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ABSTRACT

This report is a detailed analysis of 15 ecology kits and/or games. The analysis points out assets and defects of the kits/games and indicates questions and comments which may be helpful in putting the curriculum materials in perspective. Entries are arranged according to elementary or secondary schools. Information about the ecology kits includes contents, additional equipment needed but not supplied, experiments described, and concluding evaluative comments. An abstract of each game appears with concluding remarks. A school price list of games and kits available from Urban Systems, Inc. is appended. (LK)

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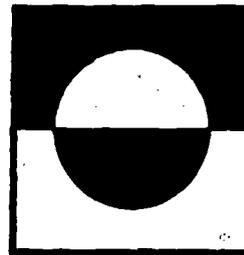
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# ENVIRONMENTAL GAMES

AN ANALYSIS

PREPARED BY  
CAROL HARMAN

Second Edition  
September 1971



VERMONT ENVIRONMENTAL CENTER

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## PREFACE

The following pages discuss some of the games and kits that have recently become available for use in elementary and secondary schools to transmit information on our environment.

The report was prepared by Miss Carol Harman of Goddard College while attending a course in Contemporary Human Ecology given at the Vermont Environmental Center during January-February, 1971. The report has been edited to some extent but Miss Harman's opinions and conclusions have not been altered.

## GAMES REVIEWED

### APPROPRIATE FOR ELEMENTARY SCHOOLS

#### Ecology Kits:

No. 1	<i>Why Are Leaves Green?</i> Urban Systems	3
No. 3	<i>Predator Prey</i> Urban Systems	5
No. 4	<i>What Moves Life</i> Urban Systems	6

#### Games:

	<i>Man In His Environment</i> Coca-Cola	11
	<i>Superhighway - A Simulation Game</i>	13

### APPROPRIATE FOR SECONDARY SCHOOLS

#### Ecology Kits:

No. 2	<i>Life in the Water</i> Urban Systems	4
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#### Games:

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	<i>Man In His Environment</i> Coca-Cola	11
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## INTRODUCTION

We learn in many ways. Parents, teachers, educators and psychologists are just beginning to piece together some understanding of the mechanisms of learning. In the midst of conflicting theories and competing practitioners, instructional materials have blossomed in a profusion of styles. At the same time, the cry for "relevance" has brought out a variety of approaches to education via current issues.

Many people are now concerned about the environment. High schools are offering seminars or full course studies. Some school systems have decided to "innovate" with supplementary materials at some or all grade levels. A few are ambitiously plunging into the development of totally new curricula where all "subjects" interlock, and the interrelatedness not only of all learning, but of all human activity and all life on earth is emphasized.

Most communities are limited to the first two approaches. For this almost-instant market, publishers (especially those already in the textbook-learning aids group) have jumped to provide a wide range of materials. Conscientious teachers and parents, looking for ways to teach themselves and their kids the fundamental principles and implications of ecology, turn with relief to a new array of kits and games designed to make this process fun and easy. It can be fun. It is rarely easy. Many of these aids can be very helpful if used in a wider context of information and discussion. They do not create instant experts, but they can contribute greatly to a layman's comprehension of the eco-crisis. They can be a good focal point and motivational tool, but, like all other curriculum materials, they should be critically examined and supplemented. Whenever possible, students should be encouraged to participate in this evaluation.

[Maybe the most vital skill to be learned in youth or acquired in adulthood is the process of careful, critical thinking, and the most vital knowledge an internal perception of self, the human family, and the environment which sustains us.]

The following pages contain an analysis of several of these kits and games pointing out their assets and defects, and indicating questions and comments which may be helpful in putting the materials in perspective.

