DOCUMENT RESUME

ED 179 359 SE 028 775

AUTHOR Bartholomew, Rolland B.
TITLE Environmental Studies Lecture Notes for Geology 361K, Environmental Earth Science.
INSTITUTION Texas Univ., Austin. Dept. of Geological Sciences.; Texas Univ., Austin. Science Education Center.
SPONS AGENCY National Science Foundation, Washington, D.C.
PUB DATE [75]
GRANT NSF-GY-9335-EZ
NOTE 83p.; For related documents, see SE 028 776-788; Contains occasional light type

EDRS PRICE MF01/PC04 Plus Postage.
DESCRIPTORS Audiovisual Instruction; College Science; *Curriculum Development; *Earth Science; *Environmental Education; Geology; *Higher Education; *Instructional Materials; Natural Resources; Oceanology; Pollution; *Science Education; Science Instruction; Undergraduate Study

ABSTRACT

This is one of a series of 14 instructional components of a semester-long, environmental earth science course developed for undergraduate students. The course includes lectures, discussion sessions, and individualized learning carrel lessons. Presented are the lecture notes for 10 lectures on the topics of geologic time, natural resources, and oceanography. Slides and transparencies used with these lectures are not provided but are described so that one may select slides from their own files or copy similar slides from the literature. Reading assignments for each lecture are provided. (BT)

SCIENCE EDUCATION CENTER

ENVIRONMENTAL STUDIES

A Cooperative Project of The Department of Geological Sciences
and the Science Education Center

The University of Texas at Austin

LECTURE NOTES

FOR

GEOLOGY 361K
ENVIRONMENTAL EARTH SCIENCE

Rolland B. Bartholomew
Associate Professor of Science Education
and
Geological Sciences

TO THE READER:

The lecture notes in this booklet show the instructional content for the Environmental Earth Science course developed for two one-hour lecture periods each week. Before reading these lectures, the prospective instructor should know that the course has four components: two lectures each week, one audio-visual-tutorial lesson each week, a one-hour discussion, and selected readings. The instructor will need to coordinate the components to avoid repetition and to let each "media form" convey specific kinds of information. The lectures develop basic factual information as well as raise stimulating and provocative questions for the students to consider. In other words, the students should recognize the complexity of our environmental problems and recognize the fact that perfectly good rational arguments can be made for conflicting points of view.

The readings, discussions, and audio-visual-tutorial lessons provide information necessary to understand the vast number of conflicting ideas in this field of study. This kind of instruction places the responsibility for learning the facts on the student, and it forces the lecturer to do that thing he can do best -- help students clarify their thoughts and develop rational points of view.

In some of the lectures, a large number of 35mm slides and overhead transparencies were used. At this time, it is not practical to duplicate these slides for a prospective instructor's use. However, each slide is described so that one may select slides from their own files or copy similar slides from the literature to illustrate a given lecture. Many of the examples used in class to expand the lectures have been omitted because it was felt the goals of the course could be achieved best if the prospective instructor selected the examples that fit their own classes and teaching style.

Anyone teaching a class in Environmental Earth Science will have to do a great deal of reading and organizing of ideas. This is not an easy job. However, the lectures described in this booklet should aid a prospective instructor in reducing the amount of preparation time.

I wish you well as you try out this program, and trust that you will have the same kind of satisfactions I have when working with students on this complex, frustrating, important, and challenging subject -- Environmental Earth Science.

Rolland B. Bartholomew
Associate Professor of Geology
and Science Education

ENVIRONMENTAL EARTH SCIENCE

LECTURE NOTES

Table of Contents

SECTION III: TIME

Lecture 1: An Introduction to the Geologist's Concept of Time

SECTION IV: NATURAL RESOURCES

Lecture 1: Introduction to Natural Resources
Lecture 2: Our Nonfuel Mineral Resources
Lecture 3: Soil and Food
Lecture 4: Water, Another Basic Natural Resource
Lecture 5: Solid Wastes
Lecture 6: Synthesis Lecture for Section IV

SECTION V: OCEANOGRAPHY

Lecture 1: The Oceans
Lecture 2: The Role of Man in Estuarine Processes
Lecture 3: Synthesis Lecture for the Course

Section III: Time

Lecture 1: An Introduction to the Geologist's Concept of Time

Before developing the ideas associated with our concept of geologic time, it is worthwhile to spend a few moments setting the stage for this brief section. For example, point out that our feelings about environmental problems is directly related to the time scale we are using. It is our concept of time that makes us talk about a "Crisis in Energy" rather than a "Problem with Energy." Many of the arguments and contradictory statements that we have been reading are due to people applying different concepts of time. It is time we began to consider what time scale we are using when we discuss environmental problems. This is one of the most difficult problems we face in understanding environmental degradation and the conflict between man and the laws of nature.

Of all the organisms living today, we alone are capable of asking questions about our world. We are truly unique. We are "one-of-a-kind." Consider for a moment the questions.

Reading Assignment

Berry, William B.N. Growth of a Prehistoric Time Scale, W.H. Freeman and Company, San Francisco, California, 1968. Chapters 1, 2, and 5.

1

How old is the earth?

(Leave on the screen long enough for all to read and consider -- no narration)

2

How old is life?

(Leave on the screen long enough for all to read and consider -- no narration)

3

How old is man?

(Leave on the screen long enough for all to read and consider)

Only you are capable of asking such questions.

4

How old is the earth?
How old is life?
How old is man?

These questions are some of the first ever asked by man, and some of the most repeated of man's questions. Every major religion has its own views on the origin of the world, and its own way of calculating when it happened.

5

An Early Time Scale: age of rocks, planets, and stars.
Fig. 5-1
page 52

One of the earliest time scales I could find is seen on the next slide. How did these men arrive at these calculations? They applied a fundamental idea -- time can be perceived only by events that occur within it. Look for the events.

6

the deluge, the temple building, David, Abraham, and the captivity

Some of the events are the deluge, the temple building, David, Abraham, and the captivity. So we, too, look for events to mark time.

Series 1-18 child

Time units measure the intervals between the beginning and end of events. Another condition meaningful events fulfill is that the event happens at a specific recognizable point along the time continuum - it must be unique. Example: here's a series of events with the interval indicated, but notice this series doesn't help us tell the time if we lack information about the specific point where it took place along the time continuum.

Blank slide

I would like you to write down the oldest event you can recall happening in your lifetime. Estimate the time interval it lasted.

(Select three - write them on the overhead)

Which event happened first? (no correct answer)

We can't tell time simply by knowing the event happened

We need more information. Similarly with the early geologists, they knew the rock sequence (event) at place 1, place 2, and place 3, but this alone didn't supply enough information to place them on a time scale.

The recognition of geologic time as we now view it did not come about easily. Three independent but closely related ideas lead to the discovery of our modern concept of geologic time.

---

7 Principle of Uniformitarianism

What is the oldest non-biological thing you can see in this room? (accept several answers) Why did you choose these things? Because you knew something about how buildings were built. So it is with geologists. They understand earth processes and apply this principle in establishing age relationships of rock layers. We say "the present is the key to the past."

---

8 Glacial Till

Another example: look at this road cut. Is the rock deposit a terrestrial deposit or a marine deposit? Is it a stream deposit, wind deposit, or glacial deposit? How do you know? Your answer depends upon how well you understand the geologic processes happening today and you project that understanding back to the time this deposit accumulated.

9

Sedimentary Beds

Here is a picture of an outcrop of layered rocks. Which layer is older? Younger? How do you know?

10

Principle of Superposition

There is a name for what you are doing. It is called the "Principle of Superposition." Younger rocks are above older rocks in a stratigraphic sequence. What assumptions are you making?

11

"Strata" Smith's map of England

Here is a picture of the first geologic map. Strata Smith constructed the map by applying the two principles you have just learned plus another.

12

Close-up of Cedar Park Limestone

This new idea developed by Smith seems simple today but it was a new and revolutionary concept in the early 1800's. Smith found that rock units (layers) could be identified by the particular assemblages of fossils they contain. This rock is easily identified by local geologists as the Cedar Park Limestone by the fossils it contains.

13 Principle of Faunal Succession.

At about the same time Cuvier established that fossils found in the younger rocks in a stratigraphic sequence resembled present day organisms more closely than the fossils found in older rocks, this lead to another major idea called the principle or law of faunal succession.

---

14 Room 103

Refer to the display case showing the change in an organism though time.

---

15 Lyell's time scale

Geologists applying these three principles were able to formulate a time scale. This is a slide showing Lyell's geologic time scale -- one of the first ever published. It took a long time for this idea to come about. Lyell's work is only 140 years old -- two lifetimes removed from today.

---

16 Slide of modern time scale

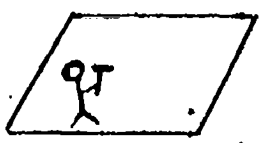
The modern time scale looks like this. It's development paralleled that of Lyell's. I'll use an example to give you some idea of how it developed. I'll use an actual case.

17

Sedgwick and Murchison (British geologists and good friends) studied a complex rock sequence in Wales. Murchison started at the top of the sequence and Sedgwick at the bottom. They worked toward each other. Each found what he considered to be natural breaks in the sequence. Murchison called his rocks "Silurian" (Welsh tribe), and Sedgwick called his rocks "Cambrian" (after another Welsh tribe). Both agreed that Silurian rocks were younger than Cambrian, but the break point could not be agreed upon. The rock systems overlapped.

The argument began, the friends became enemies, and the disagreement lasted for 40 years.

The solution was finally proposed by Lapsworth. He said the disputed rocks were a system in themselves and he called them "Ordivician" (after a Welsh tribe). This was not accepted completely by other geologists until Sedgwick and Murchison died. The locations of these rocks are called the "type sections" or "type area" for the Cambrian, Ordivician, and Silurian rock systems. These were considered to have been layed down during these periods.



18

Shot: Eichler P. 57, Fig. 3-2

Other geologists working in Europe established additional "type areas" as seen on this slide.

19

Correlation

Now consider this problem. A geologist in Austin has studied a sequence of rocks. He wants to know, "Are these rocks Cambrián, Ordivician, or Silurian? Were these rocks deposited contemporaneously with the sequence in Wales?" In order to ascertain the answer, he must match his rocks with those of the type localities or another sequence that has been previously matched. We call this process correlation.

20

Spencer, P. 32 Fig. 2-7

Show caption

There are many ways to correlate rocks in one locality with those in another. For example, by lithology,

---

21

Spencer, P. 38

Fig. 2-12

Show caption

by fossils,

22

Find pictures between continents Eicher, p. 90	even across oceans correlations are made to establish at what point in geologic time a rock sequence was deposited.
Overhead slide Spencer, p. 31	Before showing the next slide, I must remind you that knowledge of rock sequences - material things - grew up hand-in-hand with the concept of geologic time. This overhead slide shows how geologic time units, time-stratigraphic units, and rock units are related. (Use overhead transparency)
Overhead slide of time scale	I'd like to call to your attention that years have been included on the modern time scale. This should seem strange. How did these years become assigned to the time scale?
23 Geologic clock (Time prog) (Mickey Mouse watch)	How many of you have heard of a geologic clock? Describe it to me. (accept one or two descriptions) I'll show you one on the next slide. How's that?

24

Pendulum clock

It has been amazing to me that the inner workings of geologic clocks are almost exactly reverse the way a clock as we know it should work. Most clocks have a mechanism which changes the hand at regular intervals. The more consistently regular the interval, the better the clock.

25

Radioactive Decay

Not so with geologic clocks. The inner workings are completely unpredictable. The energy and events we recognize are detected in irregularly spaced bursts. Yet, we can tell time. How come?

26

$U_{238} \longrightarrow Pb_{206}$

The theory, in vastly simplified form, is like this. Uranium 238 -- we'll call it the parent element -- decays through radioactive processes to Lead 206. The radioactive process is such that the number of atoms decaying in any time interval is proportional to the number of parent atoms present in the sample.

27

10^6 gms. $U_{238} \longrightarrow$ $\frac{1}{7600}$ gms. Pb_{206} per year

For example, 1,000,000 grams of U_{238} will produce 1/7600 grams of Pb_{206} per year. As the parent U_{238} decreases the amount of daughter Pb_{206} increases. However, the rate of the process is a proportional relationship. We are able to predictably determine what is going on.

28 Table 6-1
Eichler, p. 120

(One interval of time used to measure radioactive decay is called the half-life. We could choose 1/3 life, 1/8 life, but half-life is easier to use)

Radioactive decay occurs in such a way that half of the radioactive substance decays in a given period of time, that period, called the half-life, is a constant for a given radioactive element. (Explain table)

---

29 Dating a rock

The generalized scheme for dating a rock or reading the geologic clock is as follows:

1. Select the sample to be dated. Note its position in the rock sequence -- e.g., its upper Devonian rock
2. Measure the relative amounts of parent and daughter elements.
3. Read the age of rock from the radioactive decay curve that applies to the elements being measured. We call this the radiometric age of the rock

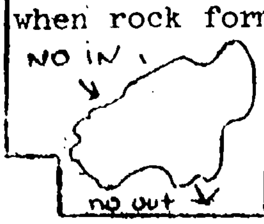
---

30 Dating the geologic time scale

Now if we can find radioactive samples for each time unit in the geologic time scale and determine its absolute age in years, we can date the geologic time scale. This may seem simple, yet the geologic time scale has only a few "really good" calibration points. Why would this be so since our technique is so excellent? (Wait for answers)

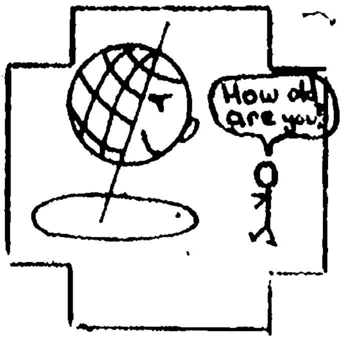
---

31 No daughter atoms present when rock formed



Also, point out that it is difficult to find samples that have been completely free of modifications and not disturbed.

32



Besides dating rock samples, there is another use for geologic clocks. Remember, I asked earlier, "How old is the Earth?" Let's see how geologic clocks are used to answer this question. We'll consider the whole earth like a single rock sample.

In a generalized way, the age of the earth is measured by this procedure:

1. Analysis of iron meteorites containing lead provide an estimate of the amount of primordial lead in the earth. We assume some lead existed when the earth was formed.

2. Estimate the amount of U235, U238, Pb207, and Pb206 that is present in the earth today.

3. Subtract the amount of primordial lead (as determined from meteorites).

4. Calculate the age using the U235/Pb207 and U238/Pb206 ratios. Each ratio provides us with a date of about 4,550 million years.

More recent calculations involving better estimates of the primordial lead ratio place the age of the earth at 4,500--4,800 million years.

33

Eichler, p. 128
Fig. 6-8
no caption

In our discussion sessions we may have time for a discussion of the Carbon 14 method as well as other dating methods. I'd like to conclude with an example that illustrates another practical result of the dating of rocks. This slide shows the migration of volcanic activity in the Hawaiian Islands. Pretty neat!

SECTION IV: Natural Resources

Lecture 1: Introduction to Natural Resources

The introductory lecture to this section of the course consists of two parts. Part I is an illustrated lecture using different students to read the narration for the slides. Part II is an illustrated lecture using overhead transparencies summarizing the use of nonfuel minerals by industry in the United States.

