave motion is affected by friction. This causes the wave to slow down. At the same time, the

height of the wave increases as it strikes the land. Sometimes tsunamis are preceded by a sudden withdrawal of water from the shore, causing the sea surface to recede from shore. Then the massive wall of water surges ashore, reaching places far out of the reach of normal waves. This situation occurred in Hilo, Hawaii, in 1923, when a great tsunami was preceded by a sudden withdrawal of water. Many people ran onto the beach to pick up fish exposed on the land. They were then all washed away when the crest of the tsunami struck and engulfed the coast (Oberlander and Muller 1987).

On March 27, 1964, the Great Alaskan Earthquake caused giant tsunamis that took lives and destroyed homes, businesses, and boats in coastal towns around the North Pacific, from California to Alaska to Japan. The damages caused by the huge waves were more serious than those caused by the earthquake that triggered the tsunamis.

> Kodiak, Alaska, was battered by an awesome 30-foot tsunami that lifted bodily a number of 50- to 100-foot king-crab boats, hurling them several blocks inland. At Seward, the big waves wrought widespread waterfront destruction. Five blocks simply disappeared—ceased to exist! Assorted warehouses and a halibut cannery were wiped out, and upward of 30 fishing boats and a similar number of pleasure crafts were destroyed or damaged beyond repair. The town of Chenenga, on a small island near the quake epicenter under Prince William Sound, took the brunt of a 90-foot tsunami that wiped out one-third of the local population. In all, 92 percent of all fatalities claimed by this great upheaval were caused by rampaging seismic sea waves (Mooney 1980, page 131).

Why do tsunamis occur in Japan?

The Pacific coast of Japan is highly exposed to tsunamis, which are mainly caused by earthquakes occurring along the "Ring of Fire." Records of the following tsunamis provide examples of the damage and the hazards to people. (Refer to Figure 1 on page 5 for locations of the places mentioned.)

- June 15, 1896—At least 27,000 people were killed by three large tsunami waves. Practically every town and village along the Sanriku coast of northeastern Japan was destroyed.
- March 3, 1933—Approximately 2,986 people were killed and 5,000 houses were destroyed by a tsunami that was caused by earthquake activity in the ocean off the Sanriku coast of Japan.
- December 21, 1946—A severe earthquake in southwestern Japan generated a tsunami that invaded the coasts of Shikoku and the Kii Peninsula. Over 1,451 houses were swept away on the coast of Kochi prefecture.

- May 24, 1960—180 people were killed and severe damage occurred in the districts of Tohoku and Hokkaido following an earthquake in Chile on May 22 (Murty 1977, pages 215–220).

Japan is especially vulnerable to tsunamis because of its location in an area where three tectonic plates converge. Earthquakes and landslides on the ocean floor are the primary causes of the approximately 150 tsunamis counted yearly in Japan. Efforts to gather data and develop more sophisticated warning systems have increased in Japan, as more human activities concentrate in the coastal areas.

4. Typhoons

Typhoon is one of the names given to a type of tropical cyclone storm. These rotating storms have winds of at least 75 mph. Such storms are called typhoons when they occur in the Indian Ocean, the South China Sea, and the western Pacific Ocean. They are identical to the hurricanes that form over the eastern Pacific, the Caribbean Sea, and the Atlantic Ocean.

> Typhoons originate out over the ocean as small cells of low pressure that develop into upward-spiraling wind patterns, fueled by the energy released by warm, moist, tropical sea air. The winds sometimes reach speeds up to 200 km/h (125 mph) and can cause enormous damage, destroying houses, bringing down power lines, flattening the ripening rice and downing tree crops. Heavy rain, often with over 300 mm (12 in) falling in 24 hours, causes flooding and landslides. Flooding in coastal areas is also caused by the huge waves that are whipped up by the wind, particularly when they are funneled into deep inlets and bays (Gregory 1990, page 233).

Why do typhoons occur in Japan?

Typhoons are a major natural hazard of the northwest Pacific. These rotating storms of the tropics bring very high winds and torrential rainfall. They strike principally between July and November and disrupt the normal seasonal weather pattern. The number in any one year varies between 3 and 30; they are more frequent in Japan than Korea. They occur more in the southern Japanese islands, because those islands are closer to warmer ocean waters.

> Typhoons reaching Japan curve first northwest and then northeast in front of prevailing winds, before dissipating their energy over colder sea or land [Figure 3 on page 18]. Typhoons

originate over the warm waters of the southwest Pacific in unstable atmospheric conditions. They are moved to the west by the trade winds but curve to the right, following northwesterly and then northeasterly tracks before they die out over the land or the cooler waters of the north. The western and southern coasts of Kyushu suffer most typhoon damage (Gregory 1990, page 233).

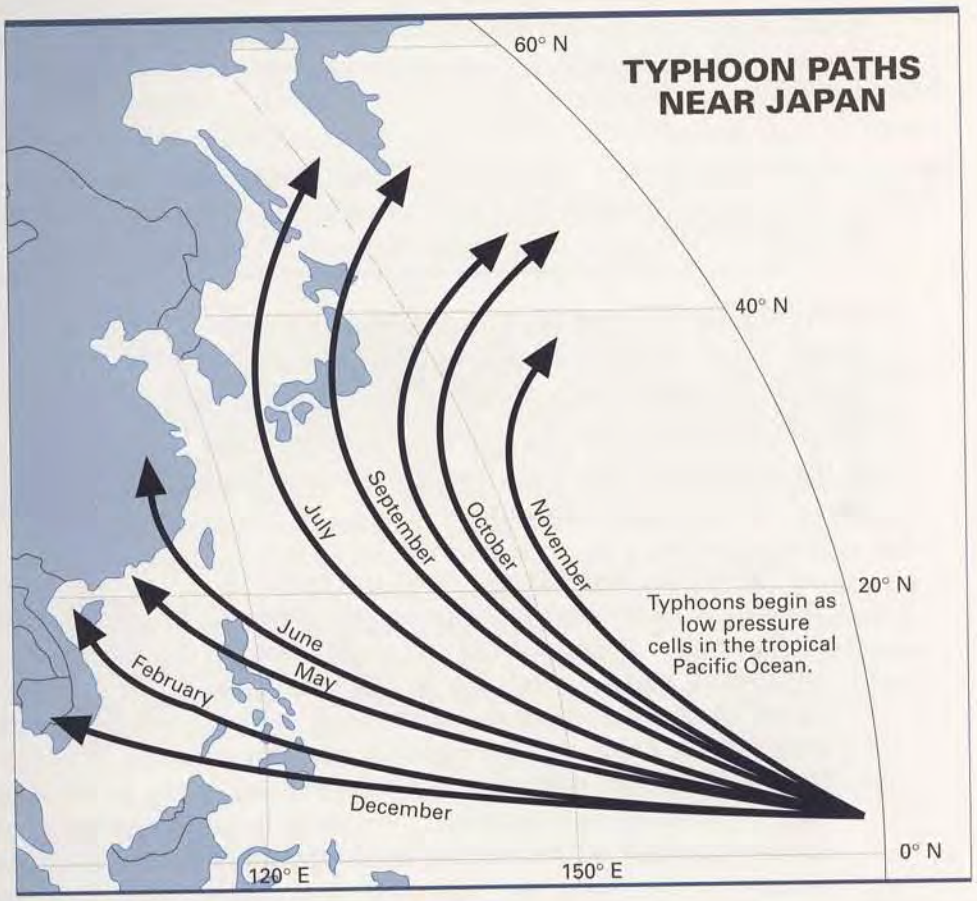


Figure 3 Typhoon paths near Japan.

Source: Gregory 1990.

Are natural events more hazardous or less hazardous today than in the past?

Objectives

In this lesson, you will

- Analyze data to decide whether natural events are more hazardous or less hazardous to the people of Japan today than in the past.
- Speculate whether the developments in Japan have global implications.

Glossary Words

density

natural disaster

Are the Japanese people more vulnerable or less vulnerable to natural hazards today?

Many people live and work in parts of the world where natural disasters occur. The global toll from natural disasters is on the rise, despite an extraordinary human effort to control the natural world. In the developing world, the loss of life is increasing. In developing countries, there is often little alternative to staying in areas known to be in danger. More developed nations, however, can afford to prepare for the consequences of natural hazards. The Japanese are leaders in the effort to predict and prepare for natural hazards.

Table 2 Changes in population density in Japan

Year	Total population	Average density (people per square mile)
1872	34,806,000	240.5
1972	107,332,000	741.8
1992	124,400,000	852.8

Sources: Takahashi et al. 1989; Population Reference Bureau 1992; *The World Almanac and Book of Facts* 1974 and 1991.

Is nature more hazardous or less hazardous to the people of Japan than it was in the past, and why? To answer this question, we need to look at a variety of data comparing conditions today to those in the past.

First note how increasing population has affected population density (Table 2 above).

Now look at the changes in population and transportation patterns (Figure 4 on the opposite page). How would these changes affect the potential hazard of natural events in Japan?

The changes in transportation patterns can be understood from the following quotation:

> Use of the Bullet Train has grown from a daily average of 60,000 passengers in 1964 to 340,000 passengers in 1981. In peak periods, as many as 1 million people use the train in one day. The length of the average trip on the Bullet Train is about 200 miles. Each train can carry a maximum of 2,000 people and, at rush hours, 250 trains are in operation (Nakamura and Tucker 1988, page 141).

Over the last 100 years, more Japanese have moved into cities. About 77 percent of the people now live in urban areas (Population Reference Bureau 1992). Table 3 on page 22 lists the cities in Japan with a population of more than 1 million.

Bullet train pulls into the station.