## ECOLOGY KITS

Urban Systems, Inc., a Cambridge, Massachusetts, firm distributes five "Ecology Kits." Each attempts to provide one way of introducing the public to the complexities of environmental problems. They differ in quality, and it is difficult to generalize about their content. A few comments, however, are applicable to the group as a whole:

- 1) There are, unfortunately, no distinct indications of the age levels for which these kits are appropriate. Kits #1, 3 and 4 seem more appropriate for elementary grades; kits #2 and 5 might be of high school caliber.
- 2) The price of the kits (\$6.00 each) seems disproportionate to the value of their contents. Components of most kits can be purchased individually. However, it would be necessary to purchase at least one kit to obtain the instruction booklet unless the teacher had an alternative source for obtaining information.
- 3) The blurb advertizing is antithetical to the nature of the subject: "...makes anyone an expert on [plants, water, population] and the environment." What we don't need is more self-proclaimed experts. We do need an aware and informed public.
- 4) The packaging is a clear example of conspicuous waste; the booklet format, for example, wastes about one half of the page area. Further, the molded plastic display tray in each kit ranges the wares for viewing above the empty interior of the box. In the environmental field, particularly, the moral suasion of example is a strong factor in public education and acceptance.
- 5) The kits would require substantial supplemental information and discussion by parents and teachers to avoid false impressions being generated.

In spite of these criticisms, each Kit should be considered separately on the basis of the particular purpose which the buyer is attempting to achieve. In some learning situations the kits are quite useful.

Kit No. 1 Why Are Leaves Green?

Contents

The box size is 8-1/2"x 8-1/2"x 4". The maximum size required to hold the contents provided is 7"x7"x2".

4 plastic vials  
20 dried peas  
small handful of dried red algae  
1 1" x 1" diffraction grating  
1 60-70 ml. bottle ethyl alcohol  
2 2" x 4" chromatograph papers  
1 eyedropper  
6 wooden applicator sticks

Additional Equipment Needed But Not Supplied

Elodea (an aquatic plant)  
a glass  
scissors  
baking soda  
light source  
bread  
detergent

Experiments Described

Light and dark growing  
Chromatography  
Oxygen production  
Light and non-green plants

This group of experiments is essentially an old game with a new name. It used to be "General Biology - Plant Life - Chapter 1;" now it's "Ecology - Chapter 1." Admittedly, the emphasis on "interactions with other parts of the environment" is new, but most texts less than ten years old deal with these investigations quite adequately even at grade school levels.

At home, some extra parental time would be necessary to expose and discuss the somewhat careless scientific method. For example, one experiment is designed to reveal that during photosynthesis, plants produce oxygen. Elodea, in its aquatic habitat, is exposed to a concentrated light source, and bubbles are seen to rise from the stem ends. Conclusion: light induces photosynthesis which produces oxygen. How do we know the gas is oxygen? How

do we know there were not air pockets in the stem which released trapped atmospheric air (as it expanded in the warmth of the light)? The conclusion is hastily drawn.

Furthermore, the booklet is careful to discuss the concept of a "control" in scientific experiments. When testing for the effect of a particular factor (i.e., light), one should test the differences between subjects in the presence, absence, and varying degrees of that factor. It makes no mention that one must be careful that all other factors (temperature, moisture, air, soil, etc.) must be the same. This is the key to a control situation. Several of the other booklets are careless (as is this one) about the degree to which conclusions are justified by the experiments.

In summary, this kit is a starting point for these investigations, but not a very good one. Most of the experiments are conducted in elementary school science classes and/or can be easily done with home supplies, a modicum of parental support, and an age-appropriate library book.

#### Kit No. 2 *Life in the Water*

##### Contents

The box size is 8-1/2" x 8-1/2" x 4". The maximum size required to hold the contents provided is 7" x 5" x 2".

- 1 small vial powdered algae
- 1 small vial nutrients
- 1 small plastic jar
- 4 plastic straws
- 2 large rubber bands
- 1 plankton net
- 3 6" x 8" plastic bags
- 1 8" diameter secchi disc

##### Additional Equipment Needed But Not Supplied

- 1 quart container
- paper clips
- scissors
- 1 glass
- 1 fluorescent desk lamp

## Experiments Described

Growth of algae in nutrient solution  
Secchi disc light penetration measure (This and other observations noted require a local pond, reservoir or lake.)

The booklet does a reasonable job of describing water's physical characteristics, the effects of these properties on bodies of water, and the plants and animals who live there in their variety of interrelations. Especially notable is the description of the seasonal cycling of nutrients in temperate zone lakes and large ponds, and (by differing mechanisms) in oceans and other bodies of water. The process of eutrophication is also well described. These are aspects of aquatic systems which have not been adequately communicated to the public until recently.

