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ABSTRACT

This instructional program is designed to be used with grade 10 students for 4 to 5 weeks to help students to predict what will happen in a given energy situation. It is designed to lead students to an understanding of their personal energy use, to a realization of the moral nature of the assumptions underlying energy decisions, and to a belief that they can and should participate in decisions affecting their lives. Materials include: (1) Understanding Energy and Order - An Activity; (2) Energy and Order Primer - Presentation; (3) The Nuclear Accident - Presentation; (4) The Automobile Accident - Presentation; (5) The Population Accident - Presentation; (6) Understanding What's on the Bill - An Activity; (7) Understanding What's in the Container - An Activity; (8) The Green Revolution - Presentation; and (9) What's Keeping Us - Presentation. (RH)

Energy & Order

A High School Teaching Sequence By
Mark Terry and Paul Witt

Energy and Order

or

If You Can't Trust the Law Of Conservation of Energy, Who Can You Trust?

A High School Teaching Sequence

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I. Introduction: If it Can't Be Destroyed, How Can We Be Running Out!?

What tools are currently provided to students and teachers to help gain an understanding of the energy crisis? Science departments cover it, right? Most science texts explain the Law of Conservation of Energy and the manner in which energy may change forms — and generally provide the definition, "Energy is the ability to do work." No more, no less.

We have usually found it impossible to go anywhere with this information. It's dry and theoretical, difficult to visualize, and not demonstrable in beginning science classes in any but trivial ways. It certainly has never helped us in understanding the energy crisis, energy and the economy, energy and food, energy and the environment, our own uses of energy, society's uses, industry's — and all the interrelationships among these. If anything, teaching about the Law of Conservation of Energy in isolation from other concepts leaves everyone thoroughly befuddled — if it can't be destroyed,then how can we suddenly be running out of it?

We have found that the essential ingredient missing in energy education is a sense of direction that allows one to predict what will happen in a given energy situation. What is needed are some principles describing the behavior of energy that go beyond the "conservation of energy." These principles have been around since the mid-nineteenth century: the principles of thermodynamics. Thermodynamics *does* assign energy a direction; it breathes life into energy terminology and makes possible the teaching of practical energy concepts.

Incorporating these principles into our teaching at the 10th grade level, we have developed the following program. Our goal is a consciousness not only of energy realities, but also of what kind of real changes need to be made in governmental, commercial, and personal policies, and how they might be accomplished.

We set out to develop an energy vocabulary and literacy that first permit confident use of energy and power measurement units. We then try to develop an ability to analyze the energy and order relationships of a system and its surroundings. Finally, we apply the above to practical analyses of systems and issues important in our lives: the kitchen, the automobile, the supermarket, the workplace, economic inflation, population growth, and per capita energy growth.

In successive stages of development over the last two years we have carried out this program as the last 4-5 weeks of a 10th grade General Biology course required of all students at our school. Each of our weeks consists of a presentation to the whole grade (using many audiovisual materials), a hands-on activity session with each section, and follow-up section discussions.

Much of this course is traditional. We also deal with value questions throughout. Preceding this unit in the course are very open discussions of various biosocial dilemmas, such as medical costs, workers' health, birth control, industrial pollution, wildlife extinction, and responsibility on many levels — including responsibility to the planet. The context is set, therefore, for an investigation of America's disproportionate use of the world's resources, the world distribution of food, national energy policies, the fossil fuel foundation for mechanized agriculture, the energy impact of the population explosion, the population impact of the energy explosion, the massive allocation of resources to the automobile. In short, we investigate The Biological Impact of Mass Industrial Society (our title for this section of the course). In addition to the resources listed at the end of this booklet, we make extensive use of news items that appear during the unit. We especially encourage the reading of the daily newspaper by the students.

Energy and Order need not be restricted to use in a Biology class or the Science Department — or any department; it leads students to an understanding of their personal energy use, to a realization of the moral nature of the assumptions underlying energy decisions, and to a belief that they can and should participate in decisions affecting theirs and the planet's life.

II. Understanding Energy And Order — An Activity

Prior to any formal presentations or readings on energy, we conduct an activity that we call Understand Energy and Order. The students bring to it only their own previous experiences and common sense. The equipment can all be found in a kitchen, garage, or elsewhere around the home and school. Other than the need for water, there is nothing that makes a science lab necessary for these activities except school protocol. The point of the procedures is to provide a range of experiences that serve as the basic examples for our later discussions of energy and order.