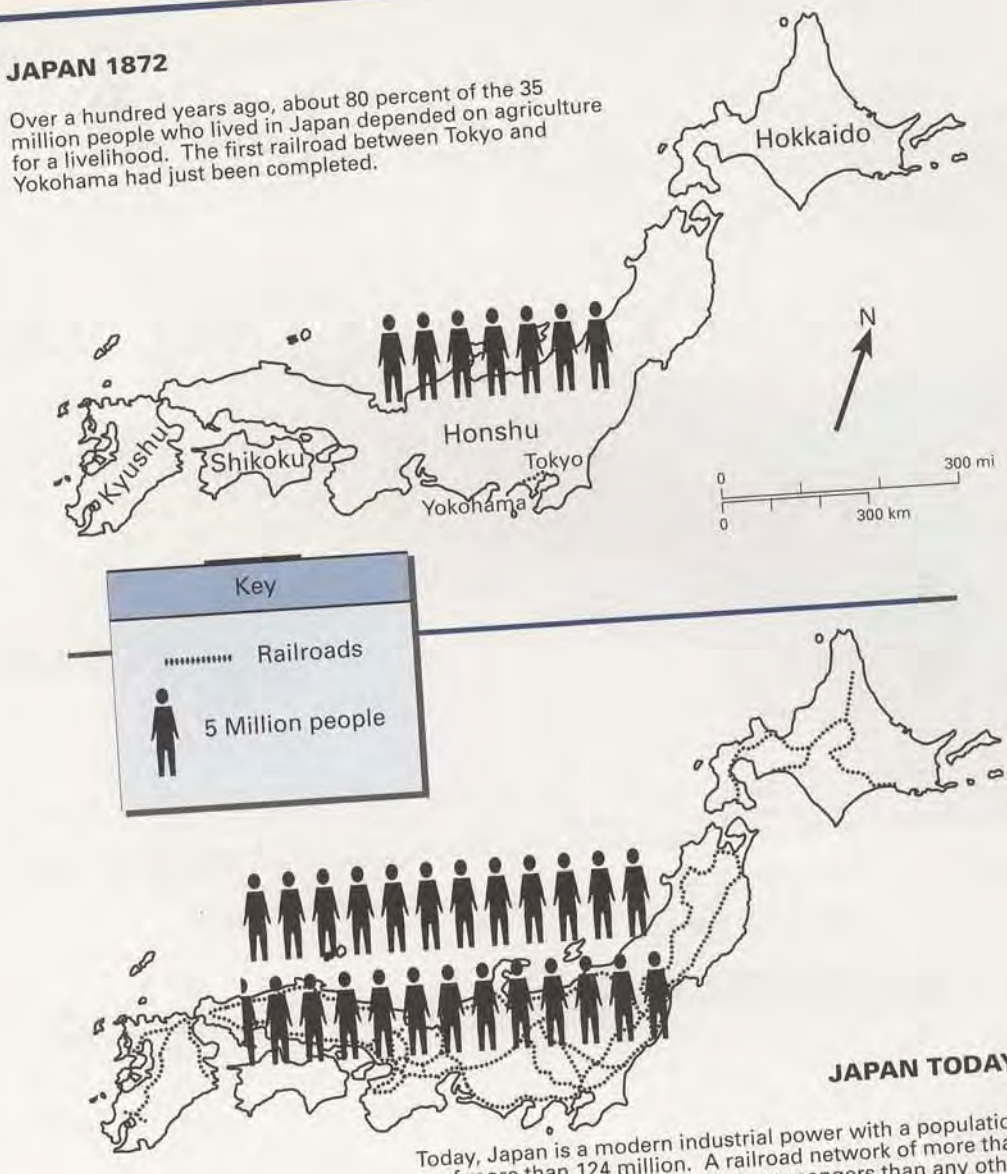


Figure 4 Population and transportation in Japan, 1872 and today.

Source: Updated from High School Geography Project 1970.

Now look at Figure 5 on page 22. How does the population density relate to the location of industrial activity in Japan? It may help to refer back to Figure 1 on page 5 to see the location of the cities with populations over 1 million (Table 3 on page 22). Where are these cities in relation to the Pacific industrial belt shown in Figure 5?

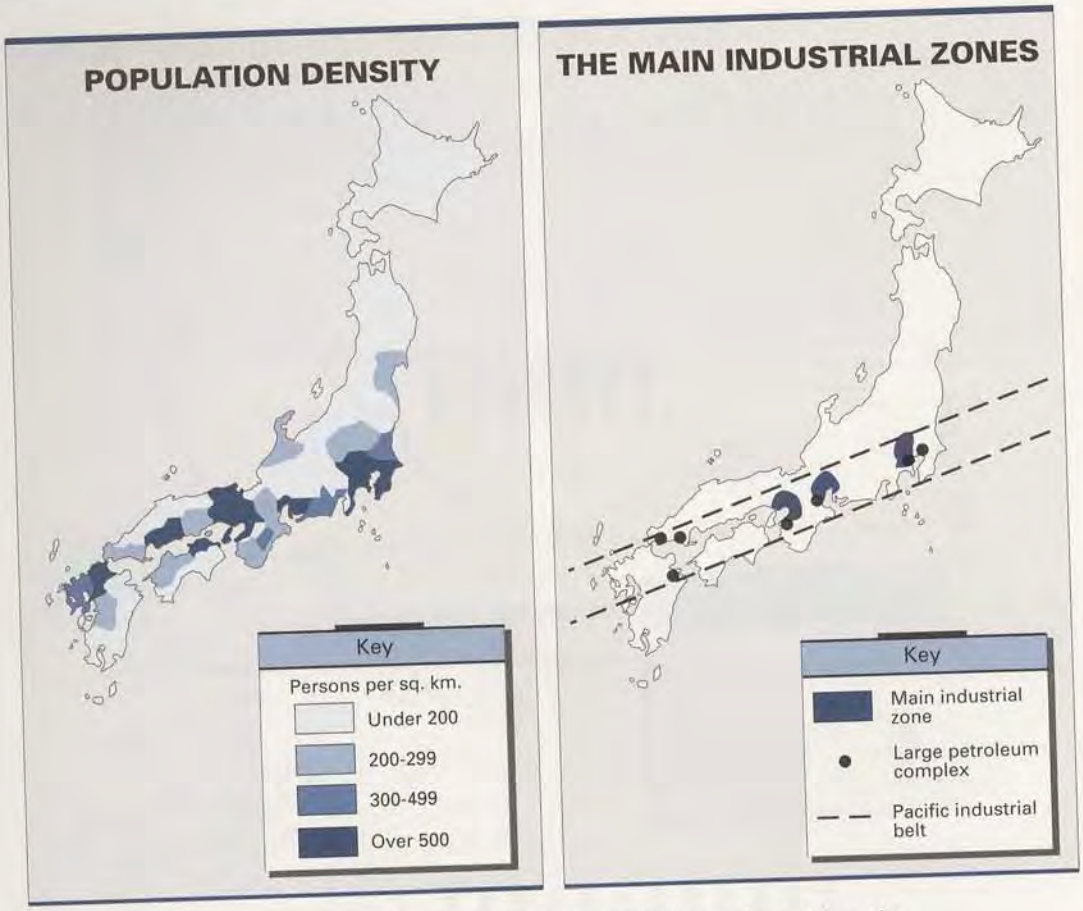


Figure 5 Population density in Japan and location of main industrial zones.

Sources: Density map from Peck 1986; industrial zones map from Takahashi et al. 1989.

Table 3 Cities with populations over 1 million, 1987

Tokyo*	8,209,000	Kobe	1,413,000
Yokohama	3,072,000	Fukuoka	1,142,000
Osaka	2,546,000	Kawasaki	1,096,000
Nagoya	2,091,000	Kitakyushu	1,042,000
Sapporo	1,555,000	Hiroshima	1,034,000
Kyoto	1,469,000		

*Figure for Tokyo is the population for the 23 wards of Tokyo proper, not that of the Greater Metropolitan Tokyo administrative district, which covers a wide area embracing some sparsely populated places and even some offshore islands.

Source: Takahashi et al. 1989.

Table 4 shows some of the energy supplies needed to keep these industrial areas running. On which primary energy sources is Japan's economy becoming more reliant? On which sources is Japan becoming less reliant? How would the occurrence of a natural disaster affect the movements of these energy supplies into the cities?

Table 4 Sources of primary energy in Japan, 1960 and 1986 (10,000 billion kilocalories)

	1960	1986
Coal and lignite	39.5	76.4
Petroleum	35.4	220.6
Hydroelectricity	14.3	21.1
Nuclear electricity	—	41.2
Natural gas and liquefied natural gas	0.9	40.4
Firewood and charcoal	3.6	0.1
Total	93.7	399.8

Source: Takahashi et al. 1989.

How do the people of Japan prepare for natural hazards?

Objectives

In this lesson, you will

- Assess the types of damages that planners must deal with when making disaster-prevention plans.
- Understand and evaluate a system by which future hazard risks are predicted.
- Compare and analyze plans for preparedness.

Glossary Words

earthquake
liquefaction
natural disaster
natural hazard
Richter scale
seismometer
tornado
tsunami

What is Japan's basic framework for disaster prevention?

How much will the Japanese government's commitment to support research and technology reduce the hazard of natural events?

The report of the Science and Technology Council in July 1981 provided the "Basic Plan for Research and Development on Disaster

Table 5 Plan for disaster prevention in Japan

Divisions	Areas
Investigation, prediction, and forecasting of natural phenomena	Prediction of earthquakes, volcanic eruptions, localized torrential downpours, heavy snowfall, typhoons
Natural disaster prevention technology	Earthquake-proof technology, disaster-prevention technology for tsunamis and ground disasters at time of earthquake
Meteorological disaster prevention technology	Technology for flood prevention, seashore conservation, snow and ice damage prevention, slope collapse and landslide prevention, and abnormal meteorological adaptive technology
Science and technology on comprehensive disaster prevention	Technology for making cities more resistant to disasters, for control of transport means at time of earthquake, prevention of secondary disasters, technology adaptive to human behavior at time of disaster

Source: Disaster Prevention Bureau, National Land Agency 1989.

Prevention" (Table 5). The plan is designed to promote a long-range view emphasizing four areas (Committee for Disaster Research of the Science Council of Japan 1989).

Figure 6 on page 26 shows the money budgeted by the Japanese government for disaster prevention. About how much more money was budgeted for disaster prevention in 1987 than in 1962? What percentage of the total budget is now spent on disaster prevention?