This booklet also seems less guilty of scientific sloppiness. Considering that the secchi disc and plankton net may be relatively hard to get elsewhere (for less than the price of the kit), it might be worthwhile to purchase for the budding do-it-yourself-at-home scientist.\* One kit would also be sufficient for classroom use.

### Kit No. 3 *Predator - Prey*

#### Contents

The box size is 8-1/2"x 8-1/2"x 4". The maximum size required to hold the contents provided is 6" x 6" x 3/4".

Cardboard squares of varying colors and sizes indicating predators and prey:

1 yellow - 4" x 4" (wolf or lynx)  
2 red - 3" x 3" (wolf)  
40 gray 1-7/8" x 1-7/8" (squirrels)  
300 white 3/4" x 3/4" (rabbits or mice)

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\* [Ed. note: A secchi disc can be constructed in a home or school shop with little difficulty. All that is required is a disc about 10" in diameter with alternating quarters of black and white. A heavy bolt, inserted through the center provides sufficient weight. A cord with feet or meters indicated on it is attached to the bolt.]

1 6" ruler  
graph paper

### Simulations

One predator and one prey  
One predator and two prey  
Two predators and one prey  
Varying birth rates of predator and prey to see  
effects on population size  
Competition between predators  
Population sampling  
Natural selection

This is the most blatant use of unnecessary packaging that I've seen in a long time. Excluding the box itself, excess cardboard packaging to hold the cardboard squares totals 1,447 square inches. (Total area of the squares is only 544 square inches.) Add to that the fact that the "pieces" used to indicate various animals in the simulations could be easily made by kids, and probably could bear designs showing what kind of animal is represented. (They should be cut to above sizes so the mathematical space and odds calculations will roughly approximate population relations.) The booklet describes several simulations in which a predator (large square) "chases" his prey (by being tossed into the populated area; he "catches" prey by landing on them). The odds have apparently been worked out so that population curves, under conditions of "litter size" and "food requirements," will simulate natural fluctuations. Commentary in the booklet helps to bring the simulations into perspective, but the exercises themselves are rather dull to perform over the number of "generations" necessary to reveal a general pattern. The most helpful element of the booklet is its comments on how populations are studied and measured in the field.

### Kit No. 4 *What Moves Life*

#### Contents

The box size is 8-1/2" x 8-1/2" x 4". The maximum size required to hold the contents provided is 8" x 5" x 2".

4 medium vials  
25 beans  
20 peas

eyedropper  
thermometer  
small vial of nutrients  
6 wooden applicator sticks  
live shrimp "hatchpack"

#### Additional Equipment Needed But Not Supplied

saucers  
desk lamp  
quart jar  
yeast  
small jar  
paper  
scissors  
glasses  
cardboard  
aluminum foil  
string

#### Experiments Described

Reaction to light (Phototropism)  
Reaction to gravity (Geotropism)  
Reaction to temperature (Thermotropism)  
Reaction to moisture (Hydrotropism)  
Reactions to Physical objects (Stereotropism)

This kit has a good selection of types of experiments, and covers the question "What Moves Life?" in quite adequate summary; but it involves some of the sloppier work on experiments and their interpretation. Experiments on photo-, geo- and thermotropism do not incorporate sufficient control factors (as they are written) to justify the conclusions that are reached. Careful editing of scientific content could tighten it up into a good handbook. Most of these experiments can be gleaned from an elementary biology text or an age-specific library volume, and materials are easily available at home or in local stores. For these reasons I would not recommend purchase of the kit unless and until it is revised.

**Kit No. 5 *Life From Death***

**Contents**

The box size is 8-1/2" x 8-1/2" x 4". The maximum size required to hold the contents provided is 8-1/2" x 8-1/2" x 2".

30 dried peas  
1 medium vial of clay  
1 medium vial of sand  
1 medium vial of milorganite  
1 large vial of mulch  
1 100 ml. bottle of CaOH (Calcium hydroxide)  
1 50 ml. bottle of methylene blue concentrate  
3 small vials  
eyedropper  
plastic straws  
capillary tubes  
nutrients  
hydrion paper

**Additional Equipment Needed But Not Supplied**

Glasses  
foil  
baking soda  
light source  
scissors  
saucer  
quart jar  
tissue paper  
local soil

**Experiments Described**

Soil properties:  
    water retention  
    retention of nutrients  
    pH  
making soil  
Ca(OH)<sub>2</sub> + CO<sub>2</sub>  
Elodea producing oxygen  
Capillary action

This is one of the better kits in the set. There are a few weak points (again, insufficient support for experimental conclusions) in descriptions of the Ca(OH)<sub>2</sub> + CO<sub>2</sub>, and the elodea experiment lifted from Kit No. 1. These are greatly compensated for, however, by the fine treatment

of natural nutrient recycling, the formation, structure, characteristics and purpose of soil, relations of soil properties and vegetation, effects of poor sewage treatment, and suggestions for better handling of waste products, especially sewage.