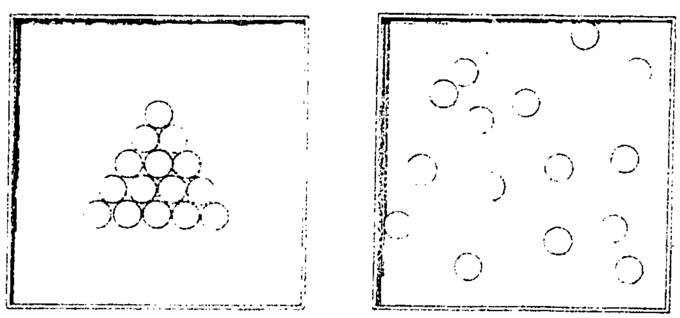
Pairs of students conduct *two* of the following procedures, then each pair discusses their observations with another pair.

Each group of four then composes a list of principles that they believe explain the relationship between energy and order in all their observations. In a subsequent discussion section, these principles are then pooled and evaluated by the whole class, testing whether each statement applies equally well to all the activities that were carried out and exploring the application of the statements to processes outside the classroom.

There is a good deal of mystery and frustration associated with this head-on approach to the subject. We make no attempt to define energy for the students during the activities. We have found that the procedures themselves and the challenge to generalize from pooled experiences bring the whole subject of energy into sharp focus — and that generalizations come with relative ease once the students get started. A brief description of each of the procedures follows.

A. Lost Your Marbles?

First, set up a small playing area on a smooth, level table top by forming the boundaries of a square using two-by-fours. Ours was only 1' by 1'. In the center of the square, arrange fifteen marbles as though you were about to start a minature game of pool. One student is then to aim an energy input (in the form of a slight whack with a wooden dowel) into the marbles, striking at one of the corner marbles. Then follows the simple task of counting how many roughly equal stikes are required to restore the marbles to their original configuration (or, if you like, to "put Humpty Dumpty together again"). We generally stop our students after 10-15 minutes to give then time to reflect on what is or is not happening.



B. Can You Put It Back?

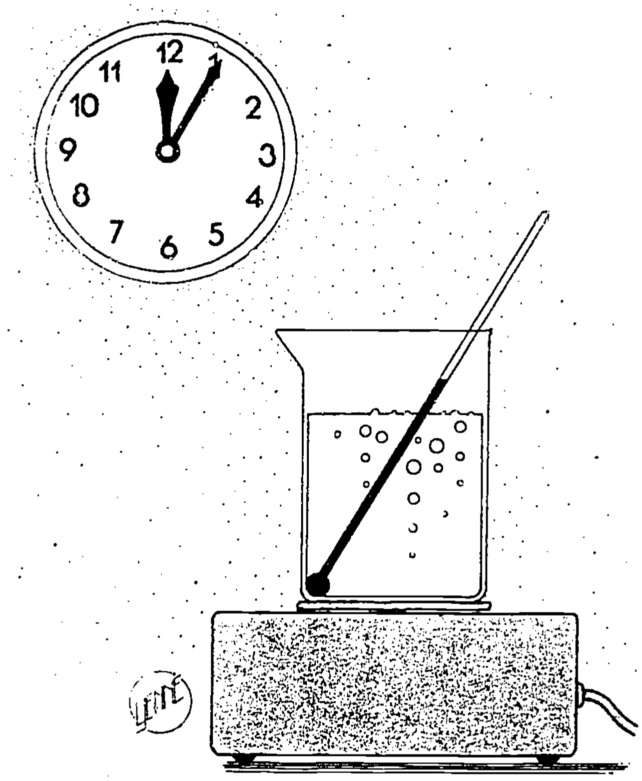
We borrowed this activity from the *Introductory Physical Science* text (Haber-Schrain, *et al.* 1972, pages 3-4). An energy input from a gas flame causes the distillation of wood splints into various gases, liquids, and solids, which generally get spread all over everything. . .(Don't use your best test-tubes or other glassware!) The disruption of an ordered system by an energy input is obvious. At the conclusion the students are challenged to reconstruct the wood splints from their component parts. This procedure is a particularly nice way to demonstrate disruption of order. Simple observations of combustion or melting would also do, however, and take less apparatus.