Experience has shown that students sense the value of the mineral industry in our technological society, but they know very little about the mining industry. For example, they are not aware of the fact that some industrial minerals are already in short supply and no adequate substitutions are available. Some geologists maintain that our shortage of nonfuel minerals will become a more serious problem in the near future than our shortage of energy.

This lecture is designed to introduce the student to an overview of the mineral industry from a geologist's point of view. The basic ideas of this lecture will be encountered time and again in this section.

Part I: Introduction to Natural Resources

You need to select four students to read the narration that accompanies the slide presentation. You need to make five copies of this narration so that each student will have a copy to read.

Assignment

Read Chapter 3 from the following:

Cargo and Mallory. Man and His Geologic Environment. Addison-Wesley Publishing Company, Reading, Massachusetts, 1974.

Blank Slide	(Narrator) "Today you are going to play 'scientist.' Not just any kind of scientist, but an 'earth resources scientist.' Here is your dilemma. You have been asked to read a paper at the International Earth Resources Conference in Peking, China. You are the keynote speaker. What are you going to say? This is the speech you will make."
Shot of earth from space	(Professor) "This is the earth. It has many resources. All of you can name the earth's resources. They are the solid earth, the liquid earth, the gaseous earth, and the biological earth. We see all of these components in the picture."
Slide of audience with a person standing.	(Narrator) "Fine, the lecture is ended. The audience claps and you are ready to sit down. Suddenly, a member of the audience stands and asks a question."
Close-up slide of a person standing in an audience.	(1st College Student) "Dr. Speaker, what is a resource? We can name them, but I don't understand what a resource is."

Slide of a person acting as a Professor.

(Professor) "An earth resource is an asset. It is something that can be used beneficially. Expressing it another way, an earth resource is a 'state of mind.' Thank you."

Slide of the person standing in an audience acting as 1st College Student.

(1st College Student) "But, Dr. Speaker, what does your state of mind have to do with it? Your remarks are very confusing."

Another slide of person acting as Professor

(Professor) "You are a persistent young man. Surely you know that your state of mind changes as you learn. Everyone knows that what is one man's treasure is another man's junk, so it is with the earth's resources. It depends upon your point of view. I say to you -- get your point of view straight."

Another slide of person acting as 1st College Student

(1st College Student) "I'd like to check with you about my point of view. Man uses the resources of the environment in three ways: (1) for materials, (2) for energy, and (3) to sustain life directly. Am I correct?"

Slide of 1st College student and Professor.	(Professor) "Certainly." (1st College Student) "Are these good examples?"
Slide showing the use of wood.	(1st College Student) "Here we see the use of wood."
Slide showing the use of rock.	(1st College Student) "Here we see the use of rock."
Slide showing earth materials as building materials.	(1st College Student) "Here we see earth materials as building materials."

Slide showing the use of metals.	(1st College Student) "Here we see the use of metals."
Slide showing materials used in making tools.	(1st College Student) "He also uses materials to make tools."
Slide showing Professor and 1st College Student	(Professor) "Excellent examples." (1st College Student) "I haven't finished. Man uses earth materials for energy."
Slide showing men working in a coal mine.	(1st College Student) "He mines coal."

Slide showing the use of petroleum.	(1st College Student) "He uses petroleum."
Slide showing man using water.	(1st College Student) "He uses water."
Slide showing Professor and 1st College Student.	(Professor) "Beautiful! You are a good one!" (1st College Student) "Don't forget he uses land resources for food production."
Slide showing Professor.	(Professor) "I couldn't have done this better myself. Did you notice that some of the resources are renewable and some nonrenewable? It is important that you notice this."

Picture of a person acting as a 2nd College Student.

(2nd College Student) "Dr. Speaker, why is this important? Will we run out of resources?"

Slide showing 1st College Student.

(1st College Student) "Of course, we'll run out of the non-renewable resources -- everyone knows that."

Slide showing forest and food resources.

(1st College Student) "Forests, food resources -- anything that natural processes can reform quickly (as fast as man can use them) is renewable. Mineral resources like ..."

Slide showing aluminum.

(1st College Student) "... aluminum,"

Slide showing iron.	(1st College Student) ".. iron,"
Slide showing oil well.	(1st College Student) " ... and oil are nonrenewable and man will eventually use these up. Some, like oil, will be used up before others. Right, Professor?"
Slide showing Professor.	(Professor) "Right! You are very sharp! Do you know anything about the price of earth resource materials? This is also important."
Slide of a barge transporting natural resources.	(2nd College Student) "Most of us know that resources having high value at the source are produced wherever they occur and are transported around the world,"

Slide showing a gravel pit.	(2nd College Student) ".. like you see here. Gravel, low pit value, short travel, "
Slide showing an oil tanker.	(2nd College Student) ".. or like you see here. Oil in tankers, long travel around the world."
(see diagram, page 13)	(2nd College Student) "I heard an economist talk about earth resources. He took a different view. As you can see from this slide, materials end up in a different place in a different form. This process empties the 'source' and fills up a 'sink.' He said price is not related to need. For example, water is low in price but needed - diamonds are high in price but unneeded."
College professor	(Professor) "That's very interesting. What are the residuals he has in his drawing?"

Slide showing 2nd College Student.

(2nd College Student) "It's obvious that the residuals represent pollutants. I'll show you a few slides of pollutants."

Slide showing pollutants.

Slide showing pollutants.

Slide showing 2nd College Student and Professor.

(2nd College Student) "Pollution occurs when there is impairment in the capacity of a resource to satisfy the need of man."

(Professor) "Very interesting."

(see diagram on page 13)

(1st College Student) "All of you are talking about the wrong thing. As you can see in this diagram, if we recycle we remove the residuals and have a greater supply of earth materials. Already we as individuals can recycle aluminum, tin, glass, and paper."

College professor

(Professor) "This is important; but recycling alone is not the answer."

Slide showing 2nd College Student

(2nd College Student) "I think you are right. But what else can we do?"

Slide showing 1st College Student

(1st College Student) "Perhaps we should consider the issues and problems relevant to forming a national policy on materials supply."

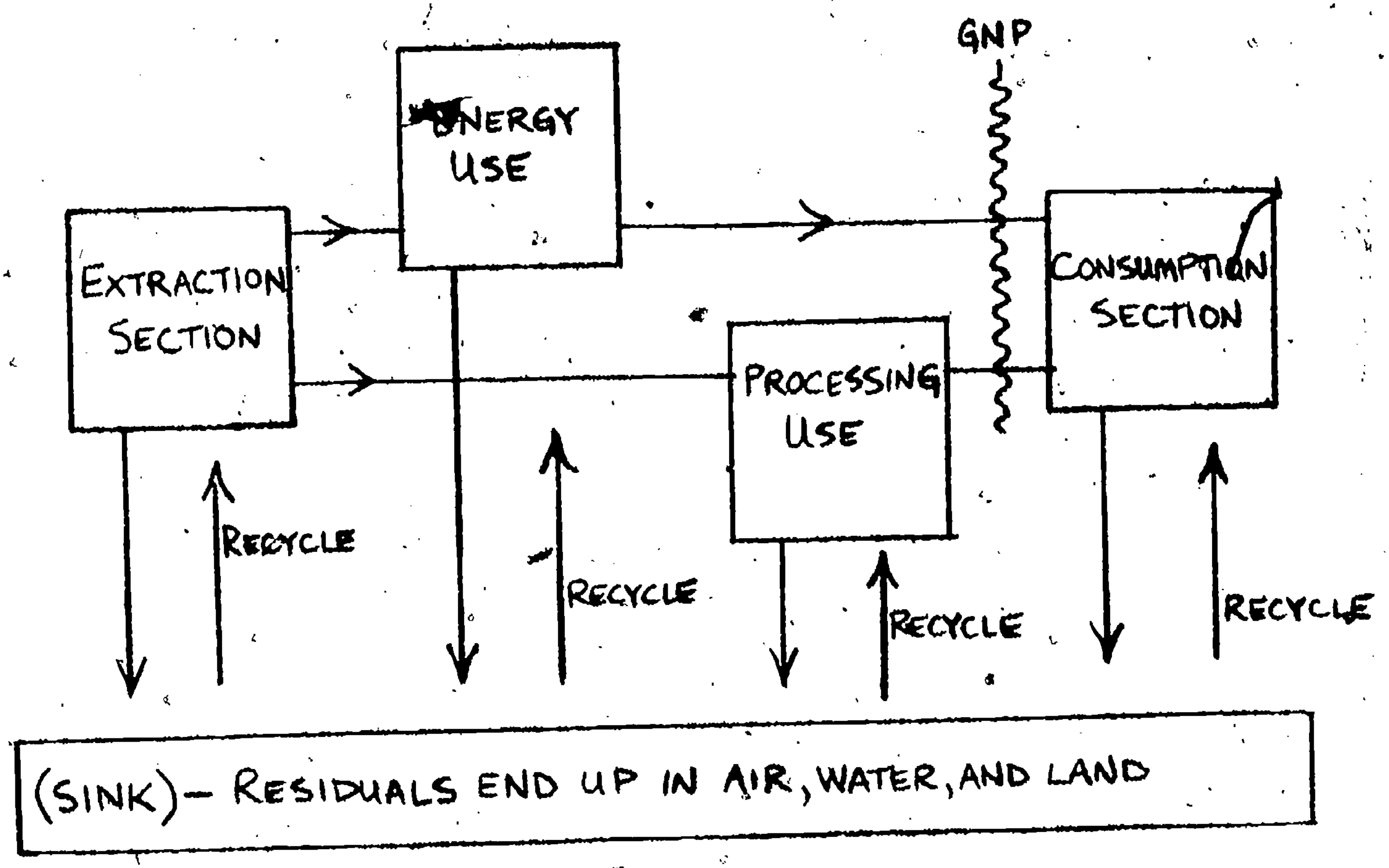
Slide showing Professor.

(Professor) "Perfect!"

Blank Slide

(Narrator) "Thank you, Dr. Speaker. Our time is up. Your remarks have been most helpful."

MATERIAL FLOW IN MAN-ENVIRONMENT SYSTEM (HAZELTON)

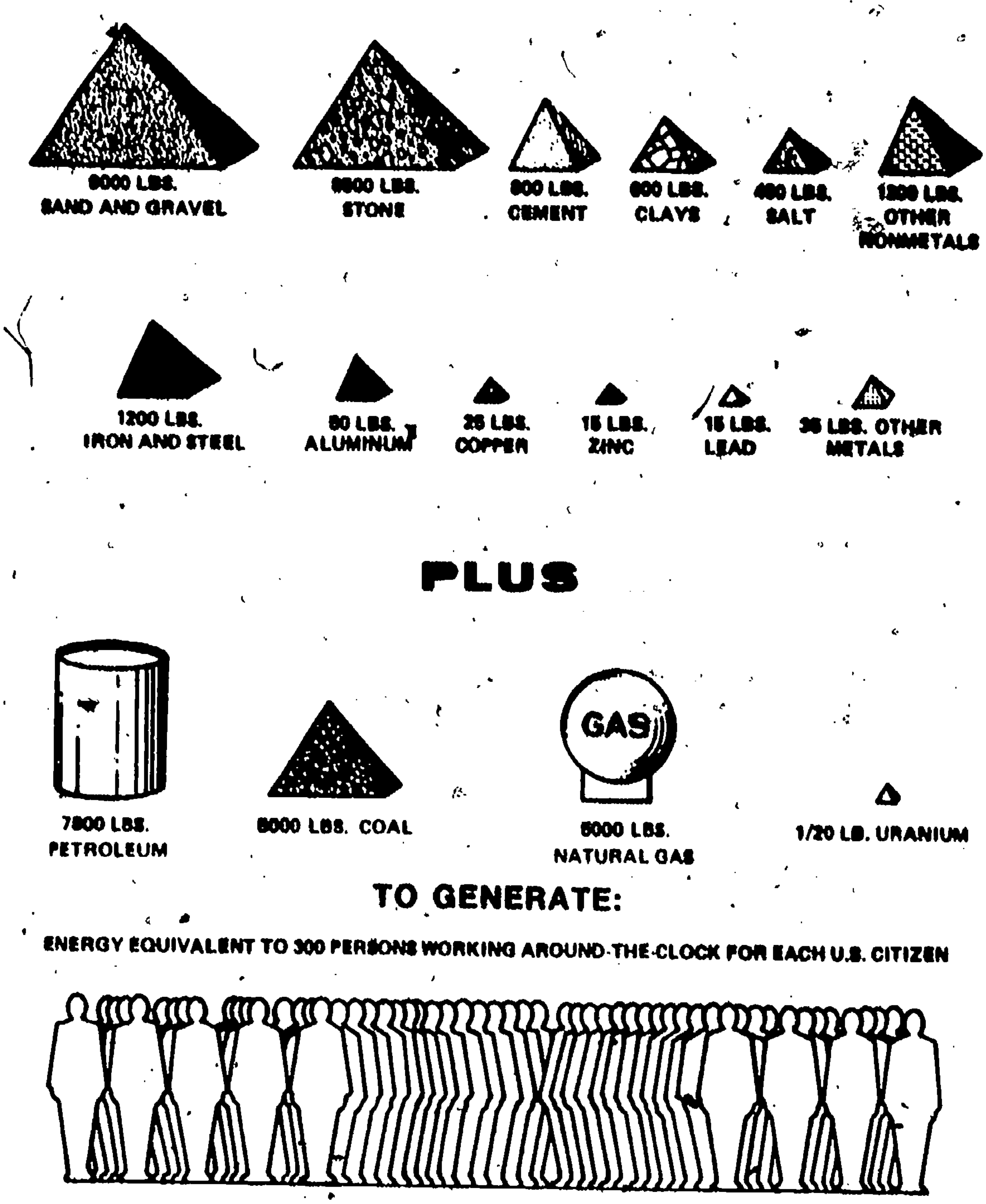


Part II: The Nonfuel Minerals

The source of the information for this part of the lecture is taken from the Second Annual Report of the Secretary of the Interior under the Mining and Minerals Policy Act of 1970. This publication is available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. The price is $1.25. Your congressman should be able to get you a free copy.

The pages of the report duplicated here make excellent overhead transparencies. A discussion of each of the transparencies focuses the lecture on the importance of the mineral industry to our technological society.