It is more informational and concise, a better presentation of the chief elements of death-to-life mechanisms and the role of soil, than I have read in science texts. The price seems a bit out of line, but it may be very worthwhile to get one for classroom use with extra supplies.

## GAMES

*Smog* by Urban Systems, Inc. \$9.95

*Smog* does a very thorough job of mirroring the frustration of trying to deal reasonably with air pollution problems. Its decision tree and rules make one almost feel that he should be able to figure out a set of "best moves" for any situation. When analyzed, however, the problem reveals itself to be of a magnitude and complexity comprehensible only to a computer. Then, you add in the element of chance (caused by drawing "Outrageous Fortune" cards after each turn) and it becomes somewhat overwhelming. Indeed, the game was designed and tested with the aid of computers.

Reverting to observation and practice, we find that some of the apparently useful tactics have curious ecological implication:

- 1) The Zoning Authority need not be renewed after the first round, unless acquisition of industry is imminent and the player to your left (who locates your acquisitions for you if you don't have zoning) is particularly mean. Players may (though it's not in the rule book) decide to save themselves a lot of money by cooperating (in life it's called regional planning) to locate industries where they won't pollute anybody, if possible.
- 2) Pollution of residential areas by industry can be largely avoided (until the town gets crowded) by locating houses on the diagonals from industry. Wind only blows N, E, S, or W in this game.
- 3) Debit financing can be very costly in Management Credits (which you are trying to accumulate to win).

- 4) In the Solid Waste Decision it may be most advisable to designate a dump site, but not use it.
- 5) Relative values of votes (+ and -) and air quality (O and X) improvement and degradation almost make improvement inadvisable, except in especially safe instances.
- 6) Most significantly, Growth is unavoidable. As stated in the rationale of the game, "This reflects the attitude which has developed in our society, that progress is best demonstrated by material growth - first by increase in population, and then by greater productivity and exploitation of the many resources of the continent." The game makers do not explicitly question this value structure, but the players confronted with it must ask why we have structured society in this way, unless they want to simply "play the game" in life, too. Theoretically, in a democracy we can change the rules so that the people run the system and not vice versa.

Smog is not a children's game. Its complexities need to be analyzed over long periods of play. In fact, it is difficult to feel that it is a game. I have not analyzed or played it sufficiently to judge the accuracy of intricacies of its life-mirror.

*Dirty Water* by Urban Systems, Inc. \$9.95

Though dealing with the same degree of natural complexity, *Dirty Water* comes across as more of a game than *Smog*. Perhaps because the chief chance element comes before the play, one is less apt to feel he should be able to work the whole thing out by reason. It seems more random, relying on the role of a die, and is more easily played once the rules are mastered.

Dirty Water does have some very specific natural parallels and contradictions:

- 1) Only a few natural lakes in populated areas are oligotrophic (i.e., young: not having developed complex food chains of higher organisms), so playing to fill the food pyramid seems unrealistic. It might be more instructive to try one of the booklet's suggested variations - to start with a fully balanced system, and play to see which

player maintains that balance most effectively over a time period or number of board circuits.

- 2) The basic organizational concepts of the game are quite good. Acquisition and exchange of organisms, preventative and last minute abatements, and downstream pollution all have their real life counterparts. Also, as in real life, it does not seem as important to protect your lake until two or three circuits have been run, and you have begun to collect the organisms you want and the money to buy protection. At this early stage of the game, some forms of pollution (paper industry, agricultural phosphates, or food processing wastes) are even beneficial in giving you a boost toward completion.
- 3) The most disturbing problem is downstream pollution. The competitive, rather than cooperative, nature of the game encourages players to try to damage the guy downstream when they themselves can afford or benefit from pollution of their own lake. This is at the crux of the problems of regional planning and enforcement.

