DOCUMENT RESUME

ED 141 151 SE 022 673

| | |
|---|---|
| TITLE | Air and Life. A Learning Experience for Coastal and Cceanic Awareness Studies, No. 223. [Project COAST]. |
| INSTITUTION | Delaware Univ., Newark. Coll. of Education. |
| SPONS AGENCY | Office of Education (DHEW), Washington, D.C. |
| PUB DATE | 74 |
| NOTE | 26p.; For related documents, see SE 022 662-687 |
| EDRS PRICE | MF-$0.83 HC-$2.06 Plus Postage. |
| DESCRIPTORS | Biology; Environment; *Instructional Materials; *Oceanology; *Science Activities; Secondary Education; *Secondary School Science; *Units of Study |
| IDENTIFIERS | *Air; Project COAST |

ABSTRACT

The purpose of these activities is to offer the secondary school student an opportunity to review what he/she has learned about air by moving quickly through a series of "Do-it-yourself" experiments. Emphasis is placed on the study of the composition of air and relating this information to life in aquatic and marine environments. Included are classroom activities, a list of selected references, and transparency masters. (RH)

# AIR AND LIFE

A Learning Experience for
Coastal and Oceanic
Awareness Studies

Produced by

MARINE ENVIRONMENT CURRICULUM STUDY
MARINE ADVISORY SERVICE
UNIVERSITY OF DELAWARE

and

POPULATION-ENVIRONMENT CURRICULUM STUDY
COLLEGE OF EDUCATION
UNIVERSITY OF DELAWARE

as part of a

PLAN FOR ENVIRONMENTAL EDUCATION

Fall 1974

Please send evaluations

of learning experiences

to

Dr. Robert W. Stegner, Director

COAST Project

310 Willard Hall Education Building

University of Delaware

Newark, Delaware 19711

Supported in part by

OFFICE OF COASTAL ZONE MANAGEMENT(NOAA)

DELAWARE SEA GRANT COLLEGE PROGRAM(NOAA)

US OFFICE OF EDUCATION

OFFICE OF ENVIRONMENTAL EDUCATION HEW

POPULATION COUNCIL

CORDELIA SCAIFE MAY FOUNDATION

CHRISTIANA FOUNDATION

DEPARTMENT OF PUBLIC INSTRUCTION

DEL MOD SYSTEM

DUPONT EDUCATIONAL AID COMMITTEE

TITLE: AIR AND LIFE

* Concept: I.B.2.b.

I. The earth is a finite natural system.

B. All living things have arisen from and are dependent upon the natural system of the earth.

2. All life energy comes originally from the sun through photosynthesis.

b. ENERGY STORED IN FOODS IS RELEASED BY RESPIRATION.

** Marine Concept: 1.1; 1.2

1. An abundance of water make the earth unique in the solar system.

1.1 Water has a unique combination of chemical and physical properties.

1. An abundance of water makes the earth unique in the solar system.

1.2 WATER IN THE ENVIRONMENT CONTAINS A VARIETY OF SUBSTANCES IN SUSPENSION AND IN SOLUTION.

Grade Level: 7-10

Subject: Life Science, Biology

Periods: Various

Author: Snow

* From A Conceptual Scheme for Population-Environment Studies, 1973. Cost $2.50.

** From Marine Environment Proposed Conceptual Scheme, 1973. No charge.

Both conceptual schemes are available from Robert W. Stegner, Population-Environment Curriculum Study, 310 Willard Hall, University of Delaware, Newark, DE 19711.

R776

## Teacher Background

Small pre-school children have an uninhibited, innate ability to question perfectly "valid" answers. For instance, during a television program dealing with the atmosphere, a child may ask a parent; "Where does the air come from?" As the parent hesitates the child continues: "Why do we need air to live?" As the parent thinks of an answer: "Why did the candle go out when the man put the cover on the jar?" There appears to be no end to these questions.

Such questions are still in the minds of children, no matter what their age. However, as they grow older, they seem to acquire inhibitions which cause them to hold back questions. It is with this fact in mind that this lesson was prepared.

Before expanding on the learning activity it should be pointed out that the success or failure of the program will depend on the teacher's ingenuity and ability to stimulate discussion so that all ideas locked in the minds of the students come pouring forth uninhibited. No matter how trivial these ideas are, there must be some way in which the teacher can make them meaningful to the other members of a class. By doing this, each child will feel that he has made a worthwhile contribution and will be more inclined to take part in future discussion.

The purpose of the program is to offer the student an opportunity to review what he has learned about air by moving quickly through a series of "Do-it-yourself" experiments.

These experiments are designed so that several conclusions may result. Some of these will be valid, while some will not. Consequently, they should stimulate discussion and learning.

A second idea investigates the possible origin of atmospheric gases and utilizes methods of testing for their presence.

A third phase of the program utilizes that which has been reviewed and/or learned about air by direct application of the uses of these gases by living things.

The fourth phase is to study the needs of living things in the sea as they are related to the atmospheric needs of land plants and animals.

Finally, the study of the cause of air movements is related to heating of the air and the sea by the sun. This culminates in the idea of circulation of water with resultant movement of nutrients to resupply those needed to support life in the seas.

Many ideas have been purposely circumvented to retain the original purpose which was to study the composition of the air and relate its influence to life in aquatic and marine environment.

However, there is no doubt that some of these omitted ideas will be suggested by the students. This is the essence of self-learning.

The conclusions accompanying the lessons indicate possible student responses to the inquiries and experiments. If materials are prepared for student use the conclusions given should be deleted and space allowed for students to respond.

# The Composition of the Atmosphere Has Influenced Life in Aquatic and Marine Environments

**Classroom Activities:**

a. The air around planet Earth is necessary for life to exist.