C. Hot Flashes

The object is to measure the caloric value of the heat that is absorbed by water from an electric hot plate, the caloric value of the electricity used by the hot plate (at point of use), and to compare the two. Place a known volume of water at room temperature in a heatable container on an electric hot plate. Place a thermometer in the water, turn on the hot plate, and record the water temperature every minute for 6 minutes (one tenth of an hour). A graph of temperature against time is always interesting. The calculations for caloric values are simple if you've stayed within the metric system, a bit longer if you've strayed: Subtract room temperature from ending temperature (in degrees Centrigrade) and multiply the volume of water (in mls.) to obtain the heat energy absorbed by the water (in calories). Multiply the power rating of the hot plate (in watts) times the time of operation (in hours) times a conversion factor of 860 calories/watt-hour to obtain the total heat energy used in operation of the hot plate (in calories). The calories absorbed by the water should then be divided by the calories used by the hot plate to obtain an efficiency-of-operation rating. There remains the question of the whereabouts of the calories not absorbed by the water. Also, if the thermometer can be left in the water through the remainder of the period, the calories lost by the water to the room can be calculated based on the decrease in water temperature. *Now* where have all the calories gone?

D. Chills

This test is only marginally quantifiable, but makes an extremely important point. The necessary equipment is an accessible air conditioner (accessible both inside the room and outside, we do not advise hanging out of a second-story window) and a thermometer. Measure first the room temperature in front of the air conditioner before the machine has been operated that day. Operate the machine on its coldest setting for 6 minutes, then measure the temperature of the cold air output. Go outside and measure the temperature of the exit air from the conditioner. How much of a drop from room temperature is there in front of the air conditioner? How much of an elevation from room temperature is there outside the air conditioner? Usually the results are intriguing, if not startling. We always like to calculate the caloric value of the electric energy used by the air conditioner by multiplying the air conditioner wattage times the length of operation in hours. The resultant value is in watt-hours



and can be converted to calories by multiplying by the conversion factor, 860 calories/watt-hour. To improve this procedure the volumes of air need to be measured and their actual heat content calculated. If anyone can help with this measurement, we'd appreciate the advice.

E. Heat Lamp

Our favorite demonstration of energy efficiency; it's close to Hot Flashes (above), but the heater is immersed in water and not ordinarily known as a heater. A long-necked 200-watt light bulb is ideal. You'll also need a 16-ounce coffee can, a 48-ounce coffee can, suspendable light socket, glass wool or other insulation material, thermometer, and secure mountings for light socket and thermometer. A volume of water is determined that will rise to the neck of the light bulb (*But not to the socket!*) when the bulb is immersed in the small coffee can. This volume is recorded. The small coffee can is placed within the larger can; the space between them is packed with the insulating material. The light bulb is carefully suspended and secured so it does not touch the sides or bottom of the inner can and leaves room for the bulb of the thermometer, which must be similarly positioned so that it is fully immersed but not touching light bulb or can. The teacher should check the set-up before plugging it in; no one should be allowed close to the apparatus during its operation to avoid jostling any of the components and splashing the water. Protective glasses should be worn. The starting temperature of the water is recorded. The bulb is plugged in, and the temperature recorded at one-minute intervals until the bulb has run for 6 minutes. While the apparatus is cooling be careful not to disturb it. Calculations are now identical to those carried out for Hot Flash (above). The difference is that this is the *heat* production of a *light* bulb. A rough calculation of the point-of-use efficiency of the light bulb can be derived in two steps: first determine the difference between total energy used (in calories) and energy absorbed by the water; second, divide this figure by the total energy used (in calories). The result is that fraction of the electric energy that *could* have gone into light production. An inspection of the apparatus, with its insulating problems, will show that a great deal of heat may have escaped and not been absorbed by the water, so that the overall measure of heat given off is conservative and the efficiency rating liberal.

F. Sun Lamp

This requires a sunny day. Clearly an interesting experiment would be a repeat of Hot Flashes using a solar cooker in place of the hot plate. We have not made a solar cooker, yet. Instead, we use the sun to make a slightly different point about energy and order. Students are instructed to take a simple magnifying lens and determine how long is required to ignite a piece of paper with sunlight in the time-honored way. They also are instructed to take a small, flat glass plate outside and do the same. This procedure needs a time limit, because of course the flat glass will not accomplish the desired end. The students are then asked to speculate why one piece of glass can accomplish the task and the other cannot. An idea of "focused energy" emerges that is later an excellent introduction to the concept of power.