*MAN IN HIS ENVIRONMENT - Role-Playing Kits.* \* Distributed by Coca-Cola. Free to school superintendents and curriculum directors from local Coca-Cola bottling plants.

*Rescue in Space* "helps children to understand that we live in an environment whose resources are limited." *Make Your Own World* "helps children to understand man's interdependence with his environment." Both represent reasonably good beginnings toward those understandings. They use the device of role-playing to enable children to exercise their minds and emotions by living "in someone else's shoes" for a while. Important concepts that are dealt with are:

- 1) "Every new answer creates new problems."

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\* [Ed. note: Although designed for students of secondary school age these games could be adapted to elementary schools by the teacher.]

- 2) "In real life, only human beings decide whether to build projects (elsewhere referred to as 'improvements'). Air, water, soil, plants, and animals have no votes. What responsibility does man have to take these other things into account?"
- 3) "Man can learn to recycle his own products just as nature recycles air, water, minerals, nutrients, etc."

The shortcomings included:

- 1) The Fact Cards, designed to help students see effects of the "improvements" they are voting on, seem geared to influence certain factions in particular ways.

i.e., All "improvements," we are informed, will help employ local people, so the Unemployed Worker is expected to vote for them.

The Wildlife Preserve is "to provide a natural habitat...for the future, and it will guarantee a home for wildlife and fish." Therefore River & Fish, Forest, and Deer would be expected to vote for it, but it really doesn't look like a good place to live.

- 2) The *Make Your Own World* board is described as a closed system - no waste can travel out, no food in; but somehow most improvements involve "bringing in industry" or "causing people to move in." Is it closed or not?

The *Rescue in Space* teacher's guide begins to raise the right questions and strongly encourages student discussion. The teacher, however, needs to supplement the guide with other points of view.

- 1) Under the question "What changes can we make [to]....improve our use of space on Earth?" The teacher might also include such possibilities as (a) reduction of unnecessary consumption, and (b) try to avoid repeating past mistakes.
- 2) Under "Quality of Life and a Look Toward the Future" a number of questions could be asked:

- a) Does the "standard of living" relate to the quality of our lives? In what way? How could it be improved as an indicator?
- b) Reference is made to population growth. Can population grow indefinitely? Must it grow? What factors encourage or discourage its growth?
- c) The section notes that atomic energy creates problems that will have to be solved. Do we "solve" the problem when it gets here or try to prevent it by more research and less development?
- d) Reduction of energy consumption is considered a "drastic step." How much power is simply wasteful?
- e) "New resources, alternate materials and recycling previously wasted materials" is considered. But doesn't this require energy too?

*Superhighway — A Simulation Game. The Instructor Magazine, February, 1971. No cost given.*

This game seems to reflect a simplistic attitude. Even though multiple views about the location of highways are delineated the voting style and results of each move are predetermined. More disturbing is the stereotyping of viewpoints by profession or role in the community. If one of the objectives is to "demonstrate the ability to think critically," it should be up to the participants to figure out how community members would feel about a highway given the ways it might affect the town and his life. Children should learn that one's ideas are influenced by many factors, not just age and job.

The questions for discussion do bring out some of the necessary considerations. Some, such as "What values are implicit in the game?" require the most careful thought. Beware that the answers are not "you can't beat 'em, so why not join 'em" and/or "'progress' and 'growth' are necessary and good in spite of all consideration for persons."

Some variations would be:

- a) Design a project in which students survey various facets of their own community on this or a similar issue, bringing in data and discussing the factors involved in people's attitudes and opinions.
- b) Create more characterizations of members of the fictional community - unemployed worker, high school students, more teachers, religious leaders, store owners, etc.
- c) Design a still more versatile set-up in which character facets (age, education, station in community, income, political views, family size, etc.) would be represented in several separate decks of flash cards. Each student would take one card for each characteristic (one from each deck). The combination would delineate a basic character. The student would then decide about how his character would probably feel about the issue and vote accordingly. If the other students or the instructor feel that his vote is inconsistent with his 'personality,' he must be prepared to outline factors which could influence his individual to that view.

The idea of role playing can be masterfully used to enlarge a child's world view, or it can be misused to contribute to his being assimilated to the society which makes "boxes on the hillsides [and in our minds], little boxes just the same."