Inquiry: If this air were suddenly taken away from us, what would happen to life on earth?
Inquiry: What is so important in the air that we need it to stay alive?
Experiment: Place a candle in the bottom of a pint jar. Light the candle. Screw the cap on the jar. Observe the flame.
Questions: 1. What happened? 2. Why did the candle go out? 3. Why didn't the candle go out right away?
Conclusions: A fire can be put out by shutting off its air supply. Air contains oxygen. Air is needed for things to burn. Oxygen is needed for things to burn.

b. There must be other things in the air besides oxygen.

Inquiry: How many of us have seen dew on the grass in the early morning before the sun evaporated it? How many of us have noticed water on the windshields of automobiles in the early morning?
Questions: 1. Where did this water come from? 2. Where does it disappear to later in the day?
Conclusion: Air must contain water.

Inquiry: But we can only see water when it rains or collects in puddles, pools, ponds, lakes, rivers or oceans.
Question: 1. Why can't we see water before it collects on automobiles and on grass during clear, cool, windless nights?
Conclusion: Water exists in the air as a gas known as water vapor.

c. Water vapor is given off by living things.

Inquiry: Have you ever watched anyone who wears glasses take them off and blow on them and then proceed to wipe them? Why do they blow their breath on the glasses?
Experiment: Blow your breath on the glass square provided. What do you notice on the glass? Blow your breath on the back of your hand. What do you notice in this case?
Conclusion: Man gives off water vapor.

Experiment: Place a large jar over a potted green plant. Leave it in the room for 24 hours. (Temperature should be fairly constant during this time.) Do you have any idea as to why controlling the temperature is important? Observe any changes that take place on the inside surface of the jar.
Question: 1. What changes did you observe?

Conclusion: Green plants give off water vapor.

d. Water vapor is given off when food is burned.

Inquiry: Have you ever very closely watched anything burn?
Experiment: Place about ½ teaspoon of sugar in a test tube. Clamp the test tube to a ring stand. Heat the test tube with a bunsen burner until all of the sugar is burned. Observe the action very carefully. Record your observations.
Questions: 1. What did you see before burning took place? 2. What did you see after burning took place? 3. What did you notice collecting on the inside of the test tube?
Conclusion: Water vapor is given off when sugar is burned. Water vapor is given off when food is burned.

e. There must be other things in air besides oxygen and water vapor.

Inquiry: So far we have learned that air contains oxygen and water vapor. We have also learned that oxygen is necessary in order for things to burn and that when things burn they give off water vapor.

Do you recall the candle burning experiment? The candle burned very nicely until we placed the cover on the jar. We agreed that the burning candle used up the oxygen in the jar.

If this is true, what replaced the oxygen in the jar? Let's do an experiment to see if we can find the answer to this question.

Experiment:

Materials: 1 clean large-mouth ½-pint jar with a cover
1 candle, 3/4" diameter
matches
bottle of freshly filtered limewater

Procedure: Place the candle in the bottom of the jar. Pour about ½" limewater into the jar. Light the candle and let burn until the flame is high. Screw the cover on the jar and observe. Without removing the cover, swirl the limewater for a minute or so. Note any changes in the color of the limewater.

Question: 1. What changes did you observe?
Conclusion: When a candle burns it gives off a substance that turns limewater milky. The substance given off combines with water.

f. Living things give off the same substance as that given off by a burning candle.

Inquiry: If a burning candle gives off a substance that causes limewater to turn milky, is it possible that living things may give off the same substance? Let's use ourselves as guinea pigs this time.

Experiment:

Materials: 3 soda straws
1 - 125 ml flask very dilute acid (.01M HCl)
1 - 125 ml flask of very dilute base (0.4M $Ca(OH)_2$)
1 - 125 ml flask tap water

Procedure: Using a separate straw for each blow your breath into: 1) tap water, 2) dilute acid, 3) limewater (base), for 10-15 seconds and observe the results.

Questions: 1. What did you observe in each case? 2. Did the three substances react differently? 3. Did any of them compare to the results of the candle burning experiment? Which one? 4. What was common to the two experiments?

Conclusion: Since limewater turns milky, your breath must contain the same substance that burning candles give off.

g. Air contains a substance that will turn limewater milky.

Inquiry: Based upon what we have learned so far, how could we find out whether or not air does contain a substance that will turn limewater milky?

Experiment:

Materials: 1 large flat clean glass dish or bowl
Freshly filtered limewater

Procedure: Pour about ½ inch of freshly filtered limewater into the glass dish and leave it overnight. Observe the color the next class period.

Questions: 1. Did the limewater turn milky? 2. If it did not turn milky, what explanation would be reasonable? 3. If it did turn milky, what conclusion would be reasonable?

Conclusion: Air must contain a substance similar to that given off by the burning candle and that given off by your breath.

Inquiry: The substance found in the air that causes limewater to change from a clear to a milky color is known as carbon dioxide. It is a combination of carbon and oxygen.

At this point, you should know a good test for the presence of carbon dioxide. What test would you use?

Where did the carbon dioxide come from?

Scientists tell us that the first carbon dioxide in air may have been part of the original atmosphere. There is also the possibility that it may have resulted from the rearrangement of atoms in the original atmosphere which was caused by the tremendous energy of the sun. However, today much of the carbon dioxide comes from the burning of organic materials (materials that contain both carbon and hydrogen) like the wax in candles, food eaten by animals, food used by plants, and the burning of fossil fuels such as oil, natural gas and gasoline.

Conclusion: Air should contain a very high percentage of carbon dioxide.

Inquiry: We have already determined that carbon dioxide is soluble in limewater. If you recall, we blew our breath directly into the limewater as well as into the plain tap water. Do you recall whether or not we tested the tap water for the presence of carbon dioxide? Should we do so? Have you any suggestions as to how we could accomplish such a test?