ABOUT 40,000 POUNDS OF NEW MINERAL MATERIALS ARE REQUIRED ANNUALLY FOR EACH U.S. CITIZEN

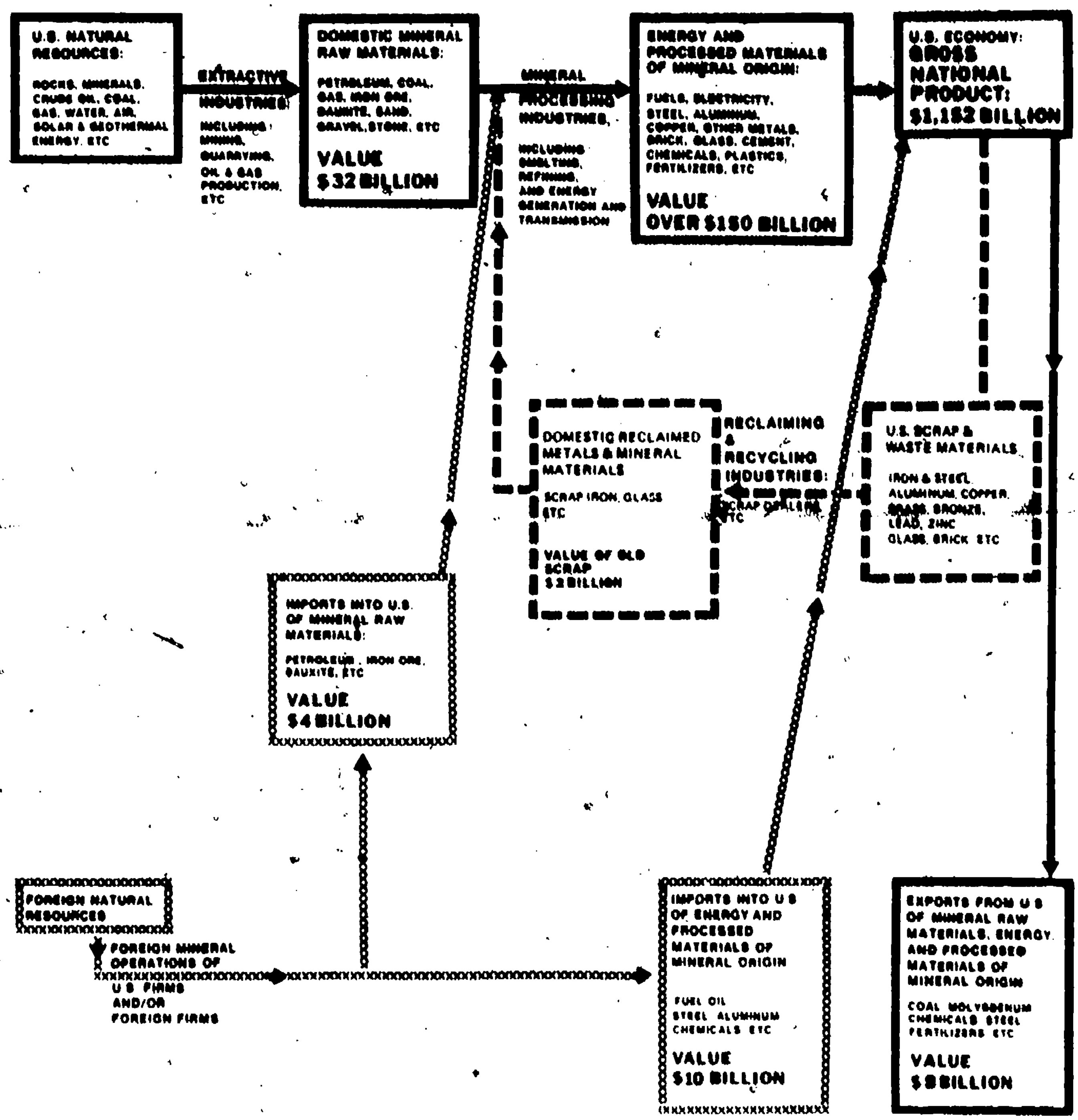


U. S. TOTAL USE OF NEW MINERAL SUPPLIES IN 1972 EXCEEDED

4 BILLION TONS !

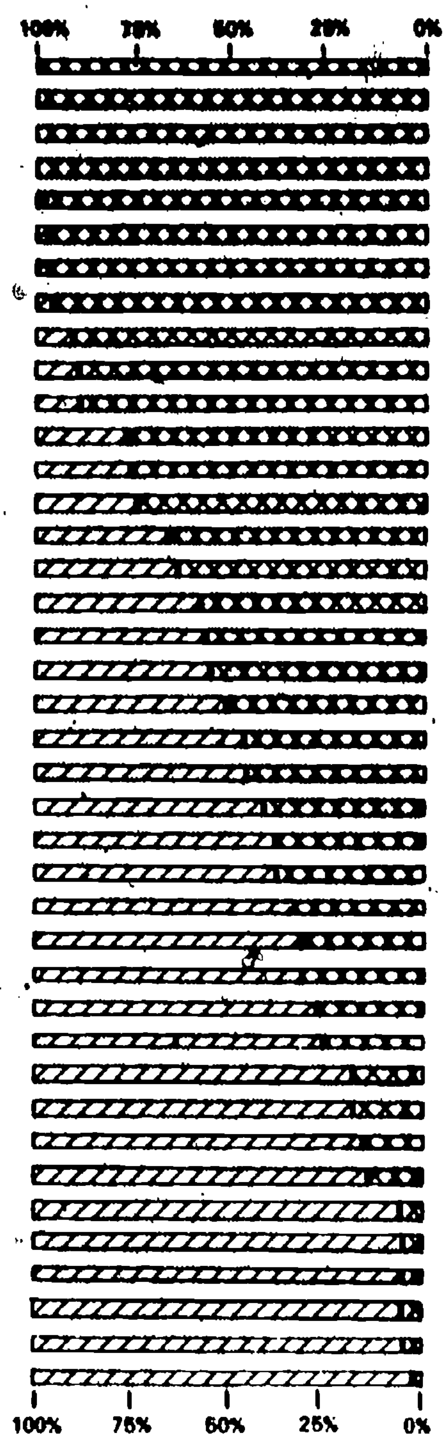
THE ROLE OF MINERALS IN THE U.S. ECONOMY

(ESTIMATED VALUES FOR 1972)



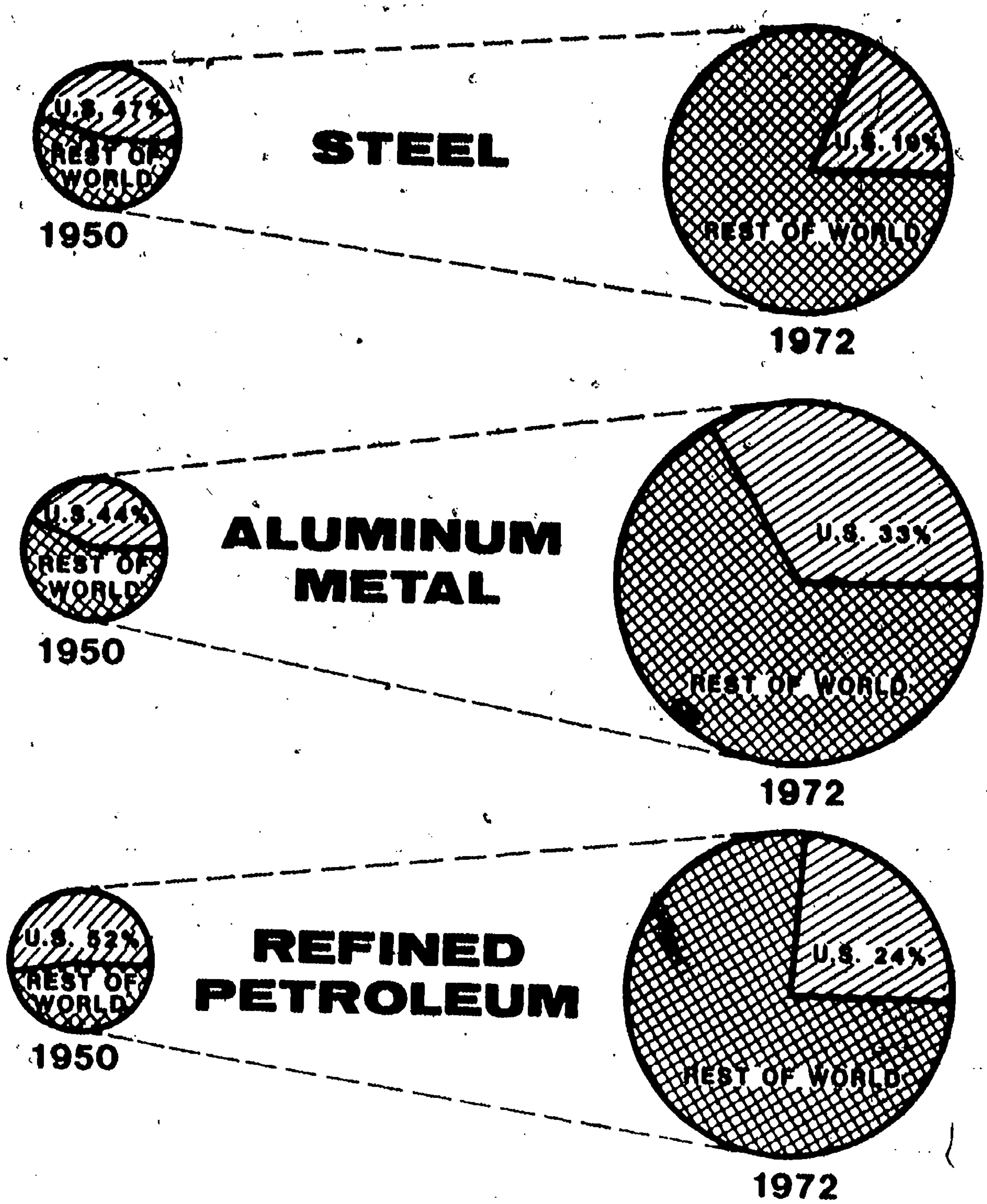
IMPORTS SUPPLIED SIGNIFICANT PERCENTAGES OF TOTAL U.S. DEMAND IN 1972

PERCENTAGE IMPORTED xx



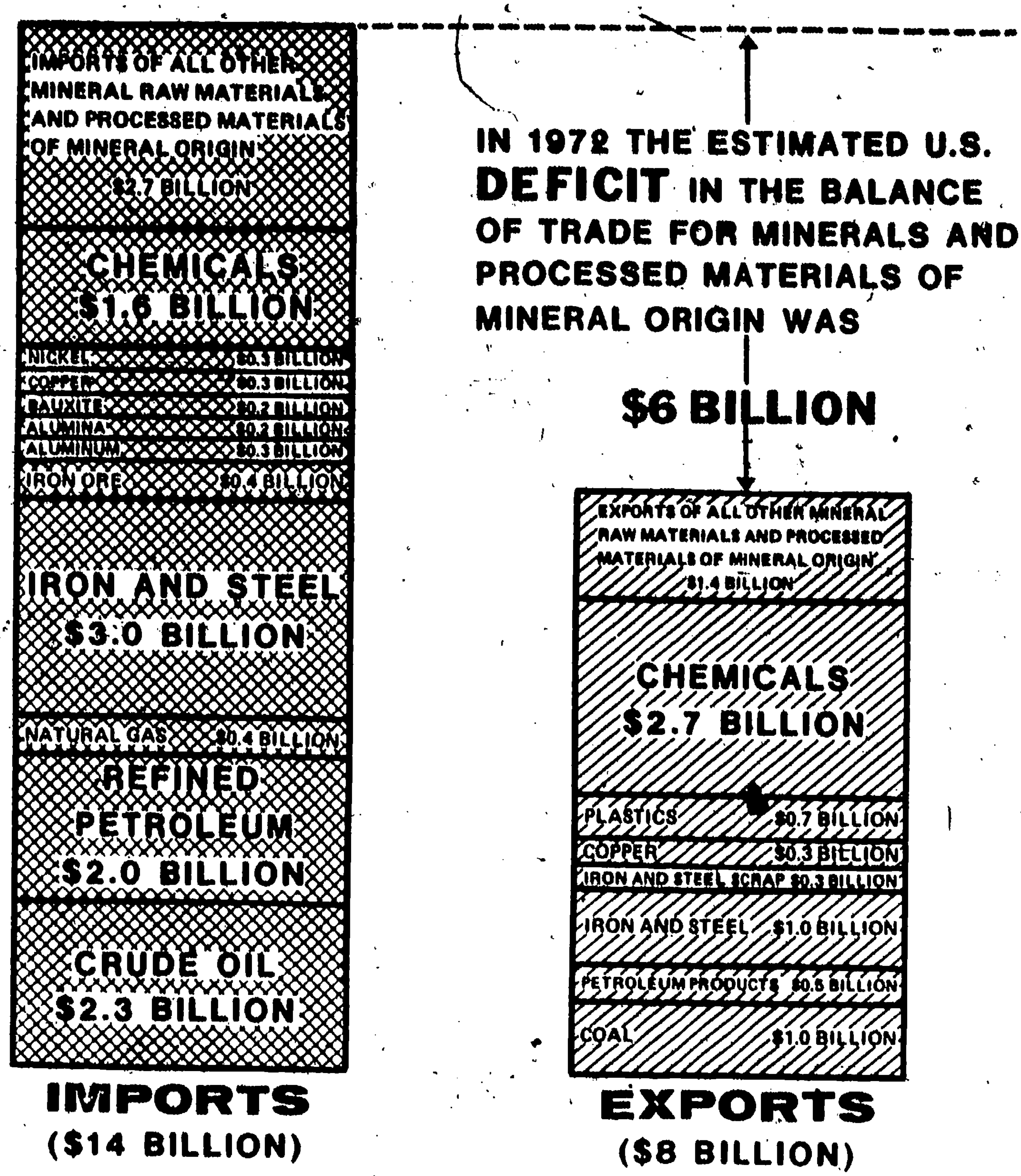
MINERAL	MAJOR FOREIGN SOURCES
PLATINUM GROUP METALS	UK, USSR, SOUTH AFRICA, CANADA, JAPAN, NORWAY
MICA (sheet)	INDIA, BRAZIL, MALAGASY
CHROMIUM	USSR, SOUTH AFRICA, TURKEY
STRONTIUM	MEXICO, SPAIN
COBALT	ZAIRE, BELGIUM, LUXEMBOURG, FINLAND, CANADA, NORWAY
TANTALUM	NIGERIA, CANADA, ZAIRE
ALUMINUM (ore & metal)	JAMAICA, SURINAM, CANADA, AUSTRALIA
MANGANESE	BRAZIL, GABON, SOUTH AFRICA, ZAIRE
FLUORINE	MEXICO, SPAIN, ITALY, SOUTH AFRICA
TITANIUM (rutile)	AUSTRALIA
ASBESTOS	CANADA, SOUTH AFRICA
TIN	MALAYSIA, THAILAND, BOLIVIA
BISMUTH	MEXICO, JAPAN, PERU, UK, KOREA
NICKEL	CANADA, NORWAY
COLUMBIUM	BRAZIL, NIGERIA, MALAGASY, THAILAND
ANTIMONY	SOUTH AFRICA, MEXICO, UK, BOLIVIA
GOLD	CANADA, SWITZERLAND, USSR
POTASSIUM	CANADA
MERCURY	CANADA, MEXICO
ZINC	CANADA, MEXICO, PERU
SILVER	CANADA, PERU, MEXICO, HONDURAS, AUSTRALIA
BARIUM	PERU, IRELAND, MEXICO, GREECE
GYPSUM	CANADA, MEXICO, JAMAICA
SELENIUM	CANADA, JAPAN, MEXICO, UK
TELLURIUM	PERU, CANADA
VANADIUM	SOUTH AFRICA, CHILE, USSR
PETROLEUM (inc. Nat. Gas liq.)	CENTRAL & SOUTH AMERICA, CANADA, MIDDLE EAST
IRON	CANADA, VENEZUELA, JAPAN, COMMON MARKET (EEC)
LEAD	CANADA, AUSTRALIA, PERU, MEXICO
CADMIUM	MEXICO, AUSTRALIA, BELGIUM, LUXEMBOURG, CANADA, PERU
COPPER	CANADA, PERU, CHILE
TITANIUM (ilmenite)	CANADA, AUSTRALIA
RARE EARTHS	AUSTRALIA, MALAYSIA, INDIA
PUMICE	GREECE, ITALY
SALT	CANADA, MEXICO, BAHAMAS
CEMENT	CANADA, BAHAMAS, NORWAY
MAGNESIUM (nonmetallic)	GREECE, IRELAND
NATURAL GAS	CANADA
RHENIUM	WEST GERMANY, FRANCE
STONE	CANADA, MEXICO, ITALY, PORTUGAL