*Extinction.* by Sinauer Associates, Inc. \$11.95.

The best analysis of *Extinction* is its own rule book (except that I suspect the Teacher's Guide is even more complete). The author-inventor is an ecologist and the game has developed under careful study. The workings of the game are complicated to analyze, but the beginner can start out playing quite satisfactory games with the rule book at hand to remind him of specific provisions. After an introductory game or two he can move into strategy development, much of which will reflect natural systems. The game is also very flexible, and the author suggests several variations of play revealing new facets of species interaction. He encourages players to try their own changes and see how they work out. [We found that rolling dice seemed to be more random than the spinner for indicating moves to be taken.]

The author is careful to point out and explain the respects in which the game differs from nature (and must to be playable). The differences, because we are made aware of them, become significant in our experience of the game. Extinction reveals an approach to eco-games that ~~could serve as a fine model for further research and development.~~ Highly recommended.

#### CONCLUDING REMARKS

At the risk of belaboring a point I would like to say that when I began this project, I held a very negative view of the "cheap stuff *they* (nasty profiteers) are dumping on the market." I still find excess packaging and excessive prices to conflict with the message of ecology - we cannot go on blithely consuming everything we can touch.

But I have come to see that, as with other learning aids, sometimes with a masterful teacher the poor "learning aid" can be a tool for learning about learning.

"But the nature of games makes them vulnerable to abuse, particularly in the hands of inexperienced or lazy teachers. Used in isolation from books or discussion groups, the danger arises that games - most of which mirror political and economic institutions as they are now - may encourage quiescent and conformist attitudes. ...success is premised on accepting the 'simulated reality' as it is rather than on examining what is wrong with it." <sup>1</sup>

With patience, skill, and the right questions we may be able to enable children to learn how to THINK!

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<sup>1</sup>Postman, Neil. *Teaching As A Subversive Activity*, p. 191.

## INTRODUCTION TO SUPPLEMENT

This supplement to Environmental Games has been written in response to the numbers of new kits published recently, and the wide distribution of the earlier report indicating interest in such evaluations. The items covered here, distributed by Urban Systems, Inc., Cambridge, Mass., were sent to the Vermont Environmental Center for our review. Their central themes are important to an understanding of the many elements of the "environmental crisis." They suffer many of the same weaknesses as the first five in the set, but with less redeeming value, as they now begin to get repetitive.

So I too, will repeat some admonitions. We do not need the "instant experts" that these kits promise to create of us and our children; we need an informed public, aware of the complexities and interrelations of our natural systems. If these tools are to be used toward that end, they must be used in the context of a well-prepared, informed and critical study. Subtle lessons are taught quite thoroughly by format that are antithetical to the purported content. It will be noted that many items in these sets are easily available in class-sized quantities at little more than one pays for these (designed for two to four at most). What does the presently understocked, overpackaged, overpriced set imply about our economic and value systems? Isn't it worth your time and energy to make this kind of lesson real for your children?

So the decisions are yours. Again. As always. Which values, which expedients, which emphases will *you* employ in *your* efforts to communicate to this generation the need for knowledge and wisdom and restraint and a constantly inquiring mind?

20

My criticisms of all of these kits are similar to those in the earlier report, and mostly derive from a rather sloppy scientific method. (I generalize them here, and use a series of symbols to mark the particular points in each kit which exemplify my comments here.)

- (X) Reagents are frequently not named, nor their concentrations specified, yet.
- (Ω) Particularly necessary is a brief description of the principle in "indicators."
- (Y) In other sections a reasonably full explanation is given of the meaning of chemical concentrations.
- (∇) Few of the chemical processes are revealed in even simplified terms, yet.
- (Δ) Others are explained quite fully.

If the reader is expected to be able to comprehend sections (Y) and (Δ), what excuse is there for some of the omissions (X) and (∇).

- (Θ) Some of the experiments are just plain poorly written, and difficult to follow even if you know from other experience what you're supposed to do.
- (+) Then if the process is relatively clear and you perform it correctly, it's often not clear why you're supposed to do what you do or why you can draw the conclusions they tell you to draw.