It is possible that everything that we have done to this point is correct; that we are correct in assuming that *if* limewater absorbs carbon dioxide, then water will also absorb this substance. However, assumptions are sometimes incorrect. Perhaps we can do an experiment to be sure that water does absorb carbon dioxide.

This time we will not use limewater. We will use an indicator known as phenolphthalein. This will indicate when the test is slightly basic by turning pink. Would bubbling your breath in water cause the water to become acid or basic? How could you tell using your knowledge about phenolphthalein?

Experiment:

Materials:
- 1 - 100 ml graduate
- 2 - 250 ml flasks or BOD bottles
- 2 straws
- 1 dropping bottle of phenolphthalein indicator
- 1 dropping bottle of .4M (NaOH), sodium hydroxide
- tap water

Procedure: Student A--obtain 100 ml of tap water in 250 ml flask.
Student B--rest quietly for five minutes.

Student A--
1. Add 5 drops of phenolphthalein to the sample of water.
2. Swirl the contents.
3. Place one drop of NaOH in sample and swirl.
4. Continue placing NaOH in sample and swirl after each drop is added.
5. When faint pink color appears and remains for at least 15 seconds after swirling, place this sample aside. (Do not destroy.)
6. Record the number of drops of NaOH used.

Student B--
1. Obtain 100 ml tap water in second 250 ml. flask. (Do not obtain the water before you are ready to proceed, as the sample needs to be fresh.)
2. Add 5 drops of phenolphthalein to the sample.
3. Bubble your breath through the second water sample for 10 seconds.
4. Proceed as in steps 3-6 as given for student A.

Questions: 1. Why was it necessary to prepare two samples? 2. How many drops of NaOH did it take to neutralize the carbon dioxide in your breath? 3. Are you quite sure that your answer is correct? 4. What conclusion would you make if the water immediately turned pink when the indicator was placed in it?

Conclusion: The substance given off by living things is carbon dioxide (from the previous experiment). Water absorbs carbon dioxide. The amount of carbon dioxide absorbed by water can be measured by the number of drops of NaOH it takes to neutralize the $CO_2$.

h. Carbon dioxide plays a major role in the life systems on the earth and in the seas.

Inquiry: Since most living things give off carbon dioxide and since the burning of all organic fuels gives off great quantities of carbon dioxide, why doesn't carbon dioxide appear in the air in much greater quantities than it does?

Much of the carbon dioxide produced by burning is used by green plants to make food. This process is known as <u>photosynthesis</u>. Examine Figures 1, 2, and 3 for information on the exchange of materials that take place during the process of <u>photosynthesis</u> and <u>respiration</u>. Can you tell from the diagrams which of the activities take place only during the daylight hours?

Conclusions: Green plants take in carbon dioxide during daylight.
Green plants give off oxygen during daylight.
Green plants give off carbon dioxide at night.
Green plants take in oxygen at night.
Photosynthesis is a natural process that tends to prevent too much carbon dioxide from collecting in the air and water.

Inquiry: Since we are particularly interested in the effect of atmosphere on aquatic and marine environments, let's experiment with life from one of these environments. What could we do that would show the effect of carbon dioxide on life in the aquatic or marine environment?

Before we start do you know what pH means?

Background Information: pH indicates (for lack of a better expression) hydrogen ion concentration. $H^+$ is the symbol. What is an ion?- an atom or molecule that has gained or lost an electron.

The excess or lack of hydrogen ions indicates how acidic or basic a solution is.

The scale may be represented as follows:

0 ________________________ 14

acid ⟵ 7 ⟶ base

$H^+$ ⟵ ⟶ $OH^-$

pH 7 = neutral--neither acidic nor basic
pH 1 = very highly acidic
pH 6 = slightly acidic
pH 8 = slightly basic
pH 13 = very basic

This is all you need to know at this time in order to use the term pH in your work.

pH test paper will change color according to the scale above.. A color chart is provided to compare colors and determine relative pH of solutions. Warning! You should check the comparator chart while your test paper is still wet.

Experiment:

Materials: small (1-2 quart) fish bowl
bowl
straws
1 goldfish or guppy (any fish will do) that has been kept in a well-aerated aquarium overnight.
pH test paper 1-12 with color chart.

Procedure: Student A--Record the number of gill beats per minute of the fish. Record the pH.

Student B--Bubble your breath through the water containing the fish, for one minute.

Student A--Record the number of gill beats again.
Record the pH.
Bubble your breath through the water for one minute.

Student B--Record the number of gill beats.
Record the pH.

Continue this procedure of alternately bubbling and recording the number of gill beats and pH for a total of ten minutes. Graph the results placing time along the horizontal axis and gill beats on the vertical axis. Project the graph to 30 minutes.

Questions: 1. What happened? 2. Did the fish become more active? 3. Did you notice any change in behavior of the fish? 4. What would you say would be the gill beat rate per minute at the end of thirty minutes? 5. Would the fish ultimately die because of the presence of a high concentration of $CO_2$?

Conclusion: The more carbon dioxide in water, the faster fish work their gills.

j. $O_2$ plays a major role in the life systems on earth.

Inquiry: Since most living things on earth require oxygen for their energy needs, it would seem proper to think that the supply of oxygen would decrease over the years. What evidence do we have that the oxygen supply is not decreasing? (Review the diagram of photosynthesis Figure 1).

Inquiry: We are aware of the means by which land plants and some floating plants in watery environments exchange gases with the atmosphere. But what about sea plants that are constantly covered with water? How do they obtain carbon dioxide and release oxygen or vice versa?