U.S. PRODUCTION IS FALLING BEHIND IN RELATION TO THE REST OF THE WORLD



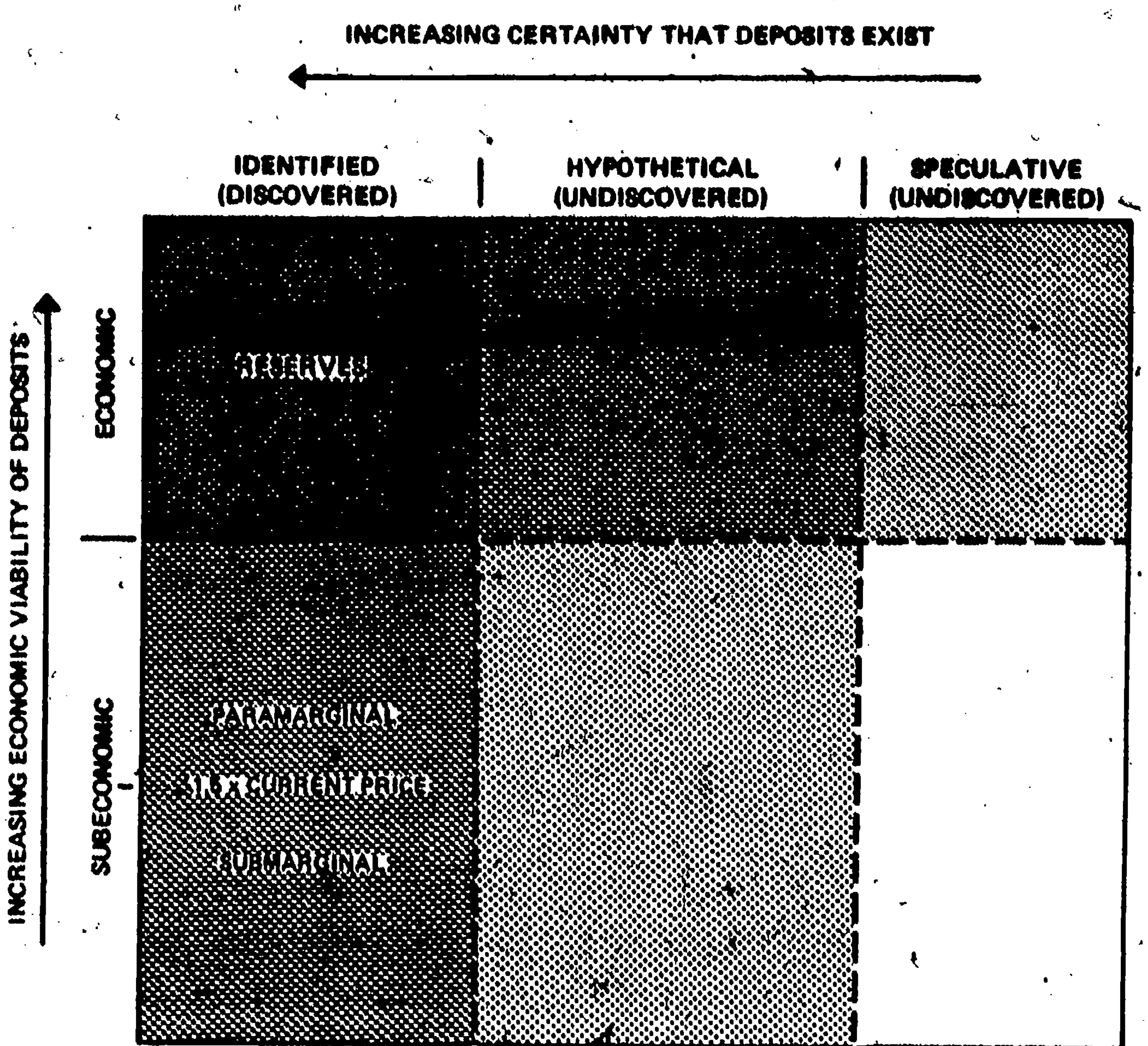
NOTE: THE LARGER 1972 CIRCLES SHOW THE GROWTH OF WORLD PRODUCTION.

U.S. IMPORTS EXCEED EXPORTS OF RAW AND PROCESSED MINERALS



MINERAL RESOURCE DIAGRAM

CATEGORIES OF MINERAL RESOURCES

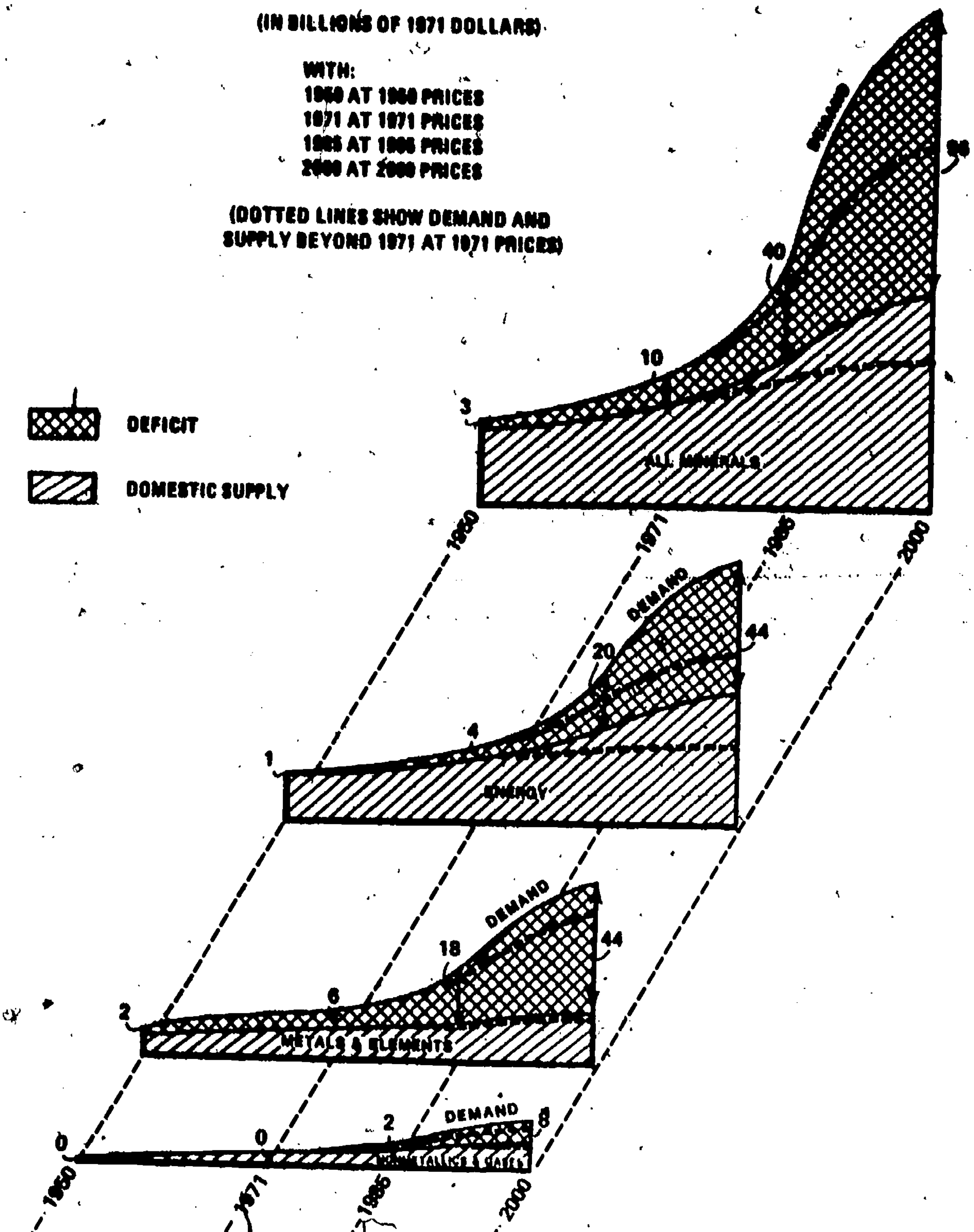


DEVELOPING DEFICITS
U.S. PRIMARY MINERAL DEMAND
VS.
U.S. PRIMARY MINERAL SUPPLIES

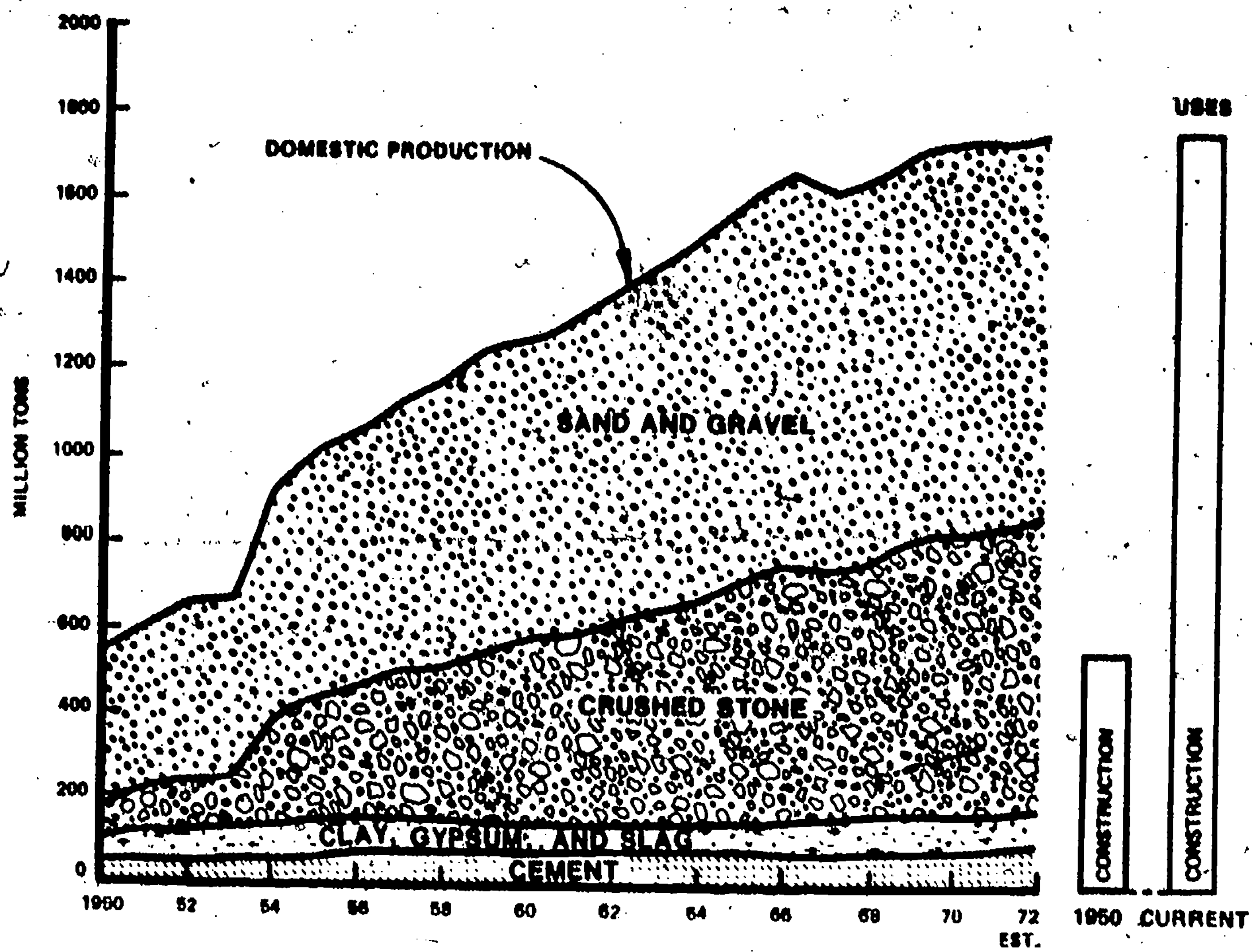
(IN BILLIONS OF 1971 DOLLARS)

WITH:
1950 AT 1950 PRICES
1971 AT 1971 PRICES
1985 AT 1985 PRICES
2000 AT 2000 PRICES

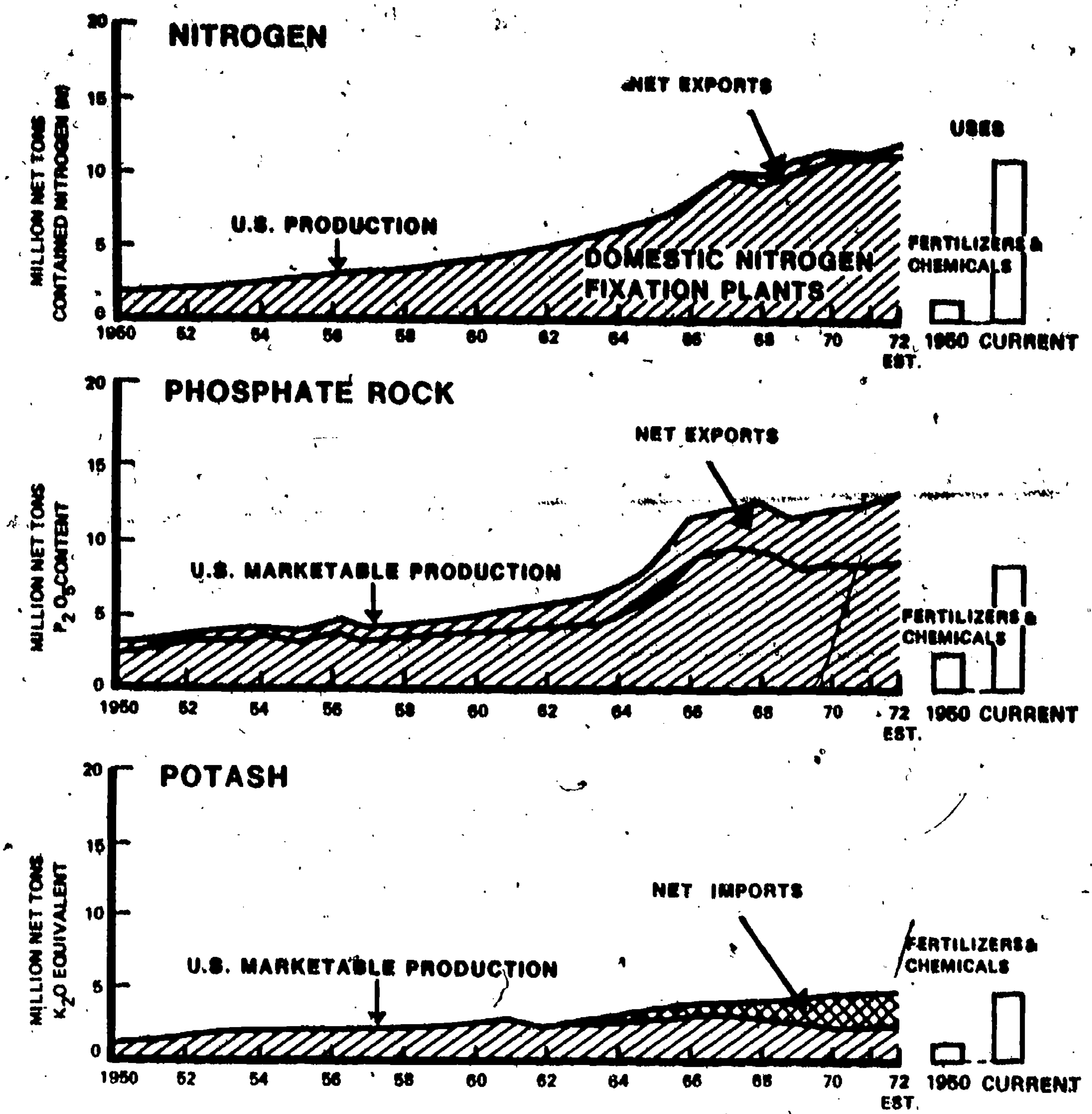
(DOTTED LINES SHOW DEMAND AND SUPPLY BEYOND 1971 AT 1971 PRICES)



U. S. SUPPLIES AND USES OF MAJOR NONMETALLIC CONSTRUCTION MATERIALS



U.S. SUPPLIES AND USES OF MAJOR FERTILIZERS



NEW MINERAL RESOURCE TERMINOLOGY ADOPTED

New definitions for such crucial mineral terms as "reserves" and "resources" have been jointly adopted by the Interior Department's Bureau of Mines and Geological Survey.