As in all three kits, general groups of pollutants are fairly well described re: their fundamental usefulness, danger in excess or lack, natural and introduced sources, and basic ways of either preventing their entering natural systems or cleaning them out when they get there. This kind of information (at many different levels of complexity) is now readily available from many sources. I do not feel that these kit booklets do a particularly more helpful job than others.

Kit No. 6 *Can I Drink the Water?*

Blurb on the box: "The water you drink is full of mysteries waiting to be discovered. Test it and find out for yourself. Learn the differences between good water and impure water, and explore the causes and effects of pollution."

Table of Contents

- (Y) What Pollutes Drinking Water
- (+) Living Things Which Pollute the Water
- (Θ, +) Experiment: Coliform Count  
Chemicals Found in the Water
- (Y) Salt
- (X, V, Ω) Experiment: Chloride Concentration
- (Δ) Nitrates
- (V) pH
- (X, Ω, Θ) Experiment: pH of Water  
Other Chemicals - cyanide, flouride, mercury,  
DDT
- Sources of Water -  
Experiment: Rate of Settling of Particles  
Safe Drinking Water

Equipment supplied:

- "C 1" -4 powder pillows (pre-measured clip-open packets)
- "C 2" -c. 10 ml
- distilled water -c. 5 ml
- hydrion papers -8 two inch strips
- agar -c. 25 ml
- 2 plastic "disposable" petri dishes\*
- 1 eyedropper
- clay - 1/4 cu. in.
- sand - 1/2 cu. in.
- 4 - 20 ml plastic vials
- 1 - 10 ml glass jar

\* "When you have finished looking at [the colonies you have grown] throw them out. DO NOT OPEN THEM. DO NOT TOUCH THE COLONIES...YOU MAY HAVE GROWN SOME BACTERIA THAT ARE HARMFUL." Why not sterilize the colonies, clean out the agar, and save the petri dishes for reuse. "Disposable" "convenience items" are a large part of our problem. Their being made of plastic is not particularly helpful either. This goes for the vials, too.

Additional Equipment Needed But Not Supplied

a cooking pot  
hot water  
tape  
water samples  
vinegar  
soap solution  
watch

"C 1" and "C 2", judging by other standard chlorine tests are probably a powdered chromate indicator with pH buffer and silver nitrate solution, respectively, the concentration of the silver nitrate being gauged to the amount of indicator in the pre-measured packets so that the titration will be standardized to Cl concentration. These coordinated reagents can be purchased from Hach Chemical Co., Box 907, Ames, Iowa 50010:

<u>Cat. No.</u>		
397-13	Chloride Test Solution in dropping bottle	
or	4 oz. (118 ml)	\$1.60
397-14	Chloride Test Solution in plain bottle	
or	4 oz. (118 ml)	\$1.00
397-11	Chloride Test Solution in plain bottle	
	1 pt. (473 ml)	\$2.50
1043-99	Chloride Test Powder Pillows	
	2 x 50	\$2.50

Hydrion paper and nutrient agar can be purchased from CCM: General Biological, Inc., 8200 So. Hoyne Ave., Chicago, Ill. 60620:

Cat. - Turtox 1969-70 (prices may need to be updated)		
420AA222	Hydrion paper (range 1 - 14)	
	2 - 15 ft. rolls	\$2.00
60V900D	Nutrient Agar - 1,000 tablets for preparation with 5 ml distilled water per tablet	\$8.15

Neither company has a minimum order level. Both will send catalogs of related supplies for your future use.

Providing your own sand, clay, distilled water and glassware, you could do 100 chlorine tests and 500 bacterial tests for about \$15.00. Compare!

Kit No. 7 Can I Breathe the Air?

the blurb: "Anyone can be an expert on air pollution! Test the air to find out how polluted it really is, and compare air near a factory with the air near your home -- you'll be amazed at the results!"