Experiment:

Materials:
- 1 small aquarium or battery jar
- 1 large glass funnel
- Splints
- 1 test tube, 18x150mm
- 1 desk lamp with 150 volt light bulb
- 1 ring stand and clamp
- 4 or 5 fresh, healthy springs of _Elodea_

Procedure: Place several sprigs of _Elodea_ under the funnel as it is placed in the aquarium or battery jar. Invert the test tube, filled with water, over the funnel. Use the ring stand and clamp to hold the test tube in place over the funnel. The gooseneck lamp should be placed approximately 1½ to 2 feet from the aquarium and should be left turned on for 24 hours. The lamp can be left on for a longer period of time, if desired.

At the end of the time period remove the test tube, being careful to prevent the gas from escaping. Test the gas collected with a glowing splint. If splint glows brightly or flares, the substance is oxygen.

Questions: Where did the oxygen come from? 2. Where did the carbon dioxide that was required for the photosynthetic reaction to take place come from? 3. How did the $CO_2$ get into the plant? 4. What is the process?

Inquiry: We are also aware of the manner in which air breathers such as ourselves use oxygen for burning food to provide energy for our bodies. But what do we know about the manner in which animals in the sea environment obtain their oxygen? We must consider that there are very tiny one-celled animals that use oxygen as well as several multicellular invertebrates.

Inquiry: Do you think the amount (percentage) of $O_2$ in the atmosphere will increase over the next million years if present life systems continue to function as they do now?

Background Information: Sea water contains dissolved $O_2$, $N_2$ and $CO_2$ (present as carbonic acid, carbonates, and bicarbonates) absorbed from the atmosphere.

Even though the amount of air absorbed by sea organisms is very small, it is important that the oxygen content in the air absorbed by sea organisms (particularly fish, which breathe through gills) is higher than the oxygen content of the atmosphere. At the surface, one liter of sea water of 35 % salinity and at a temperature of 50° F, normally contains 18.7 cc of gas, of which 6.4 cc is oxygen, 12.0 cc is nitrogen, and 0.3 cc is carbonic acid (carbon dioxide dissolved in water). The 6.4 cc of oxygen comprises 34% of the absorbed air, whereas oxygen comprises only 21% of the atmosphere.

Consequently, the percentage of oxygen from absorbed air in water is actually higher by volume than the percentage of oxygen in air.

Since the great majority of the world's food supply is in the oceans of the world, it is reasonable to assume that more oxygen by volume would be necessary to sustain the energy requirements of living things in the seas.

In Figure 3 note that where respiration takes place, (it must take place all the time), oxygen is taken in by the photosynthetic plant and carbon dioxide is given off. We might write an equation for this reaction. It could be as follows:

$$(CH_2O) + O_2 + H_2O \rightleftarrows CO_2 + 2H_2O$$

It has been determined that for each oxygen molecule ($O_2$) utilized in plant respiration one carbon dioxide molecule ($CO_2$) is released. The same ratio of these substances applies to animal respiration also.

Now let's consider the process of photosynthesis. Carbon dioxide is combined with hydrogen from a water molecule to form a carbohydrate with oxygen as a by-product which is released to the air. Almost all of the oxygen now available in the atmosphere came from the process of photosynthesis carried on by green plants and other organisms containing photosynthetic pigments.

What conclusions might we draw from this information?

Conclusion: Photosynthesis provides excess oxygen to the atmosphere. Respiration assures a relatively constant exchange of carbon dioxide and oxygen between living things and their environment.

Inquiry: If these conclusions are valid, it would appear that the earth is accumulating more oxygen every day. Why then has the relative percentage of oxygen remained at about 21% of the total atmosphere over the years?

k. Water plays a major role in the life systems on earth. Use Figure 4.

Inquiry: Water covers about 71% of the earth's surface. Where did this water come from?

Water is necessary to sustain all life on earth. Water vapor is given off by most living things when they burn food or respire in order to gain energy to carry on the activities of life. If this is true, then there should be a large percentage of water vapor as part of the total air. Defend or disagree with this hypothesis.

Discuss the terms <u>evaporation</u>, <u>condensation</u>, and <u>precipitation</u>. Of what significance are they to life systems in the oceans?

Inquiry: The component parts of air that are of particular interest to the marine environment are oxygen, carbon dioxide, and water. There is a constant water change between these gases in the air and the seas. When there is an excess of oxygen in the air and not enough in the oceans, it will flow (be absorbed) into the oceans and vice versa. The same is true of carbon dioxide. By what process do these gases move from air to sea or from sea to air?

Inquiry: Water vapor is also a component of air but is only retained at a level of less than 1% of the total volume of the air. Yet there appears to be a great amount of water vapor. How does most of the water vapor get into the air? Where does it come from? Why does it continually leave the atmosphere as rain?

(When water is evaporated from the seas tiny particles of salt are carried with it and the water tends to condense around these particles until they are so heavy that they fall to earth.)

Conclusion: The marine environment is kept in dynamic equilibrium by the action of atmospheric movement. This movement restores oxygen needed by animal life in the seas and carbon dioxide required by plant life in the seas. In addition the air removes these gases when they are in over supply.

In the seas, the evaporation of water assures that the seas will receive fresh supplies of water and enhances mixing of the materials of sea water which are required by living things.

l. The air-sea interface affects the composition of the marine environment. Use Figure 5.

Inquiry: The interactions between the ocean and the air are very complex and take place through a vertical distance of 1.0 mm from the surface of the ocean. How long is one millimeter?

Before we can discuss these reactions, we should refer to the heating effect of the sun upon the sea and air.

The sun heats air more at the equator than it does at the poles. This results in a density difference between these two areas of the world. What is meant by density?

Inquiry: The sun also heats the seas more at the equator than it does at the other latitudes. Air passing over the warm water absorbs heat as well as water vapor and to a lesser degree other components of the atmosphere. This absorption creates a low pressure area. Cooler air in the arctic zones, which are high pressure areas, moves toward the low pressure areas nearer the equator, creating winds.