The new definitions more accurately describe the estimated production potential of mineral deposits, including fuels. Adoption of the nomenclature is expected to clear up the confusion of these terms -- especially between "mineral resources" and "mineral reserves," the agencies said.

Because the Bureau and the Geological Survey both collect important information about minerals, a common terminology is essential to evaluate the data for governmental planning. The new definitions extend those officially adopted in 1943 and later used by the Paley Commission to assess the nation's mineral resources.

The classification system agreed upon by the Bureau and the Survey is based on two key criteria: the extent of geologic knowledge about the resource, and the economic feasibility of its recovery.

For example, "mineral resources" are defined as concentrations of naturally occurring solids, liquids, or gases, discovered or only surmised, that are or might become economic sources of mineral raw materials. "Mineral reserves" are that portion of "mineral resources" that have actually been identified, and can be legally and economically extracted. (The term "ore" is used for the reserves of some minerals.)

GLOSSARY OF RESOURCE TERMS

Resource: a concentration of naturally occurring solid, liquid, or gaseous materials in or on the earth's crust in such form that economic extraction of a commodity is currently or potentially feasible.

Identified resources: specific bodies of mineral-bearing material whose location, quality, and quantity are known from geologic evidence supported by engineering measurements with respect to the demonstrated category.

Undiscovered resources: unspecified bodies of mineral-bearing material surmised to exist on the basis of broad geologic knowledge and theory.

Reserve: that portion of the identified resource from which a usable mineral and energy commodity can be economically and legally extracted at the time of determination. The term ore is also used for reserves of some minerals.

SECTION IV: Natural Resources

Lecture 2: Our Nonfuel Mineral Resources

Because your students have had little experience with economic geology, it is worthwhile to use the introductory portion of this lecture to acquaint them with a few basic ideas. For example, the rarity of mineral deposits should be explained. The table below provides a good discussion point for starting the lecture.

TABLE 4-2. ENRICHMENT FACTOR FOR SOME COMMON METALS

Metal	Percent in crust	Percent in ore	Enrichment factor[a]
Mercury	0.000008	0.2	25,000
Gold	0.0000002	0.0008	4000
Lead	0.0013	5.0	3840
Silver	0.00007	0.01	1450
Nickel	0.008	1.0	125
Copper	0.006	0.6	100
Iron	5.2	30.0	6
Aluminum	8.2	38.0	4

[a]The enrichment factor indicates how many times above its average concentration a metal must be in order to be mined.

Source: Committee on Geological Sciences, The Earth and Human Affairs, Canfield Press, San Francisco, California, 1972, page 142.

Some additional ideas you may choose to develop are as follows:

1. Each mineral deposit represents an accident of geology.
2. Each mineral deposit must be exploited where it occurs.
3. Mineral deposits are finite and nonrenewable.
4. In general, continued extraction of ore leads to increasing costs.
5. The demand for earth materials comes from chemical and manufacturing industries and from agriculture.
6. Minerals most essential to civilization are iron, copper, aluminum, and fertilizer minerals.
7. Few industrial countries have reserves adequate for the next century using forseeable technology.
8. The sources of supply of mineral commodities continually shifts.

A provocative way to develop this lecture topic is to take an optimistic view about our mineral resources in the future. The views summarized below are taken from the Paley Report, from the book Scarcity and Growth (Barnett and Chandler, 1963), and Natural Resources for U.S. Growth (Landberg, 1964). (The statements are also found in the reading assignment.)

An Optimistic View of Mineral Resources

1. Technology for the past fifty years has steadily made increasing amounts of raw materials available at lower cost per unit and therefore will continue to do so in the forseeable future. (e.g., taconite, copper, and sulphur)

2. As the grade of a mineral deposit decreases arithmetically, the reserves increase geometrically.

3. Nonrenewable resources are inexhaustible (see Item #2).

4. Scarcity can always be prevented by a rise in price of the raw materials.

5. Since the cost of raw materials is only a fraction of the final cost, a material rise in price for any raw material will have an insignificant effect on the price of manufactured items and on the general economy.

6. Any industrial nation will have adequate access to deposits throughout the world. A nation sells raw materials to attain the goods it cannot manufacture itself.

7. There will be only insignificant institutional restraints on access.

8. The U.S. and other industrial nations must have an ever expanding economy and will strive to attain the minerals needed.

9. The population of the Western nations will continue to increase at a rate of about 1.5% per year for several generations.

10. The underdeveloped nations will achieve a per capita income comparable to that of the U.S. within one or two generations.

By a judicious selection of examples to support these points, you can help your students understand the basic problems related to our nonfuel mineral resources. For example, some economists and some geologists have diametrically opposing views about the reality of our nonfuel mineral resources.

The assigned reading by Lovering gives an adequate description of the reasoning followed by the economists. A basic principle accepted by economists Barnett and Morris was formulated by Lasky. This principle is now known as the arithmetic-geometric ratio (A/G ratio) -- as the average grade mined decreases arithmetically, reserves increase geometrically. Does this relationship hold for all nonfuel minerals?

A look at the processes of mineralization should help answer that question.

1. Sedimentation processes cause concentrations of minerals in some places and dilution in others. Large volumes of sediments contain metals in parts per million range. It is in these kinds of deposits that the A/G ratio is most likely to hold.

2. Mineralization forming ore bodies from igneous segregations and precipitates from aqueous solutions in fractured and chemically reactive rocks does not show gradational change. The A/G ratio does not hold. The exception to this is found in some igneous deposits where mineral concentrations were dispersed throughout the magma before freezing and gradational change occurred. The A/G ratio might apply in a limited number of cases.

3. Fracture controlled deposits for minerals containing Hg, Au, Ag, W, Pb, Zn, At, and Be show abrupt changes and the A/G ratio does not hold.

4. Weathering processes that involve leaching and redistribution of minerals to make ore deposits show both gradational and abrupt changes. The A/G ratio holds in some cases.

5. Replacement deposits generally show abrupt changes in mineral composition and the A/G ratio does not hold.

6. Placer deposits show abrupt changes in location of the minerals, and the A/G ratio does not hold.

(It is important that you select specific examples of nonfuel minerals to illustrate each of the situations described above. However, I feel each teacher will find it easier to choose the examples that best fits his own situation.)

What does the future hold for nonfuel mineral supply and demand?

1. Experience shows that demand for nonfuel minerals increases faster than the population increases. Per capita usage of these minerals is increasing.

2. Industry is requiring increased tonnage and variety of nonfuel mineral resources.

3. Industrial production in the future depends upon continued discovery of new deposits.

4. Nations will be increasingly dependent upon other nations for raw materials.

5. New discoveries require from 3 to 5 years lead time before the ore gets to market.

6. Industrial demands for nonfuel minerals will put increasing pressures on research and development.

In summary, it is clear that the economists and geologists take different views toward the future availability of the nonfuel minerals. The A/G ratio is a useful idea to apply in some cases, but as a general rule, it simply will not work out. Some nonfuel minerals are finite in quantity and we must recognize this in order to manage these natural resources wisely.

Assignment:

Read Chapter 4 of the following:

Cargo and Mallory. Man and His Geologic Environment. Addison Wesley Publishing Company, Reading, Massachusetts, 1974.

Also read:

Lovering, T.S. "Nonfuel Mineral Resources in the Next Century," Limitations of the Earth: A Compelling Focus for Geology, reprinted from the Texas Quarterly, Volume XI, No. 2., Summer, 1968, p. 127-147.

SECTION IV: Natural Resources

Lecture 3: Soil and Food

What is soil? A farmer would answer, "Something to grow crops in." An agricultural chemist might answer, "A foodhold from which plants obtain their water and most of their nutrients." A pedologist would have a different reaction. He would probably say, "This question doesn't have a simple, easy answer. What is a rock, a mineral, or a gas?" Every soil has its own unique history. Like a living organism, a soil is the result of dynamic, evolutionary processes.

For the purpose of this lecture, we will take a very broad and incomplete view of soil by thinking about soil as being the uppermost layers on the earth's surface in which plants grow. In the U.S. we depend upon about 2.3 billion acres of land (total land area of the U.S.) -- per capita share is about 11 acres. In 1940 the per capita was about 17 1/3 acres, and in the year 2000 the per capita shane will be about 6 2/3 acres.

Assignment: Read the following:

Brown, Lester. "The New Seeds," The Survival Equation: Man, Resources, and His Environment. Houghton Mifflin Company, Boston, 1971, p. 273-279.

Brown, Lester. "Human Food Production is a Process in the Biosphere," Scientific American, September, 1970, p. 161-170.

Also read Chapter 4 from the following:

Cargo and Mallory. Man and His Geologic Environment. Addison Wesley Publishing Company, Reading, Massachusetts, 1974.

A National Inventory of Our Land

Source: Available from the Soil Conservation Service, U.S. Department of Agriculture, Program Aid No. 984

1 Map of U.S.	One-third of our land is public land administered by the federal government. Two-thirds of our land is owned by individuals, businesses, industry, and by states, counties, and cities.
2 Land Capability Map of U.S.	Soils are grouped in eight land capability classes according to their potentialities and limitations for the sustained production of common cultivated crops.
3 Graph of Land Capability Classes of Soils	Soils in classes I, II, and III are suitable for regular cultivation of most field crops. Soils in Class IV are marginal for growing crops. Soils in classes V, VI, VII, and VIII generally are not suitable for growing ordinary field crops but can be used for other purposes, including growing some crops.
4 Graph of Land Use According to Capacity	Notice the percentage of land in each category - 44% suitable for regular cultivation, 12% suitable for limited cultivation, and 44% not suitable for regular cultivation.

5

Map of U.S. showing Dominant Soil Limitations

The numbers that follow the region designation are interpreted as follows: 1, 2, and 3 refers to degree of erosion hazard; 4, 5, 6, and 7 refers to degree of wetness, and 8 refers to shallowness, stoniness, droughtiness, or salinity.

6

Graph showing Dominant Soil Limitations

Notice that only 3% of our land has soils that have no serious limitations on use for farming, and on about half of our land, erosion is the dominant problem.

7

Map of U.S. showing Predominant Land Use

Locally controlled rural land is about equally divided among the three major productive uses: cropland, 30%; pasture and range, 34%; and forestlands, 32%. About half of the arable land is used for cultivated crops.

8

Map of U.S. needing Conservation Treatment

Judged according to current standards, 64% of cropland needs additional conservation treatment, 67% of pasture and rangeland, 62% of forestland, and 28% of other land is inadequately treated.

Consider for a moment how heavily we depend upon food. How much food is available in the stores in this area? Suppose all food shipments were stopped, how many days would it take for the people to eat the food stored in the stores? The best estimates place the time to eat up the food supply between one and three weeks. Clearly, we depend heavily upon timely replacement of our food supply.

A look at modern agriculture shows that it depends on four technologies: mechanization, irrigation, fertilization, and chemical control of weeds and insects. Each technology disturbs the biosphere.

Mechanization uses large amounts of fossil fuel energy that is often substantially greater than the energy yield embodied in the food produced. This process also contributes to erosion and the loss of the topsoil producing most of man's food. Soil erosion is one of the most pressing and most difficult problems threatening the future of the biosphere. Remember, the dust bowl era problems created by wind erosion have not been completely solved.

Irrigation has also created environmental problems. In some areas, irrigation has raised the water table so that plants become waterlogged. In other areas, irrigation has concentrated chemical compounds in the soil to make the land infertile. An increase in schistosomiasis (snail fever) in some areas has been attributed to irrigation.

The use of chemical fertilizers has mixed blessings. On one hand, food production per acre is increased; on the other hand, run-off containing fertilizers pollutes drinking water and stimulates algae growth, making the water oxygen poor. The demand for fertilizers is increasing at an enormous rate.

Insecticides and herbicides present yet another double-edged technology. The benefits are obvious to the farmer, but the effects of different chemicals in the food chain are not clearly understood. DDT is a classic example. It was considered the wonder chemical until we learned more about its side effects on animal life.

In concluding this lecture, I would like to focus your attention on "The New Seeds." We have read a great deal about the breakthroughs in this kind of agricultural technology. One example of the new seeds is Mexican Dwarf Wheat. This wheat produces well under a wide range of soil and climate conditions. The yield per acre is increased and the growing time is reduced. Similarly, a miracle rice, IR-8, has been developed. IR-8 and other strains respond to heavy dosage of fertilizer and are more efficient users of sunlight. One pound of nitrogen applied to the new seeds can yield up to 20 pounds more rice than the traditional varieties in a shorter growing period.

In summary, this lecture has been designed to focus your attention on two basic natural resources -- soil and food. Both resources are renewable, but at vastly different rates. Soils take years to develop but can be destroyed quickly. Food production is renewable each year. However, food production depends upon the technologies of modern agriculture which do not always operate for the benefit of mankind. Man is faced with the dilemma of producing more and more food with newer and newer technologies while trying to answer the basic question, "What are the environmental consequences of attempting to do so?".

SECTION IV: Natural Resources

Lecture 4: Water, Another Basic Natural Resource

Water is the most abundant and most important substance with which man deals. The amount of drinking water needed each year by humans and domestic animals is approximately 10 tons per ton of living tissue. To grow a ton of sugar or corn under irrigation requires about 1,000 tons of water; wheat, rice, and cotton require about 1,500, 4,000, and 10,000 tons of water per ton of crop. (Source: Roger Revelle, "Water," Scientific American, September, 1963, p. 57.) Water use varies both in time and in place, and commonly its variations do not match those of the water sources. This mismatch is the major problem of water-supply management.

Water is a vital resource for all forms of life. Given a supply of water, we are primarily concerned with its quality. In the U.S., the average total water supply is 1.2 trillion gallons per day -- the average daily discharge of streams. Total water use is more than 270 billion gallons per day, or 22% of the total water supply, but consumption of water (water changed by soil evaporation and plant transpiration from liquid to vapor) was only about 68 billion gallons daily, or 5.5% of the total supply. The main water problem is that of maintaining good water quality. Water is both the most abundant and the most important substance with which man deals.

Let's focus for a moment on some of the problems associated with water quality. Water pollution is not something new. Man has always relied on the water around him to carry away and assimilate waste. As long as these wasteloads were reasonably small, the natural self-purification processes of the waterways could cope with the addition of foreign matter. This is no longer true in many cases. Later in this lecture we will look at the Houston ship channel as an example.