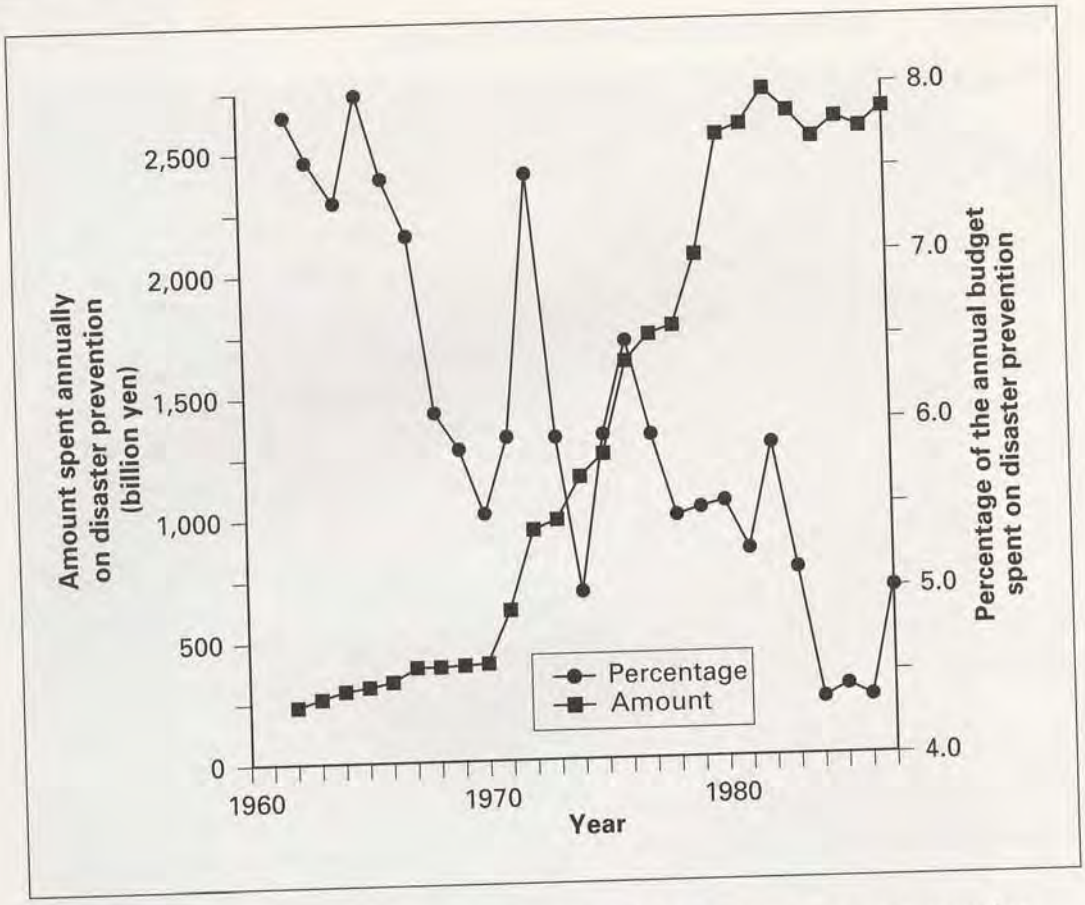


Figure 6 Budgetary appropriation by the Japanese government for disaster prevention.

Source: Disaster Prevention Bureau, National Land Agency 1989.

What kinds of damage do major earthquakes cause?

To plan for major natural disasters, we need to have some idea of what kinds of damages are likely to occur. In this lesson, you will develop a plan for the city of Tokyo to cope with the probable destruction caused by a major earthquake. But what is considered a "major" earthquake?

Magnitude is a measure of the energy released by an earthquake. With remote seismometers, magnitude can be estimated for almost all earthquakes. Earthquake magnitude is measured on the Richter scale (Figure 7 on the following page). On this scale, each larger whole number represents a significant increase in the power of the quake. For example, a magnitude 6 quake releases about 32 times more energy than a magnitude 5 quake, and a magnitude 7 quake is

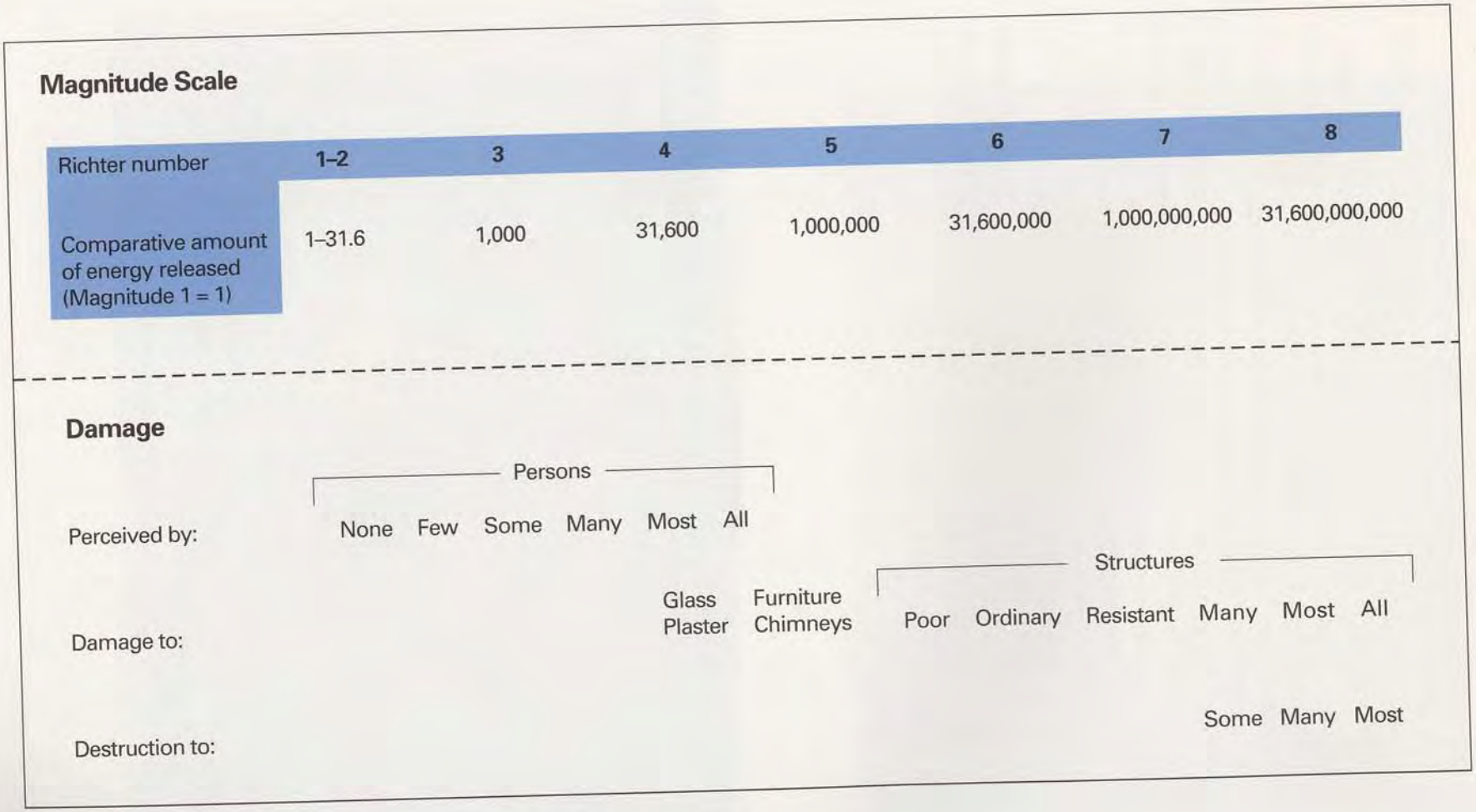


Figure 7 Magnitude (Richter scale) and associated damage.

Source: Burton, Kates, and White 1993.

1,000 times more powerful than a magnitude 5 quake (Burton, Kates, and White 1993). Figure 7 shows earthquake magnitude and the kinds of damage associated with each event.

Records at the Tokyo Metropolitan University show that since 1600, Tokyo has suffered 37 earthquakes strong enough to destroy ordinary building structures. Based on this historical record, it appears that the Tokyo area can expect a major earthquake about every 10 years—or 10 such quakes per century. Since 1929, however, Tokyo has *not* experienced such an earthquake. Based on this history, do you think the people of Tokyo should expect another major earthquake? For what sorts of damages must they prepare?

Damages from earthquakes (as well as other natural disasters) can be classified as being either *direct* or *indirect* (Figure 8 on page 30). Direct damages in an earthquake are those caused from the shaking of the ground itself, including soil liquefaction and tsunamis. Indirect damages are those triggered by the direct damages. Japanese scientists described damages in the Great Kanto Earthquake of 1923 below.

The Great Kanto Earthquake of 1923

Outlines of the earthquake. The earthquake resulted from a slippage . . . between two crustal blocks . . . [on] September 1, 1923. . . . The damage was severest in the Kanagawa and Tokyo prefectures, also extending to other parts of the Kanto Region [Figure 1 on page 5]. The number of deaths in the Kanagawa and Tokyo prefectures reached a total of about 97,000, including 50,000 in Tokyo City. While the total number of dead and missing reached about 143,000, about 104,000 people were listed as injured.

Approximately 128,000 structures were demolished, another 126,000 were heavily damaged, and as many as 447,000 structures were lost in fires. Fires were responsible for the loss of homes in almost all cases in Tokyo and for about 50 percent of those in Kanagawa.

The earthquake stirred up huge tsunami waves, which washed away 868 houses in the three prefectures of Shizuoka, Kanagawa, and Chiba. Records show that tsunamis of 3 to 6 meters [10–20 ft] high pounded the southern coast of the Izu Peninsula, the coast of Sagami Bay, and that of the Boso Peninsula. The damage was most conspicuous on the lowlands along small bays, whereas Tokyo Bay was only washed by waves of less than one meter [3.3 ft] high.

Damage by fire in Tokyo. The Great Kanto earthquake claimed a historic number of deaths and damage because of fires. Fires broke out at about noon on September 1 and continued to rage for 40 hours till 4 A.M., September 3, scorching 44 percent of the City of Tokyo. About 370,000 houses were lost and police counted about 60,000 people either dead or missing, the figure representing 2.5 percent of the city's population, which then stood at 2,437,000. The hardest hit was Honjo-ku ward where one out of every six persons was killed. The fires were to blame for 98 percent of destroyed houses and 85 percent of people dead and missing.