Conclusion: The heat from the sun causes air to move and creates winds. How many of you have noticed that during the day air masses move from sea to land? This is because the sea heats slowly and the land heats quickly, causing air to move from cooler to warmer areas. At night the land mass cools quickly but the sea temperature does not change much so that air moves from cooler land to warmer seas. What physical principle is involved here?

Inquiry: Wind produces two main types of circulation in the oceans. From your own experience can you name or explain one of these types?

Wind-driven is the strongest type of ocean circulation. However, its effect is limited to the upper 1000 meters of the marine environment. Can you think of any reason why this is so?

Background Information: Circulation in the ocean is dependent on wind and heating. When the wind blows over the oceans, it absorbs warmer air. This air is displaced by cooler more dense air. As this warm air rises and moves northward, it becomes cooled at higher elevations and latitudes and circulates downward again to complete a cycle.

The wind moving over the wide expanse of ocean creates waves which weaken the surface tension of the water and make it easier for the exchange of gases between the atmosphere and the sea to take place.

The second type of circulation of the seas is also due to wind. It is known as thermohaline or density circulation. It occurs only in deeper waters and usually when the wind is blowing from the shore. One of the most prominent ocean circulations of this type occurs off the coast of Peru.

Offshore wind blows warm water seaward piling up the water in front of it, thus causing pressure-density variations. The piled-up water is then replaced by colder deeper water which brings fresh nutrients with it. This is known as an upwelling or vertical wave.

Conclusion: Upwelling caused indirectly by wind results in replenishment of nutrients for life in the seas.

Wave action produced by wind serves as a means of transfer or exchange of gases between the sea and the atmosphere.

# BIBLIOGRAPHY


## A. Books

Biological Sciences Curriculum Study. 1970. Biological Science: Patterns and Processes, (Teachers' Edition). Holt, Rinehart and Winston, Inc. New York.

Biological Sciences Curriculum Study. 1966. Green Version: High School Biology. Rand McNally & Co. Chicago.

Carlson, J., V. Johnson and H. Cavert. 1962. The Machinery of the Body. University of Chicago Press. Chicago, Illinois.

Muller, W. H. 1969. Botany: A Functional Approach. The Macmillan Co. New York.

Ross, D. A. 1970. Introduction to Oceanography. Appleton-Century-Crofts. New York.

Schwab, J. J. (Supervisor). 1963. Biology Teacher's Handbook. John Wiley & Sons, Inc. New York.

## B. Periodical Articles

Stewart, R. H. 1969. The Atmosphere and the Oceans. Scientific American, Vol. 221, 3:76-86, September.

## C. Technical Bulletins

Moberg, E. G., et. al. 1934. Bulletin of the Scripps Institution of Oceanography of the University of California. Technical Series Vol. 3, 11:231-278, University of California Press, Berkeley, California.

## D. Encyclopedias

Encyclopedia Brittanica. Vol. 16. 1948. The Encyclopedia Inc. Chicago. p. 687b.

Young Peoples Science Encyclopedia, Vol. I. 1963. Childrens Press Inc. Chicago. p. 46.