G. Hot Food

Here we begin to break down the artificial distinction between food calories and energy calories; we demonstrate that they are really the same. An alcohol lamp is used to raise the temperature of a small known volume of water (10-20ml). To maintain equivalence with other procedures we let the lamp heat the water for 6 minutes. The hottest part of the flame must be positioned carefully for the most direct heat to the water. A great deal of heat is lost to the surroundings, so the measure of heat content is conservative. Ideally, we would fuel the lamp with a 200-proof beverage. 86-proof liquor is not adequate because the energy content is insufficient to keep the wick burning. In a pinch we use ethanol from the school's supply, indicating that this is the "meaningful" part of an alcoholic beverage. If the lamp and fuel are weighed before the procedure, then again weighed after 6 minutes of combustion, the weight of fuel lost can be used to obtain an estimate of the heat content of the fuel. CAUTION: a closed, alcohol lamp with wick is safe, any open container is *not*.

H. Hot Shit

Here we demonstrate the caloric content of an organic substance that remains after a living being has physiologically extracted some of its original caloric content. *Very* dry chunks of manure are used in the manner of charcoal to heat a small known volume of water (once again, 10-20ml). We ignited the manure on a screen with a flame from a bunsen burner. Other flames could be used, as could charcoal lighter fluid — provided enough time were allowed to pass before the water was placed above the "coals." All procedures for determining the caloric content are as described earlier. Not the least important lesson learned from this procedure is that dried manure *is* a fuel and is used as such in many parts of the world. To emphasize this, we actually toasted marshmallows over the apparatus. Surely there is something better to cook, but the marshmallows were effective. A degree of ventilation is important for this procedure.

I. Cold Cash

What is the caloric content of a one-dollar bill? The determination of this is one of our favorites, although expensive (but in real terms it would seem to cost less each year). It consists simply of raising the temperature of that familiar small volume of water by burning a dollar bill. There is a good deal of skill required to direct the heat of the bill to the water and to insure relatively complete combustion. A paper clip holding the bill rolled into a long cylinder hanging directly beneath the base of the water container seems to be the best arrangement. The bill is lit from below and burns up to the point of attachment. The caloric value of the heat absorbed by the water is calculated from the water volume and temperature change as described in preceding procedures. There are many interesting questions: Is this really the energy content of a dollar bill? Are dollar bills energy units? Why is deriving the energy content of a dollar bill in this manner illegal? Is the energy content of a five or ten dollar bill any higher? How many calories of energy in various forms can a dollar bill purchase?

J. Student Power

This procedure permits us to quantify the heat release from a living system, specifically, one of the students. The volunteer is to take a urine sample whose temperature is measured as quickly as possible. The sample's volume in mls, or weight in grams, is then determined. The difference between room temperature and urine temperature, multiplied by the volume, as in all the above caloric content calculations, gives the heat content of the urine in calories. At intervals throughout the period, the urine temperature can be recorded to check that the heat is gradually leaving the fluid and entering the room.

K. Concrete Jungle

A simple, non-quantifiable procedure from which we have always obtained extremely valuable results. Two students are asked to go out to the street and watch the traffic for 10 to 15 minutes. They are to take notes on the energy and order aspects of the scene they observe. As with the rest of these procedures, we provide no coaxing on energy itself, and mention only that order refers to the relative organization of things. By itself this procedure might not be worth doing. When the Concrete Jungle pair return to confer with another pair that have done some of the other procedures, however, the ideas and connections start flying.

L. Additional Procedures

If there is any living system in or near the classroom, it will bear looking into, using instructions similar to Concrete Jungle. Closed systems, such as terraria or sealed aquaria, are preferable, but any animal or plant or bit of landscape can serve. With the stress placed on energy and order, new insights develop around any observation. It is important in this first activity, however, to keep systems relatively simple. Concrete Jungle needs to be balanced against the better defined in-class procedures. Wait a week before tackling the school cafeteria, the boiler room, the neighborhood utilities, or Standard Oil.

If this seems like an impenetrably complex situation to let loose in one classroom, here is some advice on how it can be done. All procedures are described in the simplest, least ambiguous terms possible, on separate Instruction Cards prepared before the class. To the right is an example of one of our 5"x8" cards carrying instructions for activity H:

Do *not* analyze the reasons for each activity, but provide a few seed questions to help start a discussion following completion of the procedure. The cards are easily divided up among the pairs of students, and if made sturdy enough can be used again and again for other sections. Keep materials and apparatus as simple as possible throughout. It is quite important to get the students involved in the activities quickly. There is time planned for analysis later. None of the procedures demands skills much more advanced than thermometer reading. They can and should be done carefully and not be rushed.