Tornadoes of varying force were caused by the fires, uprooting trees measuring 40 to 50 centimeters [16–20 inches] in diameter and tossing people, carriages, and the roofs of buildings skyward. . . .

Two or three hours after the fires started, almost the entire western section of Honjo-ku had burned. Tens of thousands of people had fled to a huge vacant lot where tornadoes then struck at about 3:30 P.M., blowing bricks, timbers, carts and every other thing sky-high. An ascending current was then created, picking up human beings with their filled carts. Sparks of the fire showered over the plot and the belongings the people had brought, turning the place into an inferno. A total of 35,000 persons were burned to death or suffocated (Nakano and Matsuda 1984, pages 415–416).

1. What damages in The Great Kanto Earthquake of 1923 would you describe as either direct or indirect (according to Figure 8 on the next page)? Make a list of those damages that you believe people can reduce with preventive technology and preparation.
2. Do the direct damages or the indirect damages appear to present the greater threat to property and human life? Why?
3. For which kinds of damages can people most effectively prepare?

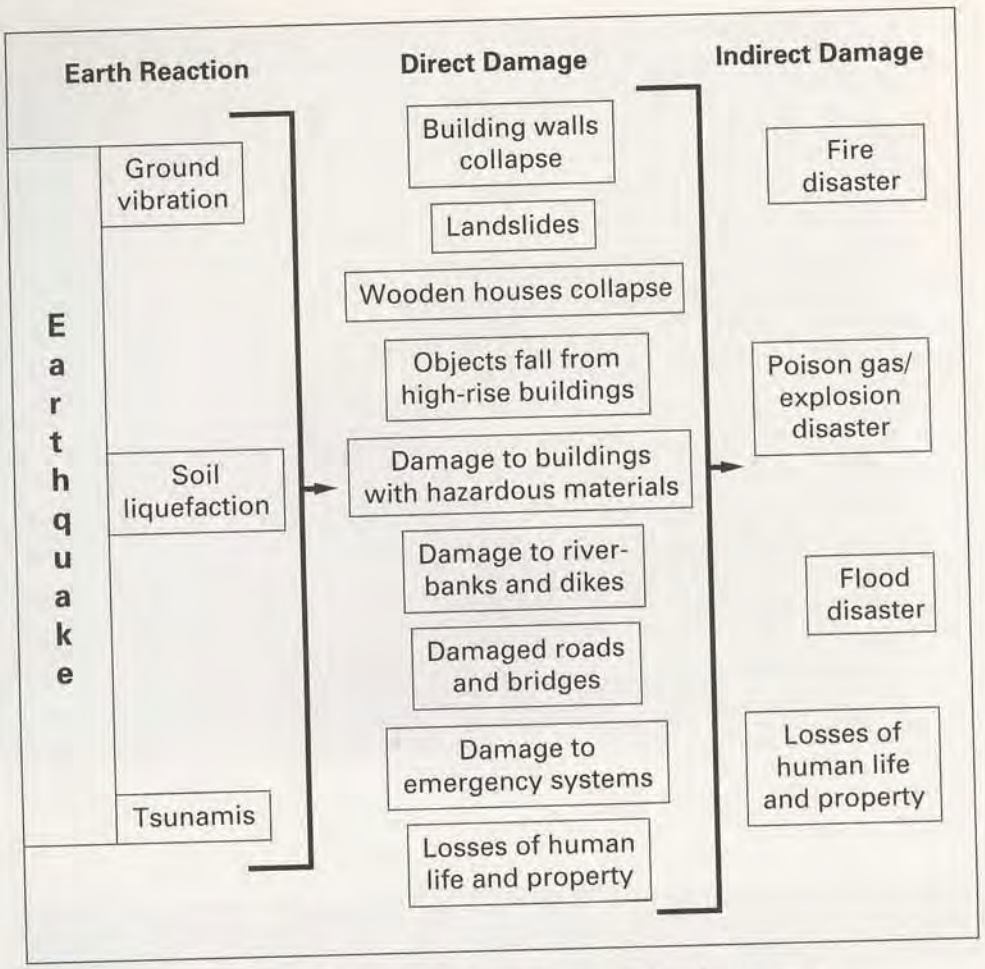


Figure 8 Flow diagram for classifying earthquake damages.

Source: Nakano and Matsuda 1984.

How should the people of Tokyo prepare for a major earthquake?

Assume you serve on a committee designing a plan to reduce deaths and damages from a disastrous earthquake (measuring 8 or above on the Richter scale) in the vicinity of Tokyo. Your committee will develop countermeasures designed to decrease expected loss of life and damages such as those identified in the Tokyo Metropolitan Government Survey. The data in Table 6 on the next page will help you identify needs. Classify which of the damages in Table 6 are direct and which are indirect. Your committee's plan of action for the city will address one of the following areas of countermeasures:

- *Prevention:* Plans that will prevent or minimize earthquake destruction related to land-use, building design, and transportation/communication systems.

- *Preparation and emergency relief:* Ways that government agencies, schools, neighborhoods, and individuals can alleviate suffering and keep damage to a minimum once an earthquake occurs.
- *Recovery:* Procedures by which people and organizations can be helped to recover from loss of loved ones and of property.

Table 6 Calculated damage from a future earthquake in Tokyo (magnitude 8 or higher)

Totally collapsed wooden houses	62,000
Collapsed walls and landslides	1,300
Major bridges damaged	3
Water-supply pipes damaged (main pipes only)	220
City gas pipes damaged	670
Houses burned by fires	470,000
Flood-damaged houses	11,000
Sufferers	3,500,000
Affected families	1,200,000
Injured	63,000
Dead	36,000

Source: Nakano and Matsuda 1984.

How do people in the United States respond to earthquake hazards?

Objectives

In this lesson, you will

- Compare earthquake preparedness in Japan and the United States.
- Analyze the earthquake hazard in the United States.

Glossary Words

earthquake

tectonic plates

How do earthquake information guides for the United States and Japan compare?

In this lesson are excerpts from earthquake information guides from the United States and from Japan. These are pamphlets distributed to citizens of these nations to provide information about what to do in case an earthquake occurs. Compare the earthquake safety guides of the United States and Japan. Think about these questions as you read.

1. What does each guide suggest for (a) self protection, (b) preventive measures, and (c) community support and emergency assistance?
2. In what ways are the guides from the United States and Japan similar? In what ways are they different?
3. The Japanese take their safety guide very seriously. Do you think U.S. citizens follow the safety guide as diligently as the Japanese? Why or why not?

Earthquake information guide for the United States

Safety Tips for Earthquakes

Civic activities. You can organize or support community programs and efforts to prepare for earthquakes.

- Discuss a plan of action with your neighbors to help each other in the aftermath of an earthquake.
- Support the enforcement or creation of local building regulations which minimize earthquake hazards in new construction.
- Support or organize earthquake drills in schools.

Before an earthquake. Check your home for potential hazards:

- Defective electrical wiring and leaky gas or inflexible connections are very dangerous in the event of an earthquake. Bolt down water heaters and gas appliances.
- Know where and how to shut off electricity, gas, and water at main switches and valves. Check with your local utilities for instructions.
- Place large and heavy objects on lower shelves. Securely fasten shelves to walls. Brace or anchor high or top-heavy objects.

After an earthquake.

- Be prepared for additional earthquake shocks called "aftershocks." Although most of these are smaller than the main shock, some may be large

enough to cause additional damage or bring weakened structures down.

- Check for injuries. Do not attempt to move seriously injured persons unless they are in immediate danger of further injury.
- Turn on your radio or television to get the latest emergency information from local authorities.
- Check your utilities. The earthquake may have broken gas, electrical, and water lines. If you smell gas, open windows and shut off the main gas valve. Then leave the building and report the leakage to authorities. Do *not* reenter the building until a utility official says it is safe. If electrical wiring is shorting out, shut off current at the main meter box. If water pipes are damaged, shut off the supply at the main valve. Emergency water may be obtained from hot water tanks, toilet tanks (*not* bowls), and melted ice cubes.
- Check the entire length of your chimney carefully for cracks. Unnoticed damage could lead to a fire. The initial check should be done from a distance. Approach chimneys with caution.
- Check to see that sewage lines are intact before using sanitary facilities.
- Do not touch downed power lines or objects in contact with downed lines.
- Immediately clean up spilled medicines, drugs, flammable liquids, and other potentially hazardous materials.
- Use the telephone only for genuine emergency calls. Don't spread rumors; they often do great harm after disasters.
- Stay away from damage areas. Your presence could hamper emergency relief efforts and you could be putting yourself in personal danger. Cooperate fully with public safety officials. Respond to requests for volunteer assistance from police, fire fighting, civil defense, and relief organizations, but do not go into damaged areas unless your assistance has been requested (Federal Emergency Management Agency 1983).

Earthquake information guide for Japan

TIPS IN CASE OF EARTHQUAKES AND OTHER EMERGENCIES

What to do if an earthquake occurs.

- *Protect yourself from injury.* Go under the table. Don't rush out of the house.

- *Put out any fire in use.* Quickly turn off any stove or gas appliance in use. In the latter, shut the stopcock.
- *Secure an exit.* Immediately open the front door. A major jolt may jam the door.
- *Don't go near any fence or vending machine.* Concrete block walls and vending machines are dangerous because they can be easily toppled.
- *Protect yourself from falling objects.* When you are walking in the street and an earthquake occurs, protect your head with both hands, or with anything you may be carrying at the time.
- *Listen to reliable information.* Don't believe rumors. Listen carefully to radio announcements and information issued by organizations concerned with disaster protection.

Minimizing earthquake disaster.

- Fix furniture, refrigerator, and piano to the wall or floor to prevent toppling.
- Always keep a fire extinguisher and a bucket of water ready for use.
- Always keep a supply of emergency food, drinking water, and fuel.
- To each family member, assign specific roles to be assumed in emergencies.

Fire, the most dangerous disaster.