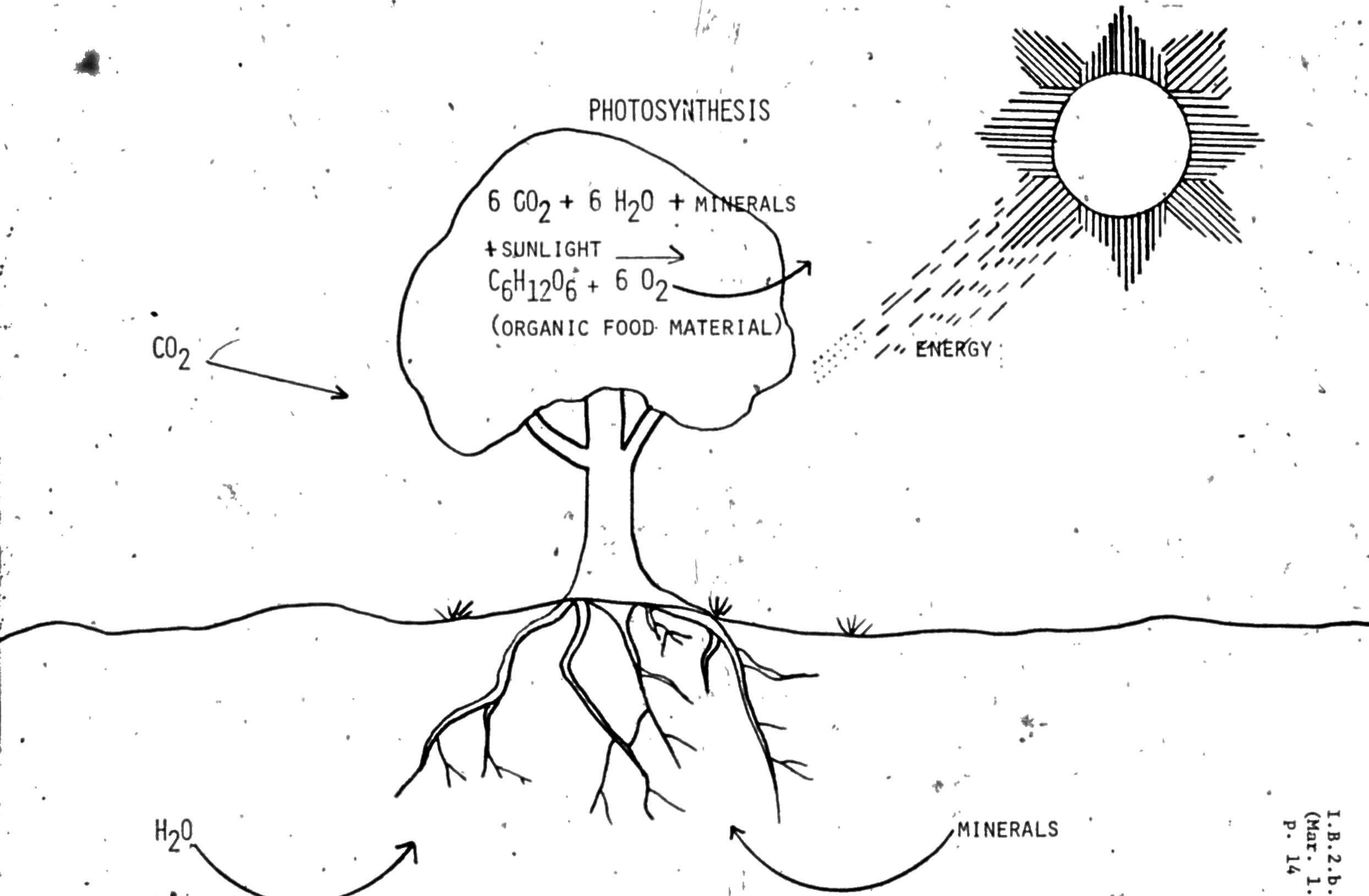
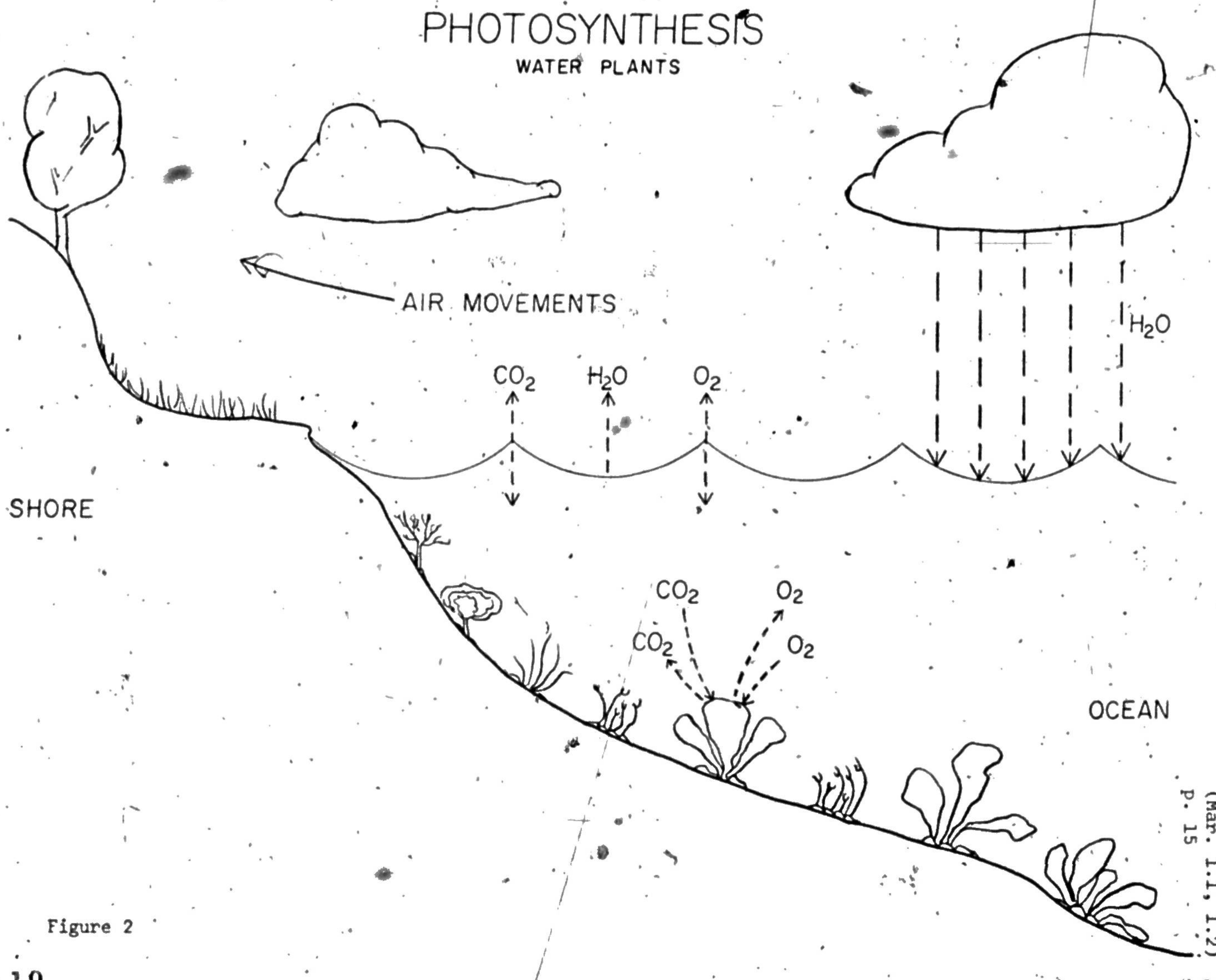