Our waters are being contaminated by the following: (1) organic wastes, (2) biological nutrients, (3) disease-bearing organisms, (4) temperature increases, and (5) synthetic chemicals. Let's look more carefully at each of these contamination sources in more detail. Water is contaminated by 12,000 potentially toxic chemicals increasing at a rate of 500 new chemicals each year.

Organic Wastes

Organic wastes come from agriculture, industry, and domestic sources. A major pollution effect of these wastes is the removal of O_2 from the water making it unfit for living organisms. In 1968, enough organic waste to have consumed more than 29 billion pounds of Oxygen (Biological Oxygen Demand - BOD) in decomposition was introduced in our water supplies. Other organic wastes included pesticides, herbicides, and hormones. For example, Diethystilbestrol (DES), added to cattle feed, was excreted in quantity in the waterways. The use of this carcinogen -- banned in chicken feed in 1960 -- caused Sweden and West Germany (1970) to outlaw imported U.S. beef because of DES residues.

Agricultural chemicals such as nitrate fertilizers, pesticides, and herbicides introduce materials that are poisoning the waters. Many different physiological effects in humans and living organisms can be attributed to these chemicals. Nitrate levels have risen to dangerous levels in many places -- even public drinking supplies in some localities. Accumulation of chemicals such as DDT in the food chain are serious threats to man.

Biological Nutrients

Another class of pollutants accelerate the growth of aquatic plant life (eutrophication) and increase the BOD of waterways. Phosphates and human excreta fall within this category of pollutants. Two billion pounds of phosphate compounds are added to laundry products each year. Heavy-duty detergents are 35-50% phosphate by weight. Phosphates are "builders." They soften hard water, help remove oil and dirt from fabrics, prevent redeposition of material, and make water alkaline. Recent developments in labeling detergents and chemical modifications to reduce the negative effects of biological nutrients help, but do not completely solve the problems caused by the wide-spread use of phosphates.

Human excreta in our waterways increases BOD as well as introducing disease-bearing organisms into water supplies. All of us are familiar with certain negative aspects of disposing of untreated human waste in waterways. Nothing more needs to be said about this serious problem.

Disease-Bearing Organisms

Water purification systems were originally designed to kill bacteria only. They cannot eliminate all toxic chemicals or all viral pollution. Consider for a moment this problem. Cincinnati increased the water pumped for domestic use 40% between 1955 and 1970, but the chlorine used to treat this water increased 200% during the same time period. Recently, studies have implied that chlorine may be harmful to humans. Yet, the benefits of this chemical to purify water is so great that we may have to continue increasing our use of chlorine and risk the trouble it may cause for humans.

Temperature Increases

Thermal pollution has already been discussed in our study of nuclear reactors. Temperature increases are devastating for fish and wildlife. Elevated water temperatures greatly increase the survival of unwanted organisms, while decreasing the life span and the number of more desirable animals and plants. The higher the heat, the more bacteria survive, including bacteria that cause disease in fish and man. Viruses thrive in fish subjected to increased heat. The toxicity of many pesticides to fish is greater at high temperatures.

Synthetic Chemicals

Synthetic chemicals both organic and inorganic found in pesticides, plastics, and detergents provide serious threats to humans and other living organisms. The pollutants may be toxic, carcinogenic, mutagenic (causing genetic damage) or tetratogenic (causing birth defects) to all forms of animal life. For example, many of these chemicals include small amounts of mercury, lead, arsenic, and cadmium that accumulate in the food chain. The effects of these chemicals on living organisms is not likely to appear for years. Treatment of public drinking water does not remove these chemicals.

To conclude this lecture, let's take a trip along the Houston ship channel.

Assignment: Read Chapters 2 and 3 of the following:

Cargo and Mallory. Man and His Geologic Environment. Addison Wesley Publishing Company, Reading, Massachusetts, 1974.

View of channel from San Jacinto Monument

The Houston shipping channel which is some 25 miles long has been recognized as one of the world's worst polluted bodies of water. Many biologists consider over half of the channel as being dead!

Water level view of channel

A trip up the channel will show numerous areas where pollutants are being allowed to enter the channel.

Texas A&M research vessel

The Texas A&M pollution research vessel is used to travel the channel and collect valuable data on channel pollution.

Oxygen recorder

This vessel is capable of continuously monitoring such things as dissolved oxygen, salinity, and temperature. It can also take samples as desired to a depth of 100 feet. Bottom cores may also be taken.

Salinity recorder	
Temperature recorder	
Close up view of bridge	This is a picture of the bridge of the monitoring vessel.
View of shoreline	A variety of industries are located on the channel.

Refineries	Here we see oil refineries.
Houston Lighting and Power electric plant	Houston Lighting and Power Company.
Ship unloading at dock	Grainery.
View of dock and plants	Steel plants.

Steel plants	Steel plants.
Oyster shell stock pile	Oyster shell dredging.
Shoreline with tanks	Natural gas storage and refinery.
Ship moving up channel	Shipping.

View from San Jacinto Monument	All of these produce their own characteristic pollution.
View of ground and stack flaring	Oil companies produce atmospheric pollution with flares,
View of smoke	and smoke.
Outflow from chemical plant	Chemicals in the water effluent.

View of electric plant

Houston Lighting and Power Company thermal pollution.

View of grain coating water surface

The grainery produces some atmospheric pollution and much of this settles onto the channel water surface and adds to its pollution. Much of this fine grain dust causes a great reduction of the oxygen in the water as it is used up in the decay of this type of pollutant.

View of steel plants

Armco Steel is a major polluter of the Houston ship channel. It not only pollutes the water, but also the atmosphere. Notice the color of the water and the plumes of dust and smoke being blown into the air.

View of solid waste on shore

Other waste products from the steel plant are dumped into the channel. These are rich in iron and do their share in reducing the available oxygen as they rust away.

Close-up of oysters and views of loading dock

Oyster shells are dredged in large quantities. This does not contribute very much to the pollution; however, it has ruined the ecology of many of the oyster beds.

Flaring from stack

Natural gas plants contribute to the pollution by the use of flares and the dumping of liquid wastes into the channel.

Outflow into channel

View of ship discharge and tugboat with barge

Shipping itself contributes considerable pollution to the channel -- bildge discharge and fuel losses and consumption.

View of ship wake	This pollution is also added to by household detergents and others that cause the waste to foam up.
Coating and debris in water	Others simply cause the water to be unusable.
Shoreline with dead trees and debris	Many times plants along the channel are destroyed by the pollutants.
Two views of tunnel crossing	Lead from the exhausts of motor vehicles driving through the underground tunnel adds its unique pollution.

(View of tunnel crossing)

Siemson Dock and trailer truck

Atlantic Richfield Company has given some indication that they are at least somewhat concerned with pollution.

SECTION IV: Natural Resources.

Lecture 5: Solid Wastes

Why is our landscape not littered with huge bones of dinosaurs or debris from living things? The answer to this question is so obvious that we seldom think about nature's recycling processes. However, we are rapdily becoming aware of man's lack of recycling processes. This is not to imply that nature's recycling processes and man's recycling processes are unrelated, just the opposite is true.

The movement of matter through the industrial process, unlike the movement of material through the life process, is generating an ever-increasing quantity of waste, mostly in the form of solid material. Natural processes degrade this material, but the process is very slow. It is the relative discrepancy in rates of degradation and production of man-made wastes that is causing our solid waste disposal problems.

Assignment:

Read Chapter 13 from the following:

Cargo and Mallory. Man and His Geologic Environment, Addison-Wesley Publishing Company, Reading, Massachusetts, 1974.

Sources of Solid Wastes and Collection Problems

The total quantities of solid wastes are large and increasing. Municipal solid waste average was 4.5 pounds per person per day in 1965 and over 5.5 pounds per person per day in 1970. The waste disposal system of an average city must accommodate about 150 pounds of waste for each 4-member family every day -- over 200 million tons per year. This amount contrasts greatly with the 1.75 pounds of waste per person per day in Sydney, Australia, and about one-half pound per day for a person in India.

Municipal waste consists of about 50% paper, 12% food, 10% wood and garden refuse, 10% leather, rags, plastic, rubber, ash, and miscellaneous dirt, 9% metal, and 9% glass. A major reason for the large accumulations of municipal waste can be attributed to the way our goods are packaged and the affluence of our society.

Figure I shows the major sources and quantities of solid wastes in the United States.

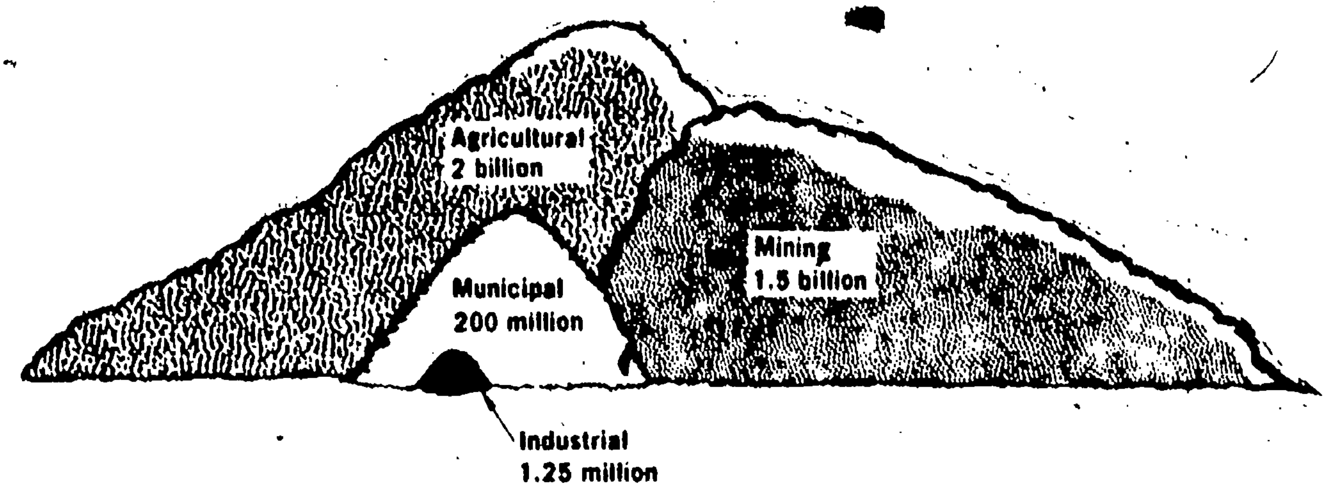


Figure I
Sources and quantities of solid wastes in the United States (approximations expressed in tons per year)

The disposal of trash causes many environmentally related problems. We are all aware of the litter we see everyday. In addition to litter, our health is endangered if we do not have rapid removal and safe disposal of many kinds of waste. The disposal of solid waste is becoming an increasingly serious problem. Ideally, we need biodegradable containers; however, the ideal is seldom found. The ice-cream cone is the ideal packaging material, but we can't find such perfect packaging material for everything we use.

The collection of trash is another serious and expensive problem. Consider for a moment the problems faced in collecting trash from a 400 unit high-rise apartment building. How can this trash be collected efficiently? One of the neatest ways I know is used in Sweden. Apartment dwellers there place their trash in a receiving hopper, push a button, and everything is sucked through a pneumatic pipe into a central receiving station for collection. Collection costs for municipal wastes in the U.S. run as high as $15 per ton in some cities.

Disposal of Solid Wastes

The most primitive form of waste disposal is the open dump. Waste is collected and dumped in an open pit where it is compacted and spread throughout the area. Formerly, open burning of the dumps helped reduce the volume of material. However, that practice has been stopped by legislation. We can all understand why an open dump is not a satisfactory solution to our disposal problem.

A modified form of the open dump, the sanitary landfill, is a more satisfactory disposal system. In this case, the waste is dumped into an open pit where the waste is compacted and covered with earth material. There are several different designs for sanitary landfills, but they all incorporate the idea of placing the waste in cells that are covered with and isolated from each other by earth material. The landfills, when completed, can be used for parks, golf courses, or reclaimed for other purposes.

A properly engineered landfill should be located on a site where rainwater, leaking through the refuse, will not pollute the groundwater, streams, lakes, or nearby land areas. Geologically satisfactory landfill sites are not easy to find and many cities are placing landfill sites in areas of convenience rather than areas that will prevent pollution of the area in the future. As good landfill sites near cities become filled, the waste will have to be transported greater distances at increased costs. This introduces new political problems because people in one locality seldom want to receive trash from another locality.

Incineration is a method increasingly being used in some metropolitan areas. This process is not to be confused with burning in an open pit. Incineration is a procedure for insuring complete combustion and a constant movement of trash into and out of the burning chamber. The ashes are removed by conveyor belt and cooled, the metals salvaged, and the remainder taken to a sanitary landfill. The heat produced in burning can be used by industry.

Some of the problems associated with this process are: (1) maintaining a constant furnace temperature for efficient operation while using a heterogeneous fuel mixture, (2) the maintenance of complete combusion, (3) the disposal of acidic gases, (4) the safe disposal of gases produced in burning of plastic (polyvinyl chloride - PVC), and (5) the pollution of the air because of incomplete combustion.

Incineration does have the following benefits: (1) it may help alleviate the energy crisis, (2) it reduces the volume of material by 80-90%, (3) it produces an inert and odorless residue, (4) it provides a relatively simple means to reclaim metals, and (5) it reduces the health problems associated with other disposal procedures.

Ocean dumping, practiced by many coastal cities, is becoming an increasingly unsatisfactory system for waste disposal. Aquatic dumping areas are almost devoid of life. This process disturbs the food web in the ocean. While this method of disposal removes the unsightly trash from land, it is polluting another part of our environment.

One of the most satisfactory ways of disposing of solid waste is by recycling. This process conserves both energy and materials. However, as ideal as this process seems to be, it is not so easy to carry out. Now everything is recyclable. Also, recycling centers need an enormous volume of material to operate economically. At present, the most efficient recycling operations are plants set up to recover metals from junked cars. Millions of cars are junked each year. Many of these cars are now being sent to recycling plants where the cars are shredded and the different metals separated mechanically for reuse. We should expect recycling plants to increase in the future even though such plants create pollution and consume valuable energy resources.

Recycling techniques include: (1) melting -- needed primarily for metals, glass, and some plastics, (2) revulcanizing -- needed to salvage rubber products, (3) pumping and converting to paper -- used to reclaim material containing natural cellulose fiber, (4) compacting -- recycling organic matter by decay organisms to make humus, (5) rendering -- cooking of animal waste to yield tallow to make soap or animal feed, (6) fermentation -- used with straw, sawdust, orchard prunings, and farm waste to make food for animals, and (7) industrial salvage -- recovery of waste materials to be reused in another product.

In concluding this lecture on solid wastes, it is a good idea to return to the ideas that were developed at the beginning of the lesson. We have enormous quantities of solid wastes that must be placed in disposal. For example, the U.S. junks over 7 million cars and buses yearly, 100 million tires are discarded annually (only about 30% are reclaimed), 30 million tons of paper, 4 million tons of plastic, 30 billion bottles, 60 billion cans, and uncounted millions of major appliances. The cost of collecting and disposing of solid wastes amounts to $4.5 billion annually and the amount is rising yearly. Clearly, our nation of affluence is burying itself in solid waste.