- *If a major earthquake occurs:* Turn off any electric or gas appliances in use in the kitchen, bathroom, living room, bedroom, etc.
- *If a fire breaks out:* Quickly put out the fire either with a fire extinguisher or with water. While putting out the fire, shout for help. Call the fire department for instructions (Disaster Prevention Section, Toshima Ward Office, Tokyo, no date).

Where in the United States are earthquakes a hazard?

The United States, like Japan, has an environment that can be hazardous to humans. The tables and figures on pages 36, 37, and 38 provide information related to earthquake activity in the United States. Think about these questions as you look at them.

4. Compare the locations of earthquakes in the United States (Figure 9 below) to the positions of the tectonic plates you saw on Overhead 2. What is the relationship of plate movement to the location of the earthquakes?
5. Does Figure 9 show all the earthquakes that have occurred in the United States? Which states have had earthquakes with a magnitude of 7.3 or higher?
6. Which regions of the United States experience the least earthquake activity? Which states show no earthquake activity at all?

Figure 9 Map of earthquake occurrences (with approximate magnitude) in the United States through 1970.

Source: U.S. Departments of Commerce and Interior 1970.

Table 7 Major U.S. earthquakes, 1900–1993

Date	Location	Magnitude	Dead	Damage (millions $)
Oct. 17, 1989	Loma Prieta, Calif.	7.1	65	5,000
Oct. 1, 1987	Whittier Narrows, Calif.	5.9	8	358
Feb. 9, 1971	San Fernando, Calif.	6.6	58	900
Mar. 27, 1964	Prince William Sound, Alas.	8.3	131	1,020
Aug. 18, 1959	Hebgen Lake, Mont.	7.1	28	26
Aug. 22, 1952	Bakersfield, Calif.	5.8	2	30
Jul. 21, 1952	Kern County, Calif.	7.7	12	150
Apr. 13, 1949	Olympia, Wash.	7.0	8	80
Apr. 1, 1946	Unimak Island, Alas.	7.4	173	90
May 19, 1940	Imperial Valley, Calif.	6.7	9	33
Mar. 11, 1933	Long Beach, Calif.	6.3	115	266
Jun. 29, 1925	Santa Barbara, Calif.	6.2	13	47
Oct. 11, 1918	Mona Passage, Puerto Rico	7.5	116	29
Apr. 18, 1906	San Francisco, Calif.	8.2	700	2,000

Source: Rocky Mountain News. Reprinted with permission.

7. Compare the information on the map (Figure 9 on page 36) with that on Table 7 above. How is the information presented on the map and table the same? How is it different? What is the advantage of showing this information on a map?

8. What is the date and location of the earthquake with the highest recorded magnitude (Table 7 above)? The highest recorded death toll? The highest recorded amount of property damage? What is one reason for the lack of correlation between the magnitude of an earthquake and the death toll or property damage resulting from that quake?

9. Compare Figure 9 on page 36 to Figure 10 below. Are there states with high-magnitude earthquakes that do not require earthquake education? Do you believe those states should require earthquake education? Why or why not?
10. Should the construction of school buildings be responsive to the danger of local hazards? Why?
11. Does your state or school district require some type of hazard education or drill other than for fire? What hazard education do you think your school should provide? Why?

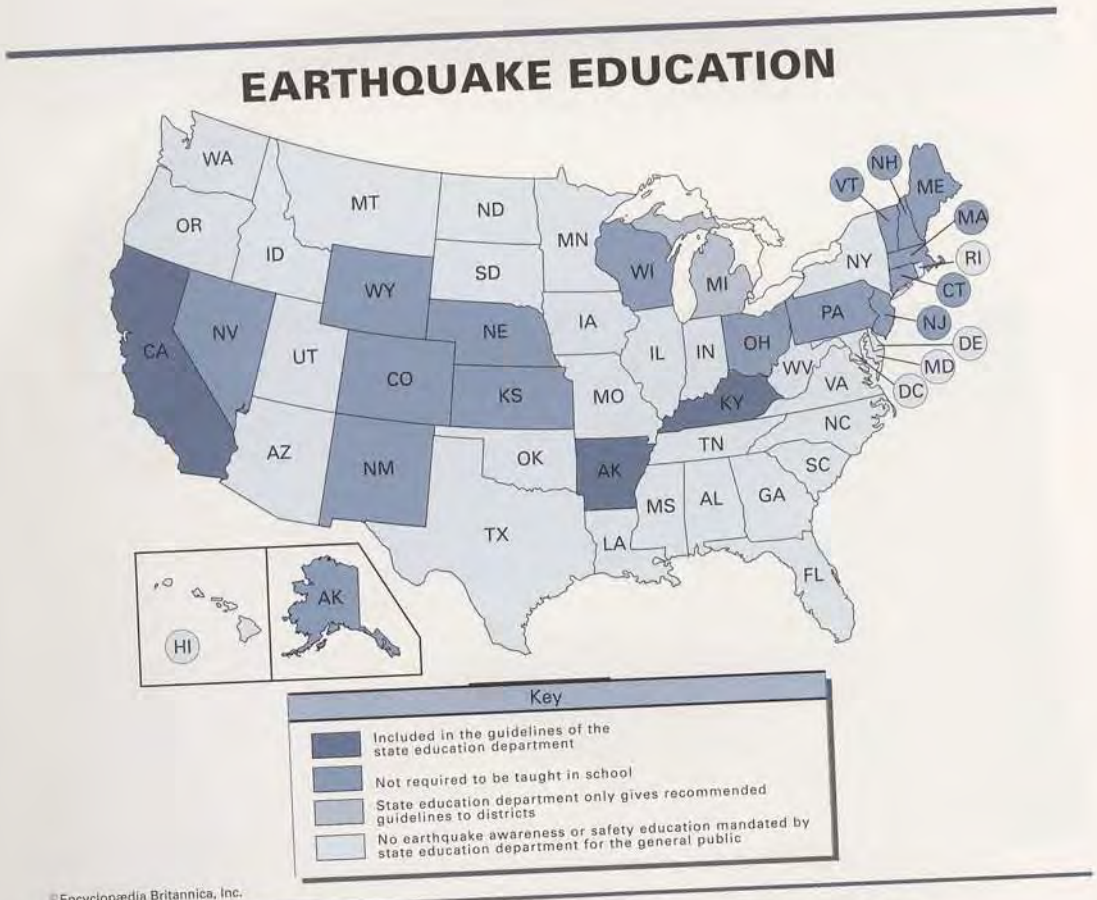


Figure 10 Map of earthquake education programs in the United States.

Source: Ross 1989, National Center for Earthquake Engineering Research.

How does preparedness affect the consequences of natural hazards from place to place?

Objectives

In this lesson, you will

- Contrast the levels of preparedness for natural hazards in developing and developed countries.
- Explore reasons for the different levels of preparedness.
- Compare responses of different countries to the consequences of natural hazards.

Glossary Words

cyclone
deltaic
hurricane
natural disaster
natural hazard
typhoon

Where do the most deaths from natural disasters occur in the world?

During the twentieth century, about 4 million people around the world have lost their lives to natural disasters. But as Figure 11 on the next page shows, some parts of the world have had a much greater share of these deaths than others.

Human Lives Lost by World Region in Natural Disasters in the 20th Century

Graphs show shares of 4.08 million total deaths attributed to various natural disasters.

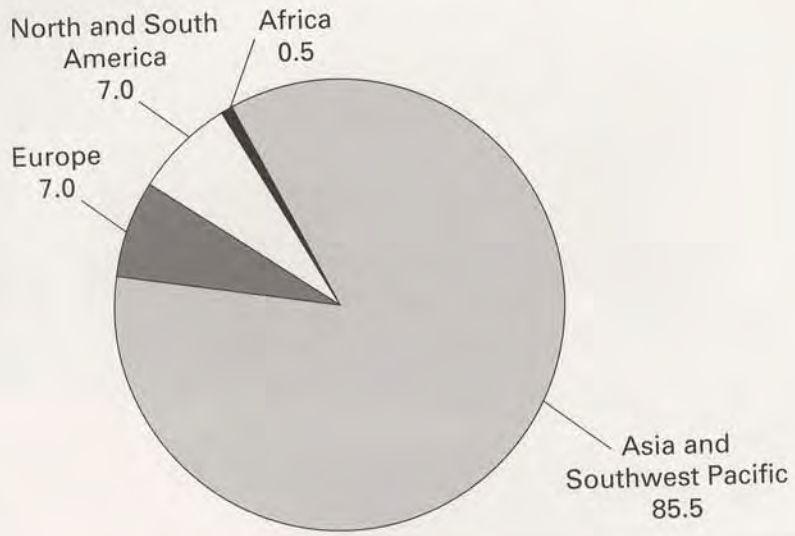


Figure 11 Deaths by world region caused by natural disasters in the 20th century.

Source: Committee for Disaster Research of the Science Council of Japan 1989.

1. In which region of the world have the most deaths from natural disasters occurred? Why do you think this is so?
2. During the twentieth century, the average number of natural disasters per year in the world has remained relatively constant. However, the average death rate per disaster has climbed significantly (Burton, Kates, and White 1993). Why do you think this is so?

Why are some regions more vulnerable to loss of life in natural disasters?

Some areas of the world are more vulnerable than others to loss of human life when a natural disaster strikes. In Lesson 6 you learned

how people in the United States and Japan adapt to earthquakes. In this lesson you will investigate how people in less-developed countries respond to hazardous events. The case study focuses on destructive storms known as hurricanes or typhoons (Table 8 below).

Table 8 Death tolls from selected storms in the 20th Century

Date	Location	Type of storm	Death toll
Apr. 30, 1991	Bangladesh	Typhoon	125,000
May 24, 1985	Bangladesh	Typhoon	11,000
Nov. 13, 1970	Bangladesh	Typhoon	500,000
Dec. 15, 1965	Bangladesh	Windstorm	10,000
Jun. 1, 1965	Bangladesh	Windstorm	30,000
May 11, 1965	Bangladesh	Windstorm	17,000
Oct. 4, 1963	Cuba and Haiti	Hurricane	6,000
May 28, 1963	Bangladesh	Windstorm	22,000
Sep. 26, 1959	Honshu, Japan	Typhoon	4,500
Oct. 15, 1942	Bengal, India	Typhoon	40,000
Sep. 12, 1928	West Indies and Florida	Hurricane	4,000
Sep. 18, 1906	Hong Kong	Typhoon	10,000
Sep. 8, 1900	Galveston, Texas	Hurricane	6,000

Note: Windstorm refers to typhoons that lost some windspeed (that is, dropped below 75 miles per hour) when they struck land.