Figure 1

I.B.2.b.
(Mar. 1.1, 1.2)
p. 14




I.B.2.b.
(Mar. 1.1, 1.2)
p. 15

Figure 2

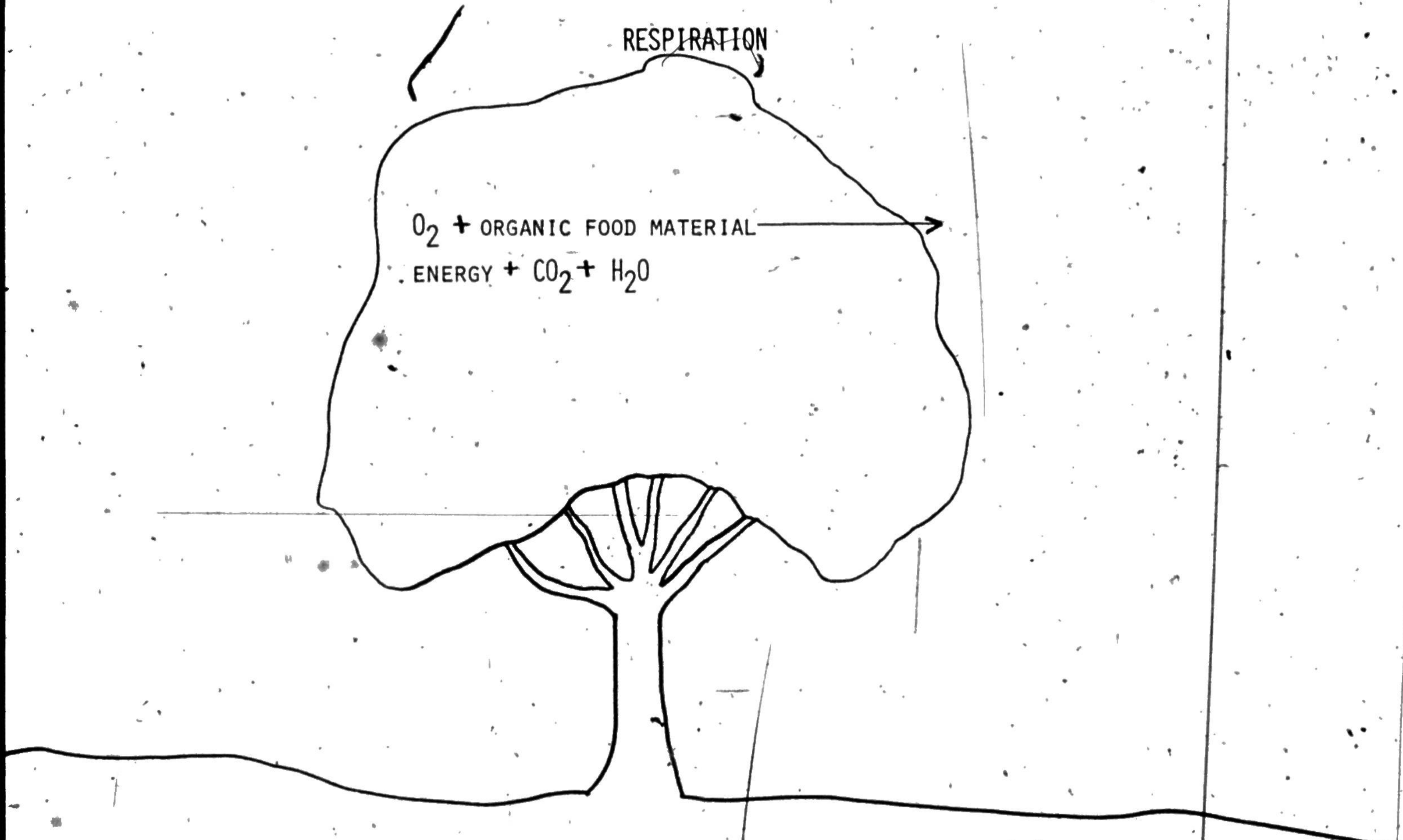
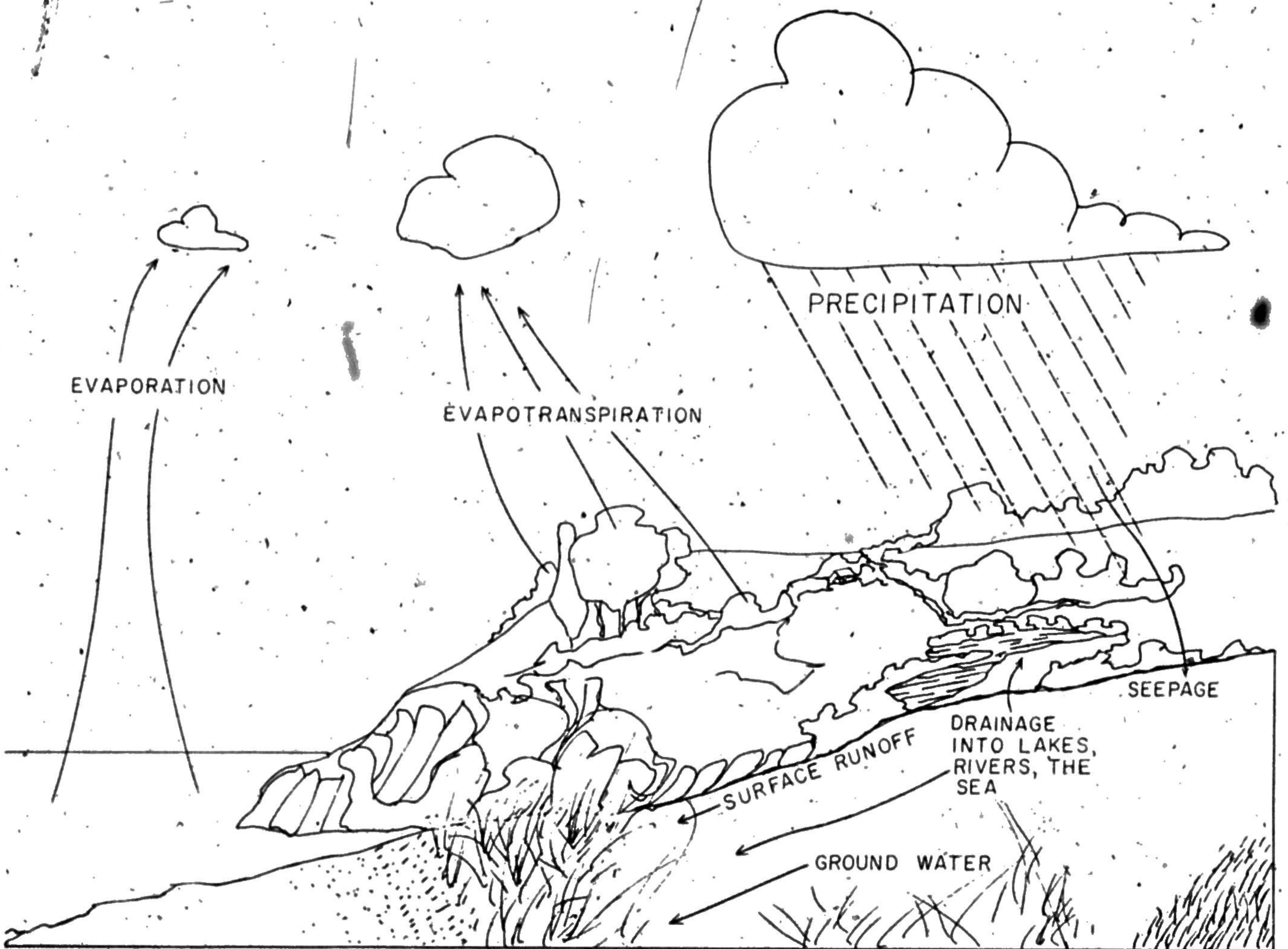