1.) Obtain a 20g mass of horse-converted plant material (HCPM).
2.) Break it into smaller chunks and place on wire screen.
3.) Ignite with burner flame until ash is forming (15-30 sec.).
4.) Maneuver test tube with 20g H_2O at room temperature over the burning H-converted plant material (1" above).
5.) Record temperatures and times until temperature stops rising. Mass (weigh) the remaining H-converted plant material.
6.) Record all pertinent observations. Calculate number of calories taken up by H_2O; number of grams lost from HCPM.

To make the arithmetic in this lab less of an obstacle, we distribute a single sheet that has all necessary conversion factors to all the students at the outset. This certainly does not solve the math problems, but it provides the teacher and student with a ready tool to carry out the necessary calculations for each pair's procedures. It also helps communicate that everyone, whether they're involved with Hot Food or Student Power, is using the same units to describe the systems. The contents of this sheet are as follows:

Units of Measurement and Conversion Factors

Characteristics of Water
- 1 gram = 1 milliliter
- 1 kilogram = 1 liter
- 1 Calorie: 1 liter is raised by 1° Centrigrade
- 1 Calorie: 1 liter is raised by 1° Centigrade
- 1 British Thermal Unit: 1 pound is raised by 1° Fahrenheit

Electricity Units
- 1 watt-hour = 1 watt running for 1 hour
- 1 kilowatt-hour = 1000 watts running for 1 hour or 1 watt running for 1000 hours

Energy and Power Conversion Factors
- 1 watt-hour = 860 calories
- 1 kilowatt-hour = 860 Calories
- 1 kilowatt-hour = 3400 British Thermal Units
- 1 Calorie = 4.0 British Thermal Units
- 1 watt = 0.24 calories/second
- 1 kilowatt = 0.24 Calories/second
- 1 kilowatt = 0.95 British Thermal Units/second

One important aside about calories and Calories. There are, alas, two common usages of the same word, and their meanings hang on the capitalization of the first letter. Throughout this first day of activity with energy and order we use the *calorie*, not capitalized. These calories are also known as gram-calories. They are the most convenient because of the small volumes of water involved in their calculation: grams as opposed to kilograms, milliliters as opposed to liters. These calories would be perfectly acceptable to use throughout this entire unit, *except* that we wish to make the point of the energy content and energy subsidy of modern food. The food calorie with which students are familiar is really a *Calorie*, a kilocalorie, 1,000 of the little guys, the gram-calories. Therefore, we switch to Calories throughout the rest of the unit. It has always seemed foolishness to us to let so much depend upon a capital C but we have also noticed that it doesn't bother the students nearly as much as it does us.

III. Energy and Order Primer — Presentation

Once we've completed Understanding Energy and Order, we begin building a structure of concepts through discussions and presentations. Any time available for discussion following the preceding activity should be used to involve students further in forming energy and order generalizations. We suggest having the foursomes (composed of the initial pairs previously described) simplify their own generalizations and write them down. We then solicit each group's main generalization, write these all on the board, and discuss ways in which they can be further simplified and applied to all the systems observed. Students are generally quick to develop the idea that energy creates disorder. More thought and discussion are needed to explore ways in which energy can be used to create order, relationships between disorder and heat, differences between fuels and electricity. If all the situations from the class observations can be fully accounted for, the next step is to generalize to familiar processes outside the classroom.

We now proceed to our first formal presentation concerning energy, power, and order, an Energy and Order Primer. At this point thermodynamic laws by themselves are still not easily understood by students. We have developed, therefore, a set of statements closely related to the students' own generalizations. These are intended to be clear and immediately applicable to discussions of the way the world works. New vocabulary is kept to a minimum. The bulk of this first presentation consists of going over these statements carefully with the students and illustrating them with examples from the shared classroom experiences. Each of the 5 groups of statements is presented to the students on a separate sheet using multi-color ditto masters and a clear graphic style:

Events

1. Any Event involves changes in Energy and in Order.
2. The Surroundings must always be taken into account to measure changes completely and to understand their effects.
3. A complicated Event is often called a System.
4. Another word for Surroundings is Environment.