Source: World Almanac and Book of Facts 1991.

3. In which season do destructive hurricanes occur? In which two seasons do destructive typhoons occur?
4. Sometimes destructive storms in Bangladesh are referred to as *typhoons* and other times they are referred to as *cyclones*. What is the *correct* name for a storm with winds of at least 75 miles per hour that occurs in the Bay of Bengal and threatens Bangladesh?
5. What is the approximate number of deaths caused by storms in Bangladesh since 1963?

The following four newspaper articles describe the major typhoon that occurred in Bangladesh in 1991. As you read the articles, look for the causes of the tremendous loss of life. Use the following seven categories to organize these causes; make a note of how much you think each category contributed to the death toll.

- Location/topography
- Land use
- Population density
- Poverty
- Type of housing
- Inadequate preparedness
- Post-disaster complications

Article 1

TYPHOON IN BANGLADESH

Over the years, the people of Bangladesh have . . . suffered from drought, famine, flooding, epidemics, and countless other troubles. [On April 30, 1991], disaster struck again, as a devastating typhoon raked the coast. When it was over, a large share of the nation was literally under water. Rescue crews began the grim search for bodies. And families gathered to mourn the loss of loved ones. Late last week, experts weren't sure how many lives were lost in the disaster. Some officials speculated that up to 100,000 people might be dead.

About ten million people lived in the area hit hardest by the typhoon. Fortunately, they knew the storm was coming, and many were able to reach shelters. The storm's timing also saved lives, as the typhoon peaked during low tide. But even with this bit of luck, the storm managed to cause an incredible amount of damage. Power lines and telephone poles were knocked down, leaving much of the nation without communication. Two vital industries—salt manufacturing and shrimp farming—were almost totally destroyed in the storm. Last week, officials in Bangladesh estimated damage at $1 billion. The U.S. pledged $2 million in medical supplies.

. . . In [the April 1991] typhoon, winds reached 145 miles per hour.

[Waves] swelled up to 20 feet. In addition to their high winds, cyclones also contain large amounts of rain, sleet, and hail. That precipitation only added to the flooding. But cyclones are not the only source of flooding in Bangladesh.

Bangladesh is one of the most flood-prone nations in the world. Devastating storms regularly hit the nation's coast. Flooded rivers submerge the low, flat land every year during the monsoons. And even when it's not raining, the Ganges and Brahmaputra Rivers regularly flood. Melting snow from the Himalaya Mountains flows into the rivers, frequently causing floods [Figure 12 on page 44].

The coastal lands of Bangladesh are only a few feet above sea level. About six percent of the land here is permanently under water. Two-thirds is flooded for part of the year. To make matters worse, Bangladesh has a huge population. More than 100 million people are crowded onto this tiny, impoverished nation. With so little land available, people must eke out a living on delta islands along the coast. These island dwellers are especially vulnerable to floods. The land is so low there is no place for flood waters to drain. Bangladesh's frequent floods often result in loss of life and enormous property damage. But flooding in the delta also has a positive side. The floods deposit rich alluvial sediments on land, making the soil extremely fertile for growing crops such as rice. Agriculture is the mainstay of the economy here (*Newscurrent* 1991).

Article 2

Millions Left Homeless: 5,000 Missing

Relief officials said about 3 million people in this poor country bordered by India and Burma were evacuated from mud and straw homes in the path of the storm before the typhoon struck.

About 80 percent of the huts were blown away, a Relief Ministry official said. "The deaths would have been on a much larger scale" if the residents had not been shifted to shelters, he said.

Many were moved to concrete buildings on higher ground that were converted to shelters after a storm packing 138 mph winds struck the same area in 1970, leaving nearly 500,000 people dead.

Figure 12 Map of Bangladesh. Note that the country lies on the delta of two major rivers: the Ganges and the Brahmaputra. (The Brahmaputra is known by the name *Jamuna* within Bangladesh.) Each of these rivers has its source in the high Himalaya Mountains and flows for more than 1,500 miles to the Bay of Bengal.

United News of Bangladesh said at least 5,000 fishermen aboard 500 trawlers were unaccounted for. It said their boats were at sea when the typhoon struck the southeastern coast where about 7 million people reside in 2,000 villages.

The typhoon battered 14 coastal districts, uprooting trees, telephone lines and electricity poles, a Relief Ministry official said, speaking on condition of anonymity.

Most information on the disaster came via radios operated by the Red Crescent, the Muslim equivalent of the Red Cross.

"Thousands of people are injured and crops and houses over a 300-mile radius are damaged," said a Red Crescent official in Dhaka.

The Red Crescent mobilized 21,000 volunteers for relief work, a television report said. The army was deployed to help, it said.

The typhoon triggered a flash flood in the Meghna River, which flows through the area, United News of Bangladesh said. The agency said river waters engulfed the railway station and at least a dozen other buildings in Chandpur, 30 miles southeast of Dhaka. (Printed with permission of the Associated Press 1991.)

Article 3

Bangladesh Fails to Appoint Official to Lead Relief Effort

Bangladeshis and international disaster experts are criticizing the government's slow response in assessing needs and moving supplies to survivors of the cyclone that struck this country. . . .

Five days after the storm ravaged a long stretch of the southeastern coast, the national news agency's estimate of the death toll stood at 125,200. Earlier speculation that 200,000 people may have drowned was not repeated yesterday, although one newspaper spoke of 150,000 deaths.

But the greatest concern now is that those who survived the storm's huge waves and floodwaters would succumb in vast numbers to disease and exposure. "Two million people are at severe risk," said Cole Dodge, representative in Bangladesh for the U.N. Children's Fund.

But no Bangladeshi official has been given authority to coordinate and command relief efforts. No substantive assessment of damages has been made. International and private relief agencies have thrown themselves into the task of assisting the cyclone's survivors, must of whom are on a long

stretch of coast between the port of Chittagong and the resort city of Cox's Bazar, or stranded on islands just off shore.

Yesterday, Nobel laureate Mother Teresa arrived with sacks of milk powder and biscuits. "I have come here to give my love and care to the suffering people. It's good to share the suffering with them," said the 80-year-old Roman Catholic nun.

Mother Teresa brushed aside a government offer to stay in a luxury hotel and chose to stay in one of her organization's two missions in Dhaka. Her organization has six other missions in Bangladesh, but none in the areas affected by the storm.

UNICEF is trying to distribute . . . shelters, along with oral-rehydration mixes, water-purification and medicine kits, and intravenous drip for severe dehydration caused by diarrhea (*Denver Post* 1991).

Article 4

Survivors Running Out of Time: Weather Slows Aid to Bangladeshis

Time is running out for survivors in the cyclone-ravaged lowlands of Bangladesh, aid workers warned Monday. Thunderstorms lashed the country, hampering relief efforts and heightening fears that the death toll of more than 125,000 could rise sharply.

Flooded roads and lack of helicopters slowed the distribution of desperately needed supplies for the victims of the cyclone that mauled the length of Bangladesh's coast April 30.

"You need 200 helicopters for this kind of operation, and I have exactly two," said a ranking officer of a unit that is flying 10 or 12 sorties a day, dropping food packets in districts near Chittagong.

The southeastern port bore the brunt of the mighty storm that left an estimated 10 million people homeless and ravaged one-fifth of Bangladesh.

Relief organizations fear a cholera epidemic may break out in areas where decomposing bodies are contaminating water. The Red Crescent, the Muslim equivalent of the Red Cross, said 100,000 more people may die if the impending epidemic is not contained.

In Washington, the American Red Cross said 4 million people are imperiled by lack of food or clean water.

An independent Bengali-language newspaper reported Monday that 200 people have died of diarrhea (Colorado Springs *Gazette Telegraph* 1991).

The terrain is very flat in Bangladesh. Flooding is a common problem.

How do Bangladesh and the United States compare in terms of disaster preparedness?

The most common mode of reducing loss from natural hazards is to alter the vulnerability of society by designing human activities that prevent injury. Some of the ways countries have tried to reduce risk are listed in Table 9.

Table 9 Selected preparedness measures for natural hazards

- *Control works:* Include coastal barriers, levees, dams, water-storage projects, earth stabilization, and so on.
- *Building design and construction:* Helps resist wind, water and earth movement, and provides protection for humans.
- *Warning systems:* Include forecasts and warnings communication.
- *Emergency relief systems:* Include emergency evacuation, food supplies, preparation to take effective action upon receipt of a warning, hazard insurance.
- *Changes in land-use:* Restricts settlement and development in areas vulnerable to hazards.

Source: Burton, Kates, and White 1993.

A country's ability to employ the preparedness measures listed in Table 9 depends on several "effectiveness factors." The dollar sign and letters in boldface are symbols for these factors.

- **$** National or personal affluence (wealth)
- **t** Availability of technology
- **g** Government action (local, national, international)
- **e** Education of public (awareness of hazards, risks, and what can be done to alleviate suffering)
- **c** Cultural beliefs and practices
- **d** Level of economic development

Beginning on page 49 are two quotations from a book called *The Environment as Hazard*. They describe the disaster preparedness in Bangladesh and in the United States. Table 10 on page 49 provides some basic data about these two countries. Consider these questions as you read about Bangladesh and the United States.

6. How do Bangladesh and the United States compare in terms of the preparedness measures listed in Table 9 on page 47?
7. Which of the "effectiveness factors" influence the ability of Bangladesh and the United States to prepare for natural hazards?
8. What conclusions can you draw regarding the consequences of natural hazards in a highly developed nation such as the United States and in a developing nation such as Bangladesh?
9. How does the description of the 1970 Bangladesh typhoon in the following quotation compare to the articles you read on the 1991 typhoon? How has Bangladesh tried to reduce risks in the past 20 years? Have those efforts been successful? Why or why not?