Figure 3




THE HYDROLOGIC CYCLE

I.B.2.b.
(Mar. 1.1, 1.2)
p. 17

Figure 4

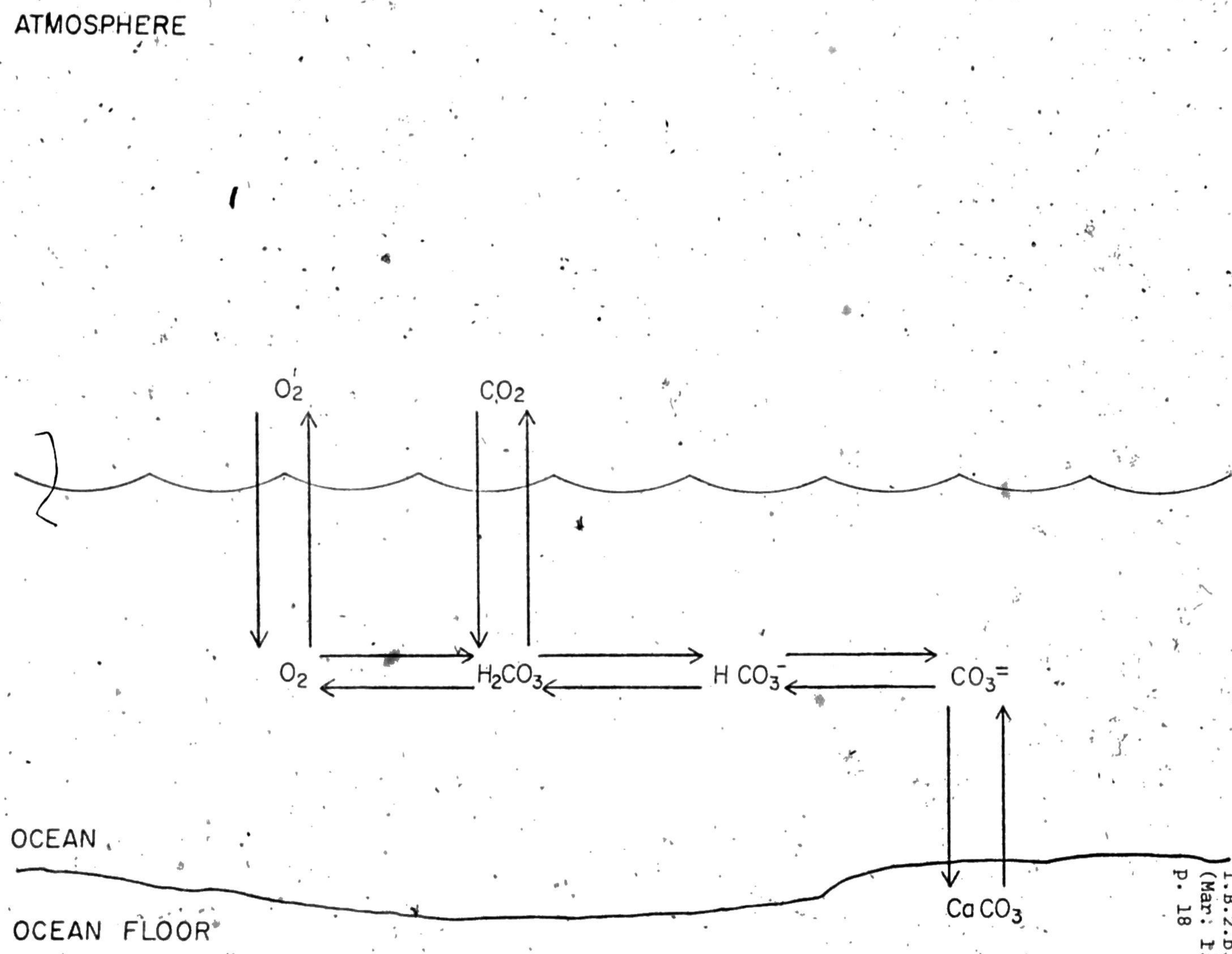



Figure 5

I.B.2.b.
(Mar: I.1, 1.2)
p. 18