Energy

1. Energy is measured by the effect it has on Matter.
2. Energy is the ability to cause change.
3. Energy may exist in a concentrated form, in which case it may be directed to cause a desired change.
4. Energy may be too disorganized to be directed, in which case it cannot be used to cause a desired change.
5. The amount of *concentrated* Energy is *always* decreased during an Event.

Order

1. Order is measured by comparing the complexity of one arrangement of Matter to another.
2. Most of the changes man requires in his Systems call for an *increase* in Order.
3. The total amount of Order in a System plus its Surroundings *always* decreases during an Event; the total amount of Disorder always increases.
4. Energy may be used to increase Order within a System, but in so doing it will also create an increase in Disorder in the Surroundings.

Thermodynamics

1. Energy cannot be created or destroyed, but moves and changes form during Events.
2. Any Event in which Energy flows (that is, all Events) degrades some of the Energy to its least useful form, Heat (relative Disorder).

Power

1. Power is the rate at which Energy is being used during an Event or within a System.
2. Power can be a measure of how concentrated Energy is.
3. Disorganized Energy has very little Power; for most Systems, Heat that is released to the Surroundings has little or no Power.
4. Fuel is a form of Matter that contains Energy concentrated

enough that it will have relatively high Power when it is released in a System.

5. The release of Energy from a Fuel is an Event that uses Energy and releases Heat and usually creates other kinds of Disorder.

Notice that the key words are relatively few and are not completely new to 10th grade students: Energy, Order, Power, Event, System, Surroundings, Environment, Disorder, Heat.

In addition to calling up examples from the students' classroom observations, we describe the energy transformations, heat losses, and other disruptions of order that occur in some of the common energy delivery systems. Our favorite example is gas-generated electricity being used to provide heat: the natural gas is extracted, transported, and refined. All these processes require energy and generate disorder, and they occur no matter how the gas is used. The gas may then be transported to a power station (energy used, disorder generated) where it is burned for its heat content. Of the heat released from the gas, most is released directly to the surroundings, while some changes into mechanical form by way of the expansion of steam and its impact on the generator's turbine blades. Mechanical energy becomes electrical as the generator is made to sweep through a magnetic field. Ultimately electricity leaves the plant in transmission lines, bearing only about one-third the energy content of the natural gas when it arrived at the plant. In transmission there is some loss through conduction to the surroundings. Finally, in the home the electric energy is changed back to thermal energy as it passes through a resistance coil and then enters the surroundings (the air or water to be heated).

This process is contrasted, after the point of refining the gas, to the transmission of the gas directly to the home in a pipeline, from which some small amounts escape, where it is burned, releasing heat to the surroundings (the air or water to be heated). The simplicity of the direct-use system is translatable into efficiency in real, quantifiable terms (Clark, pp. 74-77).

We point out that there is disorder, and then there is disorder. Some kinds are of no consequence to life and may even form an essential part of the cycles of life, such as the heat and disorganization that result from the decay of living organisms. Other kinds may be totally hostile to life. The example of plutonium is given: a substance that generates a kind of disorder that disrupts living things, potentially leading to cancer, to death, and to genetic disruption, a form of disorder that may pass from generation to generation. The desirability of a particular kind of power delivery system cannot be judged on the basis of fuel efficiency alone. The kinds of disorder generated by the system must be carefully examined. A bomb, after all, can provide a great deal of energy in a very short time in a very small package.

We describe life's very presence on this planet as being dependent upon its ability to utilize the sun's energy in such a way that disorder resulting from life's own processes is either useful, avoidable, or negligible in amount. The development of systems designed to utilize energy in such a way that most waste products are of use to other systems has led to the great complexity and beauty of living things. Low-level heat given off by the various forms of life eventually leaves the Earth, radiating into space at a rate that balances the incoming heat of the sun. The Events of the System and its Surroundings are everything we know as life, the history of life, and all the affairs of our species.

IV. The Nuclear Accient — Presentation

Young people, 15 or 16 years old, will quickly be confronted by major decisions involving systems that have decisive effects on the quality of their own lives and the planet's health. We feel the most urgency about two of these, the nuclear and automobile industries. Our students will soon be voting, with both ballots and utility bills, for the kind of energy future they want.