Table of Contents

- (Y) The Air We Breathe
  - What is Air Pollution
  - How We Know the Air is Polluted
  - What Are Some Air Pollutants
  - Carbon Dioxide
- (Δ) Experiment: Effect of Breathing
- (Y, Δ) Sulfur Dioxide
- (V, Θ, Ω, X) Experiment: Detection
- (Δ) Carbon Monoxide (Particularly good description of the mechanism which makes CO toxic)
- (X) Experiment: Detection
- (+) Particulates
  - Oxides of Nitrogen, Hydrocarbons and Ozone
  - How do Weather and Geography affect Air Pollution
  - Can I Breathe the Air

Equipment Supplied

- 1 Plastic straw
- 1 eyedropper
- 45 ml CaOH
- 1 squeeze bulb
- 1 CO detector
- 4 SO<sub>2</sub> filter papers
- 1 filter holder

Additional Equipment Needed But Not Supplied

- 2 clear glasses
- water

Notes on Supplies:

- 1) any straw or piping will do
- 2) eyedroppers and squeeze bulbs are available at most drugstores for a few cents
- 3) the other items are available in quantities for classes at these rates:

from - Hach Chemical Co., Box 907, Ames, Iowa 50010

<u>Cat. No.</u>		
192-11	Calcium Hydroxide 1 pt. (473 ml)	\$2.40
192-16	Calcium Hydroxide 1 qt. (946 ml)	\$3.95
393-33	Hydrogen sulfide test papers (100)	\$1.50

- Millipore Corp., Bedford, Mass. 01730  
M000 037 00 Styrene Monitor Case 50/pk \$8.25

- American CO Detector Corp., 642 Coral Dr.,  
Cape Coral, Fla. 33904  
CO Detectors

Doing these tests can be valuable experience, but the concepts must be integrated, too, and there's no need to pay \$6.00 for one set. It might be worthwhile to get one booklet (\$1.00) to see how they do it, but it would be better to work from there on your own.

Kit No. 8 How Fish Breathe

The Blurb: "Learn how fish breathe under water and discover how fish may contain poisons dangerous to man - such as mercury and DDT - While you compare different marine worlds and the ways fish respond to them."

Table of Contents

Tally of number  
of Dissolved  
Oxygen Tests

The need for Oxygen	
How Do Fish Breathe	
Experiment: Diffusion	
(Y) Dissolved Oxygen	
(Θ, Ω, V, X) Experiment: Quantity	I
(+) Experiment: temperature dependence	III
(+) Biological Oxygen Demand	II
Experiment: Quantity	
Chemical Effect on Dissolved Oxygen	I
Experiment: fresh vs. salt water	
(Y) Osmosis	
(Θ, +, Ω) Experiment - O <sub>2</sub>	} in logical development these would be reversed
(Y) Experiment - H <sub>2</sub> O	
	<u>8</u>

Water Pollution  
Aquarium

Supplies Included:

6* powder pillows "D01"	1 glass bottle (50ml)
6* powder pillows "D02"	1 #1 rubber stopper
6* powder pillows "D03"	1 #2 single hole stopper
20 ml jar "D04"	1 eyedropper
1 empty plastic vial	2 - 3 in sq. yellow cards
1 plastic thistle tube	3 rubber bands
1 plastic straw	1½ in. rubber tube
1 paper clip	1 ft. sq. cellophane

\* N.B. not even enough for one of each suggested test

Additional Equipment Needed But Not Supplied

watch	pan
matches	cups
ink or food color	mixing bowl
candle	paper cup
glass	plastic wrap
water samples	molasses

What is the reason for them to supply rubber bands and a paper clip, while sending us to hunt up molasses and ink?

Knowledge of the chemical process involved in standard dissolved oxygen determinations reveals that D01 is iodide-azide, D02, manganous sulfate, D03, conc. sulfuric acid, and D04, PAO. Their packaging in this form is convenient and safer than liquid forms. They are available in quantity as follows:

Hach Chemical Company, Box 907, Ames, Iowa 50010

Cat. No.

981-99	Dissolved Oxygen I pillows 2 x 50	\$2.00
982-99	Dissolved Oxygen II pillows 2 x 50	\$2.00
987-99	Dissolved Oxygen III pillows 1 x 100	\$2.60
1079-11	PAO for Dissolved Oxygen 1 pt.	<u>\$2.40</u>
	(good for 100)	\$9.00



**Urban Systems, Inc.**  
 1023 Mass. Avenue, Cambridge, Mass. 02138, (617) 461-6620

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\*The School Size Ecology Kits include equipment for 10 students, 10 instruction booklets of experiments, and a teacher's manual. Equipment for 10 students, 10 instruction booklets purchased separately.

--Minimum order for games and kits=\$35.00.