Section IV: Natural Resources

Lecture 6: Synthesis Lecture for Section IV: Natural Resources

In this lecture the intent is to focus the student's attention on the difficult choices man will have to make in learning how to live in a world that appears to be running out of everything. Experience has shown that students appreciate learning about ideas that encompass more than a "doomsday" approach. Therefore, I chose to emphasize basic facts -- what the real situation is -- and alternative procedures that hold promise for helping us solve our environmental problems related to the expanding use of our natural resources.

Assignment:

Barnett, Harold J. "The Myth of Our Vanishing Resources," The Survival Equation. Houghton-Mifflin Company, Boston, Massachusetts, 1971, pp. 180-186.

Ingram, Earl. "The Lemings are Coming," Phi Kappa Phi Journal, Spring, 1974, pp. 22-30.

McKetta, John J. "Has the World Gone to Hell?" Speech given at a Technological Awareness Meeting, May 22, 1974, at the Sabine River Works. (Unpublished speech as far as I know)

The economics of mineral exploration, extraction, processing of raw materials, and consumption of manufactured goods cannot be separated from the geological setting when discussing man's use of our natural resources. Whether we like it or not, our society and its institutions are directly concerned with the monetary cost involved in using our natural resources. We may not like the way economical considerations limit our use of natural resources but we must face up to these limitations.

For example, industry has no idea of society's value of how clean air or water ought to be. Society must set these limits. The problem is something like this: Society will set a limit on how much it will pay for meat or toothpaste, but it has not set limits on how much it will pay for clean air or the disposal of radioactive wastes. What happens when we don't know the cost of eliminating or reducing environmental pollution? What is the cost of eliminating wastes? These are hard questions to answer, but you can begin by deciding what environmental quality limits you are willing to set and what you are willing to pay.

One way to help organize a rational view of our natural resources is to consider the idea of "trade-offs." As the economists put it, "There is no such thing as a free lunch." We benefit by using our natural resources wisely, but there is a cost in some form of environmental quality in every case. If we remove raw materials from the earth, we must leave the earth in a different condition than it was before we started work. What "trade-offs" are you willing to make?

Consider for the moment our nonfuel mineral resources. Man will continue to extract raw materials from ever-poorer natural resources. As the grade of a mineral deposit decreases, the reserves increase, but production and processing costs increase. Energy demands increase as the grade of ore decreases -- cheap energy means cheap raw materials. What does the future hold when we accept the conditions mentioned above?

<u>Idea 1</u>: Man's demand for more raw materials will remain high and the variety of materials used will increase at a cost of environmental quality. The amount of environmental degradation will depend upon what limits society sets.

<u>Idea 2</u>: Man will learn to live with the problems of decreasing easy accessibility to raw materials by developing mineral policies that incorporate efficient relationships between demand, exploration, extraction, production, and consumption.

<u>Idea 3</u>: Conflicts of interest represent one of the best ways man has of communicating his aspirations and needs with others, and only through increasing intensities of political conflicts (short of war) can realistic environmental mineral policies for all be developed.

Let's change our point of view to another basic natural resource -- water. We learned that man's demand for water is increasing at a rapid rate and that the supply of water is sufficient on a large scale, but insufficient on a local or regional scale in many places. Furthermore, innovative technological schemes are available to make efficient use of water possible by industry, agriculture, and domestic users. What does the future hold for our water management procedures?

Idea 4: Water will be recycled more times in the future and water-supply management procedures will include new technological processes for making water use more efficient but at a higher cost.

Idea 5: Water distribution plans will be carried out to bring water from areas of surplus to areas that are water deficient. These distribution plans will cause environmental changes that are both positive and negative.

Idea 6: Our water problems of distrubution and water quality will be worked out in a series of short-term events that will ultimately be combined to provide a long-term solution.

With respect to our natural resource -- the soil -- man is faced with many serious problems. Soil is a natural resource that requires a long time to recover from environmental damage. The use of fertilizers is increasing rapidly and will continue into the forseeable future. New seeds and new kinds of plants provide temporary or "stop-gap" solutions to our food supply. However, with the rapid increase in population, food supplies will continue to be limited in many areas. What does the future hold for our soils and food supplies?

Idea 7: We should expect to see man use a greater proportion of the arable land and new seeds and plants will increase the total food supply. However, per capita consumption of food will depend upon man's ability to maintain a population of reasonable size. I cannot feel optimistic about our ability to prevent famines in many areas. Ehrlich's predictions have been and will continue to be correct.

Idea 8: Man's approach to maintaining productive soils will depend upon how he treats the basic causes of soil degradation -- his ignorance of the value of soil and his attitude toward maintaining this natural resource.

The problem of the proper disposal of all kinds of waste is a new kind of environmental problem that man is just beginning to recognize. Our studies verify that waste disposal problems are not something that will disappear in the near future. The per capita increase in waste and the increasing complexity of wastes that require disposal -- e.g., radioactive wastes -- poses a challenge to industry, agriculture, and residential users. We learned that our current waste disposal procedures are primitive and only short-term solutions. What does the future hold for the proper disposal of all kinds of waste?

Idea 9: Man will continue to use an increasing variety of short-term solutions for waste disposal problems -- e.g., biodegradable packaging.

Idea 10: The development of recycling processes will greatly expand and provide a stop-gap solution for disposal of many industrial, agricultural, and residential wastes.

Idea 11: The disposal of radioactive wastes is a serious problem that has no adequate solution in the forseeable future.

Idea 12: The variety of wastes -- e.g., plastics -- will increase and require new technological solutions that will be utilizing increasing forms of biodegradable materials.

In summary, this section has tried to take a "hard look" at a few of our major natural resources. There was no intent to cover the whole field of natural resources; rather, it was felt that an intensive look at our dependency upon natural resources would best fit the needs of this class. In some respects the ideas covered in this section provide students with a reasonably straightforward cause-and-effect relationship in our use of earth materials. For example, if we mine an ore certain predictable environmental effects will result. Therefore, I have tried to emphasize that we must attack the basic causes of environmental degradation, not just the symptoms.

Section V: Oceanography

Lecture 1: The Oceans

The major focus of this lecture is to introduce:

1) ideas that students will find helpful in organizing their thoughts about the oceans. For example, information about the size of the oceans, their origin, the effect of sunlight on living organisms, the distribution of life in the oceans, and the dependence of man on the oceans for food are suitable topics to include in this lecture.

2) ideas describing the physical resources of the ocean, including the resources found in seawater, on the ocean floor, and beneath the ocean floor.

3) information that will help students see the relation between man, oceans, and climate.

4) environmental considerations that are affecting man's relationship with the ocean.

In this lecture, I have purposely omitted specific examples that can be used to convey the ideas above. I feel the instructor can easily find examples that exemplify the ideas from his own background that will be better than the ones I might suggest. However, I have found the slides I recommend highly satisfactory, and I feel that your embellishment of the narration will best serve to make the lecture interesting and informative for your students.

Assignment

Read the following:

"Ocean Bottom Minerals," Ocean Industry, Volume 3, 1968, p. 61-73.

Slide of entire earth from space	This slide shows the contrast between the vast area of the oceans compared to the land. 71% of the surface area is ocean compared to 29% land. The average depth of the oceans is 2 1/2 miles and the ocean volume is about 350 million cubic miles.
Sketch of earth illustrating the opening of the oceans	This slide introduces the idea that the oceans as we know them today are a relatively recent geologic feature. A brief discussion of continental drift and seafloor spreading is appropriate.
Surface of the ocean showing sun glare	The sunlight supplies energy to the surface and the uppermost layer of the water. The distribution of this energy is important for living organisms. A brief comment about the penetration of sunlight is desirable. For example, 90% of the basic material that fuels and builds the life in the ocean is synthesized within the lighted surface layer of open water by the many varieties of phytoplankton.
Photo showing the distribution of living organisms within the ocean	We find that living organisms are distributed both vertically and horizontally in the ocean. This slide reinforces the idea that life is more abundant near the surface where sunlight penetrates is most effective.

Fishing vessel

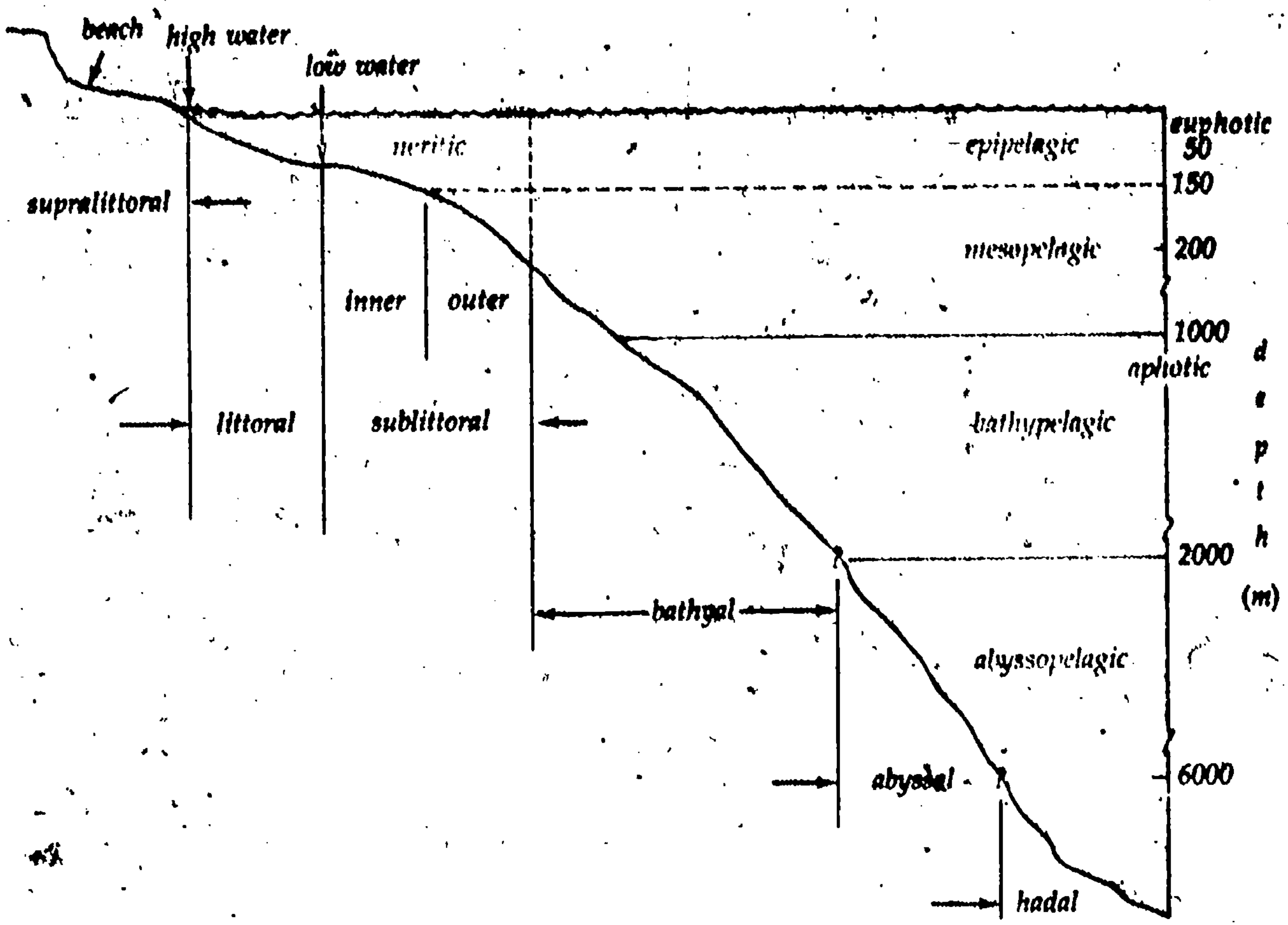
Both directly and indirectly, man is dependent upon the oceans for food. Anything that we do to interfere with the production of food from the ocean is disastrous for man. Consider for a moment the effect on man if our new chemicals were killing off the plankton in the oceans. Pollution of the oceans must be prevented at all costs.

Sketch showing upwelling

This slide illustrates that upwellings bring nutrients to the surface and most good fishing areas are associated with such upwellings. The cause of upwellings should be explained and locations of good fishing areas identified.

Configuration of the near continental ocean floor

Many of the physical resources of our earth are associated with continental margins. From this slide you should point out and identify the elements of the shore profile and the major divisions of the life zone of the sea. The sketch before could be used as an overhead transparency in place of this slide.



6-1 *Marine environmental zones.*

(Reference: Ingmanson, Dale E. and William J. Wallace. Oceanology: An Introduction. Wadsworth Publishing Company, Belmont, California, 1973, p. 218.)

Slide: "Man and the Ecosphere," from Scientific American, p.86-87, shows major fishing areas	This slide is excellent for showing the political implications of oceanic food resources. Fish catch is reported in millions of metric tons for the different oceans. Countries bordering the ocean are changing their boundaries to include more of this economic resource zone. As we expand our take of more resources -- oil and mining -- the political conflicts will increase between nations.
Slide: "Man and the Ecosphere," from Scientific American, p.92 shows the exploitation of fisheries	This interesting slide shows the location of the 30 major fish stocks taken from oceans and identifies those fish stocks that probably are fully exploited or in danger of being overfished.

Sketch of a cubic mile of seawater

What is the value of the elements found in a cubic mile of seawater that contains 165 million tons of dissolved matter -- mostly chlorine and sodium?

Chart showing the elements, minerals, and other materials found in seawater and on or beneath the ocean floor

Since early times man has depended on the ocean for food. Now he looks to the sea for other resources. Oil, gas, and sulfur are produced by offshore drilling; coal and iron ore from mines driven from dry land; heavy minerals -- tin, diamonds, and manganese by dredging; and fresh water, salt, manganesium, bromine, and other materials are obtained from seawater.

Slide of experimental living quarters from the aquanaut program

The search for new techniques to explore and live in the ocean environment has long been studied by man. New diving devices and specially designed vessels are being created and used by man to learn how to obtain the greatest benefit from the oceans.

Slide showing the surface circulation patterns of the oceans

The circulation of the ocean waters transfers heat energy across latitudes and make some places warmer or colder than they would be if such circulation did not occur. An explanation of ocean currents would be helpful at this point. The effect of ocean currents on climate and weather systems should be developed.

Slide showing the shoreline near Miami or Corpus Christi

In the final slide, or slides, for this lecture, it is worthwhile to show how man is modifying the shoreline to fit his desires. Dredging and filling in many areas has completely changed the nature of the shoreline in populated areas. Equally serious in the long run may be modifications man has made by damming up the streams that enter the ocean. Dams stop the movement of earth materials to the oceans. As a result, wave energy and currents are eroding areas that formerly seemed stable or in equilibrium. The long-term effects of man's modifications are not fully understood at this time.

In summary, we find that the oceans are:

1. a major source of food for many people
2. a receptacle for waste
3. a source of tidal and current energy
4. a medium for cheap transportation
5. a source for fossil fuels
6. a storehouse for dissolved materials and fresh water

While it cannot be denied that the ocean is a tremendous resource for many things that man needs, it must be pointed out that the concentrations of these materials is much less in seawater than in earth materials. To extract materials from seawater will be costly and inefficient. For example, to just move 1 cubic mile of seawater through an extraction plant would require 2.1 million gallons per minute for a year -- to remove the materials we wanted would require an additional amount of energy that is beyond comprehension.