Table 10 Comparison of Bangladesh and the United States

	Area (square miles)	Population (millions)	Population density (people/sq. mile)	Per capita income (U.S. $)
Bangladesh	55,598	113.9	2,049	220
United States	3,618,770	258.3	71	22,560

Sources: National Geographic Society 1990; Population Reference Bureau 1993.

Preparedness for Typhoons in Bangladesh

The tropical cyclone threat in Bangladesh is concentrated in two seasons—April–May and October–December—when vigorous storms sweep up the Bay of Bengal. The storm surges arising from these have ravished the coast of the Bay of Bengal for many centuries.

Bangladesh is one of the more densely populated nations of the developing world. Its rapidly growing population . . . constantly threatens to outgrow its food supply. Consequently, sons of farmers, many themselves sharecroppers, are faced with either feeding their families from progressively smaller plots of land or searching for new areas to settle. The press of hunger has forced villagers southward onto the fertile, flat deltaic plains; many of the *chars* [shifting deltaic islands] subject to the full force of winds and storm surges of tropical cyclones were not settled until 60 years ago.

The deltaic plains are eminently suited to rice cultivation, and 80 percent of the workers are farmers, 10 percent fishermen, and the rest traders, clerks, day laborers, and professionals. A large body of migrant laborers comes in to sow or harvest the crops. The people live in bamboo and straw houses, thatch-roofed and placed on mounds elevated sufficiently to keep them out of summer monsoon floods. Most houses are grouped in family compounds, and are often shaded by a few fruit and other trees (banana, date, coconut palm, and bamboo) growing close to them.

The farmer here has a very small margin of survival, so that he and his family are particularly vulnerable to any minor fluctuation in climate. In this setting the impact of a tropical cyclone is disastrous. In the cyclone of November 1970, . . . the massive surge striking the central coastal region brought death to more than 17 percent of the population of the affected area. Mortality was greatest among those who were too old, too young, and too weak to hold on to the trees that in many places offered almost the only place of refuge. On some offshore islands all the inhabitants were killed, and no one knows how many were lost of the migrant laborers accustomed to sleeping in the fields. . . .

In the setting of a marginal and highly vulnerable existence, there are few resources for individuals to use in making adjustments to the threat of tropical cyclones. People do take active measures to protect themselves from the yearly storms by building raised-earth platforms in their houses, by tying down house roofs, and by planting trees to absorb wind and provide refuge in their tops. These measures afford little protection in an extreme storm. Moving away is scarcely an option, and farmers were observed resettling offshore islands that two months before had been swept bare of any trace of human habitation by the November 1970 storm.

The national government has concentrated on protective shore works, cross dams, and other structures (behind which newly formed land is used for agricultural purposes), a warning service, and protective plantings of trees along embankments. In the 1970 storm the protective works were breached, unable to withstand the waters that rose more than 7 meters [23 feet] above normal high tide. The tree plantings, useful in bank protection against small storms, were washed away in the larger one.

The government cyclone-warning services issued timely warnings of the storm, but they were not fully effective in 1970 because the social organization required to make them so proved inadequate. Radios, for example, are not available for all the population, and stations were off the air during the most critical hours of the night. In addition, although there were some community buildings and raised structures available for refuge, women accustomed to the seclusion of *purdah* [the Hindu practice of secluding women] were likely to resist evacuation to them.

The combination, since the 1970 storm, of intense economic pressure that drives the farmer and his family to settle low-lying lands, the government construction of protective works that offer a sense of security, and a higher level of relief and rehabilitation aid than in previous disasters, is probably setting the stage for enormous destruction and loss of life in future severe storms unless much heavier attention is given to land-use patterns, building design, and warning systems (Burton, Kates, and White 1993, pages 79–81).

Agriculture in Bangladesh.

Preparedness for Hurricanes in the United States

In the United States, hurricanes (as tropical cyclones are known there) account for large losses of lives and property. The major components of the hurricane hazard are storm surge, wind, inland flooding, coastal erosion, and tornadoes, with storm surge the principal cause of loss. About 30 million people are exposed to hurricane wind hazard, and some 6 million are directly subject to the storm surge arising from a storm, which is more likely to cause loss of life. About two hurricanes affect the East Coast per year, and from them winds of over 70 kilometers per hour may affect . . . nearly one-quarter of the nation's territory.

The losses caused by a hurricane are a function of the magnitude of the storm, the population, and the economic development of the area affected. In recent years there has been a rapid development along the U.S. coast. The trend is for loss of life to decrease and for property damage to increase. . . .

Individuals and families may suffer great losses, but these are somewhat compensated for by federal and local assistance. Communities are probably the social level hit hardest of all, for they suffer loss in public buildings and equipment such as schools and service facilities, and in addition have a diminished tax base after the disaster. They also receive heavy federal aid for rebuilding. Hurricanes cause significant damage to offshore installations such as oil rigs, fisheries, and boats of all kinds, this amounting to an average of $75 million per year.

Loss of life, amounting to some 60 fatalities a year since 1940, has decreased despite increasing population along the coast, but this downward trend may not continue much longer, for the growing urbanization of coastal areas means that some escape routes are becoming insufficient to take care of the population. One Florida county, for example, is exploring the possibility of vertical evacuation into sturdy high-rise buildings rather than attempting to get people out of the area endangered by the storm when evacuation routes may become clogged.

A recent response by the U.S. government to the hurricane hazard has been its experiments in modifying damage potential of the storm through seeding of the clouds. Since, however, the [origin] and behavior of these storms is poorly understood, no one is entirely sure of the possible adverse effects of this procedure (such as reduction in rainfall or change in direction), and seeding operations might therefore cause increased damage.

In the past, protective shore works have been erected widely at a high cost, borne mostly by the federal government. Such works are now being criticized as inspiring a false sense of security, and also because they interfere with shoreline ecology and scenery—values more recently significant on the American scene. Dunes and forest plantings have been used with some success in coping with minor storm effects, but these are unlikely to withstand a major storm.

The adjustment most directly related to saving lives has been the development of an effective warning system, with cooperation between federal and local officials, public and private sectors. [It has been estimated] that such a warning system saves about $25 million during an average season, and perhaps as much as $100 million during a very active one. Overwarning may result in unnecessary protective or evacuation measures costing from $7 to $17 million. Each time a

warning goes into effect in southern Florida, programmed measures taken by corporations and businesses cost them about $2 million, regardless of the severity of the storm. Public response to warnings is not uniform. . . . Adequate explanation for this varied response is not available, but it may be related to prior experience with hurricanes.

Land-use management and the modification of building requirements are used as adjustments for lessening the deleterious effects of hurricanes. The potential pay-offs from coastal and land management are reflected in the value of property in storm-surge hazardous areas, estimated at $25 billion. Other measures available to individuals to reduce hurricane damage include protection against flooding, and wind-proofing/emergency measures such as tying down loose materials and shuttering windows.

Despite the considerable body of knowledge available to the American people about possible adjustments to hurricanes, adoption of such measures is not widespread. For example, in the vulnerable coastal area of Miami, Florida, a leading shutter and awning company estimates that only 20 percent of the residents take the protective measures open to them. . . . The trend of increasing damage as more and more people move into expensive structures on the coastal areas and as mobile homes proliferate may be expected to continue. The downward trend in loss of life may also be reversed if, as more people move in, no means are provided for evacuating them in an emergency (Burton, Kates, and White 1993, pages 81–84).

A message of "HELP" is spelled out in scrap lumber beside a roofless Florida City home destroyed by Hurricane Andrew.

10. Based on what you have read in this lesson, what kinds of knowledge and expertise can more-developed countries provide to less-developed countries to help them reduce their losses from natural disasters?
11. Why would an increasing concentration of population in urban areas throughout the developing world bring added problems with natural disasters?
12. Do you think economically advanced countries, such as the United States, should help less-developed countries? Why or why not? If you answered *yes*, how do you think the United States can help?

Glossary

Asthenosphere A soft layer of Earth's mantle, lying just below the lithosphere. Because it is not rigid, the asthenosphere allows the movement of the tectonic plates above it. See **lithosphere, mantle, tectonic plates.**

Crust The outermost solid rock layer of Earth's lithosphere. Earth's surface is the top of the crust. See **lithosphere.**

Cyclone General term for any center of low atmospheric pressure, usually associated with stormy weather. Sometimes **cyclone** is used interchangeably with **typhoon.** See **hurricane, tornado, typhoon.**

Deltaic Pertaining to a river delta. For example, deltaic soil is the fine sediment, or silt, that accumulates at a river's mouth.

Density A measure of the number of objects in a certain area, for example, the number of people in a square mile.

Earthquake A shaking of the ground caused by the energy released when rock masses shift along a fault. See **fault.**

Epicenter The place on Earth's surface directly above the subsurface point where an earthquake occurs. The subsurface point where the quake occurs is the focus. See **earthquake.**

Fault A fracture or crack in Earth's crust along which there has been movement of rock masses relative to one another. See **crust.**

Hurricane A severe tropical cyclone storm of the Western Hemisphere, with masses of air rapidly turning around the low-pressure center. Winds exceed 75 miles (120 km) per hour and are usually accompanied by heavy, intense rains. Compare **typhoon.** See **cyclone.**

Island arc A chain of volcanic islands produced by subduction zones in areas where tectonic plates collide. Island arcs run parallel to deep ocean trenches. See **subduction, tectonic plates, volcano.**

Liquefaction The process whereby soil turns to liquid under unusual stresses, such as those that occur during strong earthquakes. Liquefied soil is very unstable and cannot support buildings. See **earthquake.**

Lithosphere The strong, rigid outer layer of Earth, including both the crust and the rigid uppermost part of the mantle. It is located above the asthenosphere. See **asthenosphere, crust, mantle.**

Magma Hot, molten rock with dissolved gases. Magma is found in the asthenosphere, but because it is less dense than solid rock, magma can rise toward Earth's surface. Magma is called lava when it erupts onto the surface in volcanoes. See **asthenosphere, volcano.**

Mantle The layer of Earth between the outer crust and the inner core. See **crust.**

Natural disaster/natural hazard An event not directly caused by humans, capable of causing large loss of life and/or damage to property and the landscape. The disaster is the occurrence of the event; the hazard is the risk of the event occurring.