Most students are seriously ill-informed about nuclear power. They believe on the whole that nuclear power is safe, limitless — a panacea. The bulk of their knowledge comes from government and industry propaganda. We, for instance, have had quite an enjoyable little magic show put on free for a school assembly by the engineering department of a local college explaining the miracle of fission power (funded, of course, by the then-AEC).

The recent election battle over California's controversial Proposition 15, the nuclear initiative, was only the first of many such struggles. At latest count, almost 20 states were considering legislation to limit the development of nuclear power in one form or another. Since these battles will be waged, if California is any indication, with utility and vendor-funded public relations efforts, it is important that students be exposed to both sides of the nuclear controversy in a non-advertising context. priesthood, we attempt to broaden their basis for choice.

We present the following information to the whole group. (It could just as easily form an outline for class discussion and student research.)

A. Why bother with nuclear power?

A background for the rush to nuclear power is provided through a capsule history of the exploitation of fossil fuels. The statistics to support this history are widely available. We like Hubbert (1969) and pp. 23-54 of Amory Lovins' *World Energy Strategies*. For an excellent brief history of the subsequent development of the nuclear industry, see pp. 268-313 of Clark (1974). The essential points within all this material are: 1) fossil-fuel depletion rates; 2) disorder associated with fossil-fuels (heat and chemical pollution); 3) fossil-fuels' value as non-energy materials (plastics, drugs, other synthetics); 4) development of the desire to do something "good" with the atom; 5) trend toward centralization and electrification of US energy; and 6) location, operating status, and reliability records of present reactors.

B. How is nuclear power generated?

Essential points usually missed by the AEC or ERDA in its school programs need to be emphasized. We present the basic plan of a fission plant. We point out that the plant suffers the same thermal pollution problems as any fossil-fuel electric generating facility, and in fact, has worse problems because of the need to keep core temperatures down. This information is essential to offset the common idea about nuclear power, which is that it represents some quantum leap forward in the design of power plants.

C. How much power is generated?

The students have already received the message of limitless power from uranium. Here we point out the necessity of energy accounting: calculation of the energy returned for the energy invested. The concept is simple. The data are largely unavailable. (Some help is available in *NonNuclear Futures* by Amory Lovins and John Price: FOE/Ballinger.)

D. How much disorder is generated?

Students *must* learn about radioactive wastes and the incredible schemes proposed for monitoring them through geologic time. Radioactivity happens to be a kind of disorder that many molecules of life cannot endure, even in remotely minute amounts. Students must also be introduced to the wonders of "de-commissioning," that is, living with dead reactors (alive with disorder) scattered all over the countryside and beaches. It makes a wonderful thought-problem: what do you do with a reactor that can't be moved, can't be destroyed, can't be approached? (We rely heavily here for up-to-date information from FOE's "Nuclear Blowdown."

E. Who is Mr. Price and who is Mr. Anderson?

Students *must* learn the history of the Price-Anderson Act. (Hugh Nash's "Nuclear Insurance — Questions and Answers" is good for this.) Students still know pretty well how to smell a rat.

F. Why bother with nuclear power?

We end by returning to our original question and raising some others of prior importance: How much is power worth to us? What do we want power for? What right do we have to bequeath nuclear dumps to our grandchildren? These questions help set the tone for subsequent discussions and for our final presentation, in which alternative sources of power and alternative ways of living are considered.

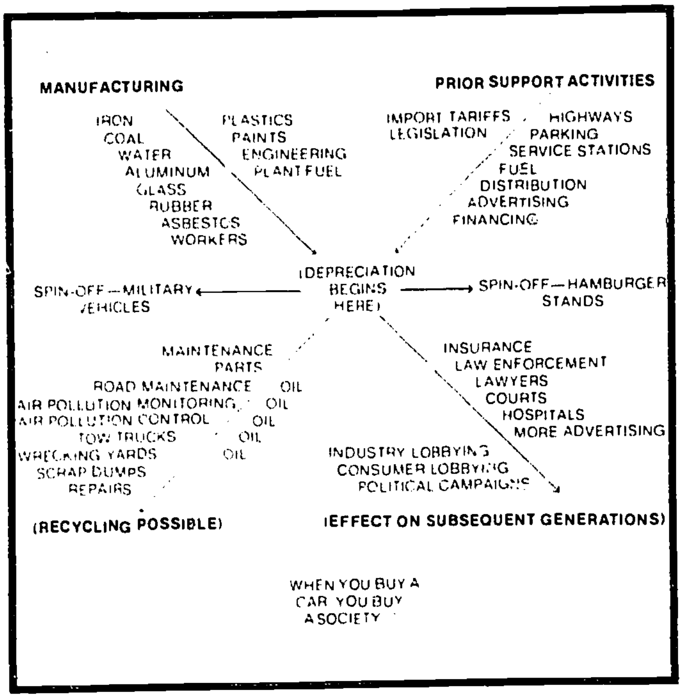
V. The Automobile Accident — Presentation