Section V: Oceanography

Lecture 2: The Role of Man in Estuarine Processes

"Estuaries are places of dynamic interaction, where rivers meet the sea and deposit their wastes, where fluvial and oceanic processes interact -- a complex interface. The qualities of estuaries are of extreme importance to man because they also are foci of human interaction and settlement. Of the world's thirty-two largest cities, twenty-two border on estuaries, including the four largest -- Tokyo, Lonon, New York, and Shanghai."*

Imagine the problem as described in the New York Times, February 25, 1970: Sewage produced by New York City totals 1,300 million gallons a day, including 360 million gallons of raw sewage, producing a large polluted area 12 miles out to sea. Similar problems are found in Europe, and the continental shelf of France in the Mediterranean is a sterile stretch of black muck from the cities of Marseilles and Nice.

Assignment:

Read the following:

Cronin, L. Eugene. "The Role of Man in Estuarine Processes," Man's Impact on Environment, Thomas Detwyler, editor. McGraw-Hill Book Company, New York, 1971, pages 266-294.

---

* Cronin, L. Eugene. "The Role of Man in Estuarine Processes," Man's Impact on Environment, Thomas Detwyler, editor. McGraw-Hill Book Company, New York, 1971, p. 266.

What is the geologic setting? Estuaries are located at the mouths of rivers, are semi-enclosed, many are natural harbors, and they are ideal locations for disposal of waste products that can be carried by water. Estuaries usually have high flux and flush conditions that are advantageous for the disposal of great quantities of waste. In addition, estuaries are frequently natural transportation centers. Historically, estuaries primarily received only silt erosion prior to the 1850's. For the past 125 years, estuaries have had industrial, agricultural, and domestic waste added to the erosional load.

What are some of man's activities that affect an estuary?

1. Modification of river flow. Man's efforts to control rivers by dams reduces river flow and erosional load. Water taken from lakes behind these dams for irrigation and domestic consumption represents a diversion of river water from the estuary. Conversely, river flow can be increased by diversion of water into the river watershed and by man's activities modifying the watershed by denuding the land or covering it with asphalt to prevent infiltration.

Some of the environmental effects resulting from the modification of river flow are: (1) saltwater intrusion further upstream, (2) enlargement of the area of oxygen depletion, (3) both an increase and decrease in nutrient supply (depending upon the chemicals added to the water), (4) destruction of spawning areas for fish, (5) destruction of shellfish beds, and (6) increasing erosion of shorelines because of a decrease in sediment normally transported by longshore currents.

A number of studies have shown that modification of river flow by man can result in positive environmental effects. In Florida, the intermittent controlled release of fresh water has probably enhanced the fisheries by increasing nutrient supply. Also, bays with little flushing may develop higher productivity and more effective regeneration of nutrients. Clearly, the effects of regulated water flow can be both positive and negative and until man has a better understanding of the estuary ecosystem, some effects are speculative.

2. Thermal addition. The addition of warmer waters in estuaries causes profound changes in chemical and biological rates and processes. The dispersion processes for warm water in estuaries is not completely understood and thermal effects are different in estuaries where tidal flux contributes to mixing. In one study, it was found that warm water remained below cooler fresh water and above cooler salt water. The interplay of salinity and temperature on the density of water produced this effect. In general, the effects of thermal additives to estuaries produces more negative than positive environmental effects.

3. Changed salinity. In locations where estuaries have been closed off from the open sea and fresh water diverted into the area, vast changes in the ecosystem occurs. The Dutch completed such a conversion in 1932. Obviously, the saltwater communities were destroyed; however, the fresh fish production and the increase in pork production from reclaimed land more than trebled food production from that area.

4. Modification of basins. By dredging and filling, man has changed the flow patterns of many estuaries. The usual effects on the estuary are: (1) reduction in water area, (2) denudation of bottom as fill is removed, (3) modification of currents and tidal exchange, (4) alteration in salinity, temperature, and oxygen content of the water, and (5) sediment dispersion. The environmental results of dredging and filling are both positive and negative on the estuary ecosystem.

5. Chemical effects.

(a) Rachael Carson named those chemicals that affect living organisms "biocides." They destroy life and are appearing in estuaries in increasing amounts. If "biocides" in small quantities (below the toxic level) are introduced in the food chain, organisms at the upper end of the food chain are found to have quantities of the chemicals at a level many times greater than the level found in the surrounding water. A major effect of these chemicals is to inhibit growth of many organisms. In general, we should expect increasing damage to the estuary ecosystem as new chemicals and increasing amounts of regularly used chemicals are carried to the estuary.

(b) Nutrient chemicals containing nitrogen and phosphorous stimulate algal blooms in estuaries. A major source of these two elements is human sewage. Other chemicals that serve as nutrients are phosphates and nitrates. Algal bloom causes deoxygenation of the water and gives off undesirable odors.

(c) Radioactive wastes are found in higher concentrations in estuaries than in the oceans. Radioactive wastes are of concern because they may cycle and recycle until they enter human food supplies. These wastes also effect the genetic structure of aquatic organisms.

In concluding this lecture, I chose to end with a positive point of view. Experience has shown that it is easier to remember and use negative examples in describing environmental problems involving estuaries. Therefore, it is unfair to the student to provide only this point of view when there is a positive viewpoint to be developed. Consider the points below:

(1) estuaries by their nature resist change
(2) estuaries contain within themselves the mechanism for providing recovery by natural processes
(3) estuaries show great biological variation and are, therefore, easily degraded by waste
(4) chemical additives, intelligently used, could protect or enrich estuaries
(5) thermal waters produce many desirable effects and might be used to improve estuary conditions and habitats for living organisms
(6) diversity among living species provides the opportunity for man to develop new species that are beneficial for man
(7) efficient management of estuaries provides the opportunity to increase the benefits man acquires from estuaries.

Manipulation of the gross ecology of estuaries may ultimately result in improving this natural resource for the benefit of all men.

Section V: Oceanography

Lecture 3: Synthesis Lecture for the Course

Environmental Earth Science

In the final lecture, I prefer to review the major points that have been proposed for each synthesis lecture in the different sections of the course. Several reasons support the use of this approach. First, the major points developed in each synthesis lecture are broad in scope and refer to many different but specific ideas discussed in this course. Second, the major points were designed to be "anchor points" around which the subject ideas could be fixed. Third, the major points were designed to show the students what is fact -- what does the information we have studied say that is concrete, reasonable, and worthwhile to assess when we study environmental problems from the viewpoint of geologists?

The major points of each synthesis lecture are reproduced here for your study and consideration in designing a final lecture for this course. Slides and overhead transparencies used in teaching the course will be helpful in making the final lecture meaningful and complete for your students.

Major Ideas of the Synthesis Lectures

Section I: Man's Effect on Nature

1. Overemphasis on environmental degradation is not always helpful. We must learn to recognize and cultivate positive environmental values. Man has improved on nature as in some cases — e.g., introduction of different plants into new areas, introduction of animals in habitats that were void of these animals, improvement of food production by new kinds of plants.

2. The environments men create through their wants constitute to a very large extent the formula of life they transmit to succeeding generations. . . . . the characteristics of the environment condition young people and thereby determine the future of society.

Rene Dubos

3. The present trends of life in prosperous countries are usually assumed to represent what people want, but in reality the trends are determined by what is available for choice -- e.g., the kind of automobiles we can buy.

4. If we want to reduce the conflicts between man and nature, we must maintain a diversity of ideas, a full range of options so to speak, to insure that a wide range of possibilities exist among men. (Use selected slides from the AVT lesson on Population to illustrate this point.)

5. Environmental degradation has many causes, however, one primary cause is related to how man views the use of property. We must develop multiple uses for the land. (Use selected slides from the AVT lesson on Land Use Planning to illustrate this point.)

6. The concentration of large numbers of people in urban areas intensifies many environmental problems. We must learn to spread out the effects.

7. Environmental hazards are so subtle as to be beyond the individual's perception and control -- e.g., The Tragedy of the Commons. We must find out the true cost of our actions.

Section II: Energy

Idea #1: Energy sources, regardless of how you view them, have to be considered as finite at this time, and in the immediate foreseeable future. Operationally this means that any adjustments in our energy supply in the near future will be "stop-gap" in nature. Our study verifies that no new major sources of energy are available to replace the fossil fuels as fast as we use them. This does not rule out the possibility that some relief in energy supply will come about, however, per capita use of energy seems likely to increase as fast as man can develop new sources of energy. Obviously, demand for energy will continue to be boundless whereas energy supply will continue to be limited.

Idea #2: The application of technology to increase or simply maintain our current energy resources will increase the degradation of parts of our environment. The economists continue to emphasize "there is no such thing as a free lunch." Consider for a moment the development of our coal reserves in the West. Clearly, strip mining of coal will greatly degrade parts of our environment. There seems to be no choice in this matter, however, many safeguard procedures will be setup to help alleviate the worst aspects of the situation.

Idea #3: It is becoming increasingly evident that the problems and potential solutions associated with the use of energy touches the life of every individual. Our study of energy usage and the shortage of energy clearly demonstrates the impact that energy plays in our lives. A few years ago we listened to the television commercial that reminded us "that a nation that runs on energy cannot afford to run short." Now we know what that message was trying to convey. We are running short of certain kinds of fossil energy, and we are having to adjust our life styles in response to this problem. No one talks about cheap energy anymore and our recognition of this fact is reflected in what we do or plan to do in the future.

Idea #4: The lack of a national energy policy will continue to handicap us in solving energy problems now and in the future. In our study of Man's Effect on Nature, we learned about Hardin's idea of the "Tragedy of the Commons." This same concept can be applied to our thinking and actions relative to our use of energy. As long as we hold to the concept that "what belongs to all belongs to no one" we increase the probability of mismanagement.

Idea #5: Energy is the glue that holds our economy together. Any change in the nature of the glue sets off a chain of events that compounds man's environmental problems. We must recognize that our current social and business relationships depend primarily upon the widespread use of cheap petroleum and natural gas. As we shift from these forms of energy to coal, nuclear, and solar energy sources, political and business institutions will experience vast changes. Furthermore, our study supports that major new energy sources do not hold the promise that our environmental problems will be simpler in the future.

Idea #6: Our desire to take a short-range view of energy supply has greatly increased our technological dependence on fossil fuels--particularly petroleum and natural gas. Diversity in using all kinds of energy sources must become accepted as the normal operating procedure in the future. Chauncey Starr in the Scientific American article entitled "Energy and Power" summarized this point when he wrote, "The development of new speculative energy resources is an investment for the future, not a means of remedying the problems of today. It is equally clear that the qualify of life of the peoples of the world depends on the availability now of large amounts of low-cost energy in useful form. This being so, we must emphasize an orderly development of the resources available to us with present technology, and these are primarily power plants based on fossil fuels and nuclear fission."

This concludes the major points of the synthesis lecture. As the different ideas are developed during the lecture, many specific examples can be made to reinforce the implication of each idea. Specific examples can be taken from the audio-visual-tutorial programs, previous lectures, the readings and the discussion sessions. Experience has shown that your students will supply many of the examples that help to make this lecture meaningful.

Section IV: Natural Resources

Idea 1: Man's demand for more raw materials will remain high and the variety of materials used will increase at a cost of environmental quality. The amount of environmental degradation will depend upon what limits society sets.

Idea 2: Man will learn to live with the problems of decreasing easy accessibility to raw materials by developing mineral policies that incorporate efficient relationships between demand, exploration, extraction, production, and consumption.

Idea 3: Conflicts of interest represent one of the best ways man has of communicating his aspirations and needs with others, and only through increasing intensities of political conflicts (short of war) can realistic environmental mineral policies for all be developed.

Let's change our point of view to another basic natural resource -- water. We learned that man's demand for water is increasing at a rapid rate and that the supply of water is sufficient on a large scale, but insufficient on a local or regional scale in many places. Furthermore, innovative technological schemes are available to make efficient use of water possible by industry, agriculture, and domestic users. What does the future hold for our water management procedures?

Idea 4: Water will be recycled more times in the future and water-supply management procedures will include new technological processes for making water use more efficient but at a higher cost.

Idea 5: Water distribution plans will be carried out to bring water from areas of surplus to areas that are water deficient. These distribution plans will cause environmental changes that are both positive and negative.

Idea 6: Our water problems of distrubution and water quality will be worked out in a series of short-term events that will ultimately be combined to provide a long-term solution.

With respect to our natural resource -- the soil -- man is faced with many serious problems. Soil is a natural resource that requires a long time to recover from environmental damage. The use of fertilizers is increasing rapidly and will continue into the forseeable future. New seeds and new kinds of plants provide temporary or "stop-gap" solutions to our food supply. However, with the rapid increase in population, food supplies will continue to be limited in many areas. What does the future hold for our soils and food supplies?

Idea 7: We should expect to see man use a greater proportion of the arable land and new seeds and plants will increase the total food supply. However, per capita consumption of food will depend upon man's ability to maintain a population of reasonable size. I cannot feel optimistic about our ability to prevent famines in many areas. Ehrlich's predictions have been and will continue to be correct.

Idea 8: Man's approach to maintaining productive soils will depend upon how he treats the basic causes of soil degradation -- his ignorance of the value of soil and his attitude toward maintaining this natural resource.

The problem of the proper disposal of all kinds of waste is a new kind of environmental problem that man is just beginning to recognize. Our studies verify that waste disposal problems are not something that will disappear in the near future. The per capita increase in waste and the increasing complexity of wastes that require disposal -- e.g., radioactive wastes -- poses a challenge to industry, agriculture, and residential users. We learned that our current waste disposal procedures are primitive and only short-term solutions. What does the future hold for the proper disposal of all kinds of waste?

Idea 9: Man will continue to use an increasing variety of short-term solutions for waste disposal problems -- e.g., biodegradable packaging.

Idea 10: The development of recycling processes will greatly expand and provide a stop-gap solution for disposal of many industrial, agricultural, and residential wastes.

Idea 11: The disposal of radioactive wastes is a serious problem that has no adequate solution in the forseeable future.

Idea 12: The variety of wastes -- e.g., plastics -- will increase and require new technological solutions that will be utilizing increasing forms of biodegradable materials.

Section V: Oceanography

1. The trend of using the oceans for single-purpose uses motivated by short term advantages to individuals, industry, and local governments will continue into the forseeable future.

2. Political conflicts will increase over the ownership of ocean resources because of nationalistic desires and the realization of the value of ocean resources.

3. We should expect the pollution of the oceans to intensify near population centers and industrial complexes, as well as becoming more widespread through the work of natural processes.

Some Trends and Features of Man's Impact on the Environment*

Five major trends of man's recent impacts on the environment are:

1. increasing variety of impacts
2. intensification of impacts
3. geographical spreading of impacts
4. increasing complexity and repercussions of impacts
5. increasing per capita impact

Eight common features of man's alteration of environment are:

1. cities are modes of greatest environmental impact
2. many environmental changes are irreversible or persistent for long time periods
3. man is simplifying and homogenizing the biological landscape.
4. some organisms have greater power than man to adapt by evolution to environmental change.
5. man's unique ability to adapt culturally to environmental change may not be sufficient to compensate for new environmental demands on him as an organism
6. War or preparation for war is an important influence on environment
7. Political control has been required to develop and maintain major environmental modifications

* Detwyler, Thomas R. Man's Impact on the Environment, McGraw-Hill Book Company, New York, 1971, p. 695-697.

8. The same few basic causes of environmental degradation underlie a vast spectrum of impacts. These causes are:

   (a) ignorance
   (b) attitude
   (c) population growth
   (d) technological development
   (e) economics
   (f) synergism

If your students respond to this course in the same way my students responded, you will be pleased to see how well they understand and act relative to the basic causes of environmental degradation mentioned in Item #8 directly above.