Plate tectonics A theory describing the movements of Earth's lithosphere and the processes associated with the interaction of the tectonic plates. At plate boundaries, two plates may either move apart from one another, collide with one another (see **subduction**), or simply grind past one another. These motions can cause earth-

quakes, volcanoes, and tsunamis. See **earthquake, lithosphere, subduction, tectonic plates, tsunami, volcano.**

Prefecture A political division in Japan similar to a state in the United States.

Richter scale A scale used to measure the magnitude or strength of an earthquake. Each higher step on the scale represents a significant increase in the energy released by the quake. See **earthquake.**

Seismic waves Movement of the crust along a fault creating shock waves that are transmitted through the solid earth—in other words, an earthquake. See **crust, earthquake, fault.**

Seismometer An instrument measuring the magnitude or strength of the shock waves produced by an earthquake. See **earthquake, Richter scale.**

Subduction A process in which one tectonic plate plunges beneath another one at a zone where the two plates collide. This process generates powerful earthquakes and produces chains of volcanoes. See **island arcs, tectonic plates, volcano.**

Tectonic plates Earth's lithosphere is broken up into about twenty huge, rigid slabs that are carried atop the soft asthenosphere by slow-moving currents; these are the tectonic plates. See **asthenosphere, lithosphere.**

Tornado An intense localized cyclone with a rotating column of air, usually accompanied by a funnel-shaped cloud. A tornado has a vortex several hundred yards in diameter whirling at speeds of up to 300 miles (483 km) per hour. See **cyclone.**

Tsunami A huge ocean wave caused by underwater earthquakes, landslides, or volcanic eruptions. Tsunamis are often referred to—incorrectly—as tidal waves. See **earthquake, volcano.**

Typhoon A severe tropical cyclone storm of the Eastern Hemisphere, characterized by masses of air rapidly circulating around the low-pressure center. Winds exceed 75 miles (120 km) per hour and are usually accompanied by heavy, intense rains. Compare hurricane. See **cyclone.**

Volcano A mountain formed by the build-up and cooling of lava and ash. Active volcanoes periodically emit more lava and ash.

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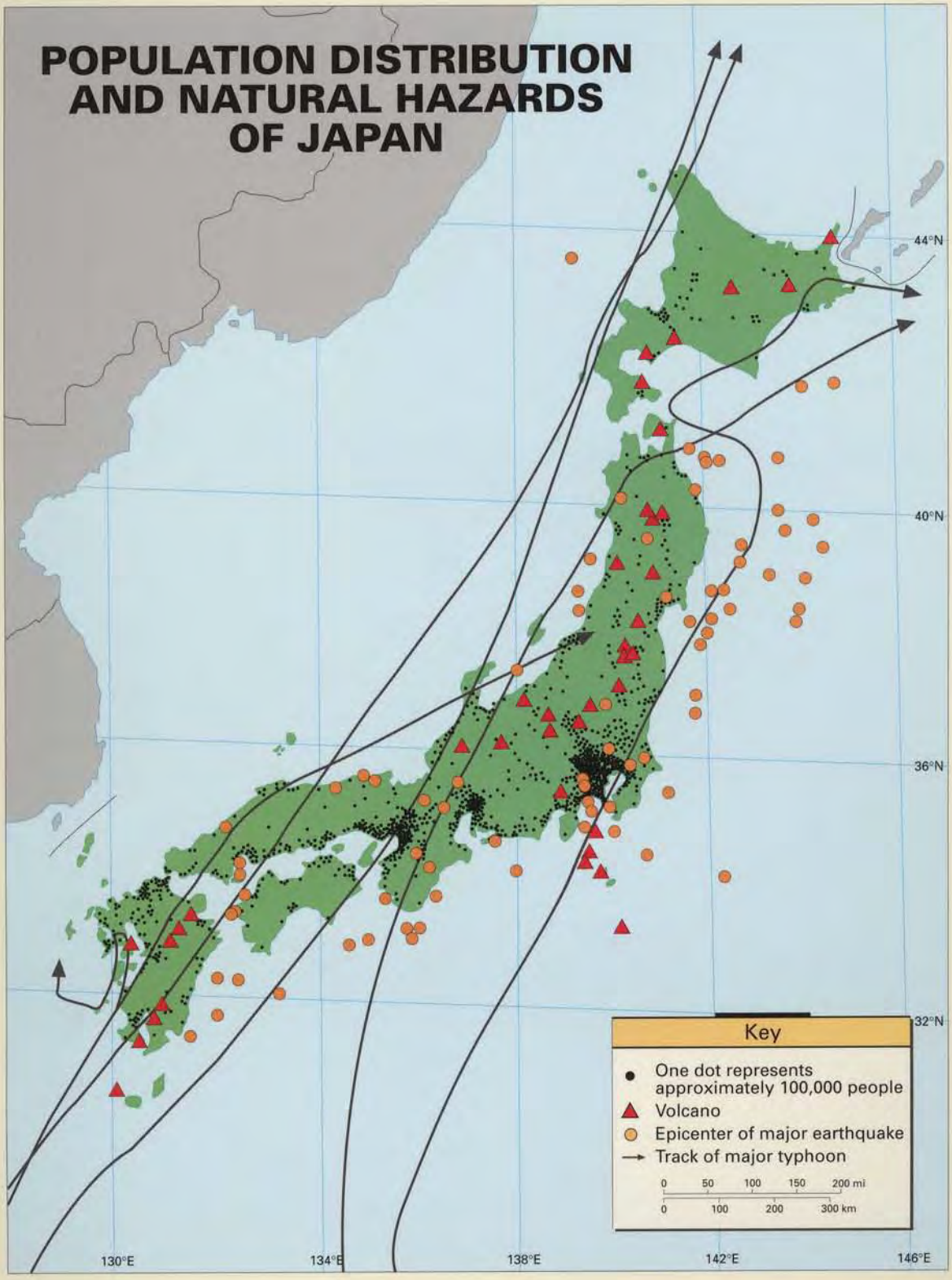
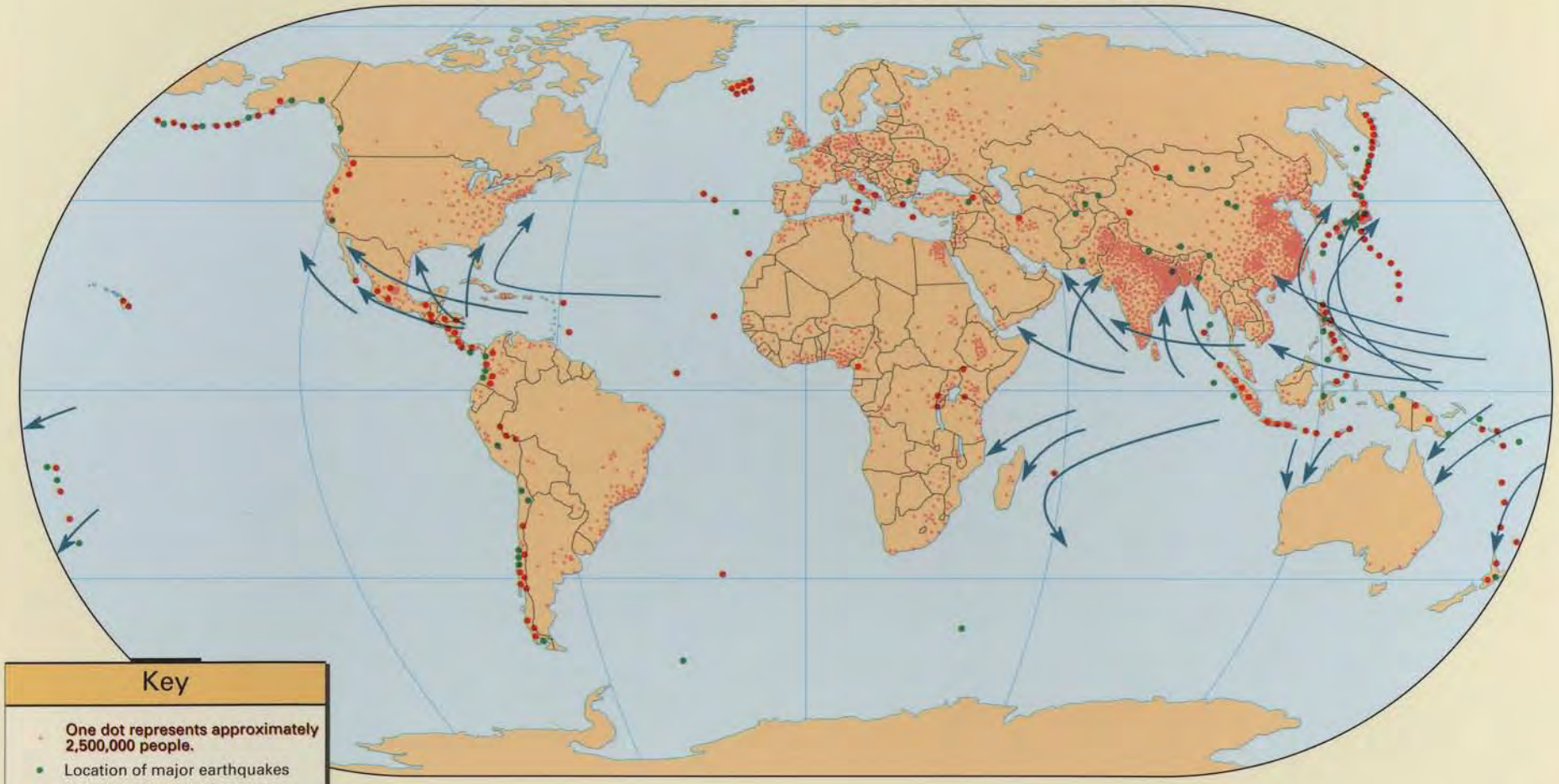
Map 1



Map 2

Geographic Inquiry into Global Issues
NATURAL HAZARDS

POPULATION DISTRIBUTION AND NATURAL HAZARD OCCURRENCES



Key

- One dot represents approximately 2,500,000 people.
- Location of major earthquakes
- Location of major volcanoes
- Typical paths of tropical cyclones

Source: Britannica World Data Annual (1994)