The purpose of this section is to expand the students' awareness of the massive resource allocation to (and all-but-complete dependency on) the automobile in the United States. The automobile is safely enshrined as the most important of all status symbols for the maturing adolescent. The magic of power and mobility has been well evoked. It has become an article of teen-age faith that driving, done safely, demonstrates responsibility. Seldom is the need for driving questioned, or to the impact of driving on the community.

To prepare for this presentation, students are asked to list all the industries and economic activities that are connected to and/or form the automotive industry, to be specific, and to work only from their current knowledge. These lists are brought into the presentation. Using an overhead projector, we diagram the interrelationships among the students' suggestions and any additions of our own.

A diagram such as the example given is worth a few minutes quiet, contemplation. Of course, it's a gross over-simplification. Many more sectors of life are involved and all the relationships are more complicated. Most of our students are concurrently involved in driver education, and it is worthwhile at this point to ask how much of the life of the automobile is studied in that setting? A few signals and signs are not much help in trying to understand the shape of a society, the reason for a brown haze, the impact of a purchase. We certainly encourage wide-ranging questions and discussions to be brought before the driver education instructor to prompt a wider view.

We use slides to develop this picture further — images of mobile America, many from inside cars, many detailing construction work. Judicious use of statistics can be effective here, particularly if they can be related to personal experiences and anecdotes. We find most of our students can empathize with our



Understanding the automobile's impact on society involves much more than comparing various relative efficiencies – the more extended the understanding, the better.

own stories of changes in communities we have known since childhood.

Once this perspective has been set, there is no better aid to understanding than the automobile industry itself. General Motors, for instance, provides films for no charge and has an extensive library. (For "Body Builders," "Pontiac Pours It On" and the like, write General Motors Film Library. Early booking is advised.) And most automobile assembly plants provide school field trips. With small numbers of students, less formal trips can be equally effective — start with tours of new-car showrooms, follow with a trip down a used-car alley, and finish with a walk through a junkyard. (A census might be in order, as in a nature walk: Cougars, Mustangs, Larks, Rabbits. . .) The students that carried out "Concrete Jungle" in the first activity section of this unit are a logical choice to lead a discussion or make a presentation providing more detail on the energy and order effects of the automobile. Ultimately, this section should aim at an assessment of how dependent on the automobile students are willing to be, what alternatives they can see in their own lives, what choices they might have to make in order to make alternatives workable (such as living close to place of work; car sharing).

VI. The Population Accident — Presentation

In an earlier section of this course, we already established a strong foundation for personal concern about family planning. Students studied the anatomy and physiology of reproduction in detail, saw and discussed all the major birth control devices, and had in-class discussions with mothers who have gone through prepared childbirth and traditional childbirth. Students talked with drug store proprietors about the availability of birth control devices (students were assigned to carry this out on their own "in the field") and with mothers and fathers about the adventures and trials of raising children.

The final assignment was an interview with the student's own parents, asking them about the best and the worst parts of raising children, why they chose to have children in the first place, what options they might rather have pursued. Throughout, we made occasional references to population, but we intentionally tried to let a concern for the reality of bringing children into the world grow on a personal level.

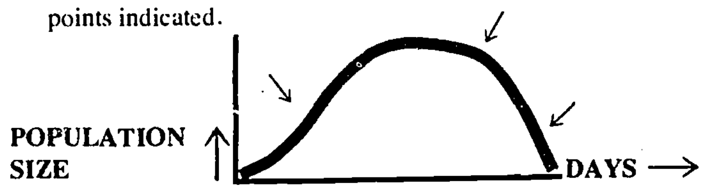
With that as background, we now want to establish the following: the existence of the population bomb; the tempo at which it is ticking; the existence of population limits even if resources were infinite; the existence of population limits due to the limits on resources; the effective size of the population of the United States at well over one billion (due to the fact that every baby born in the United States will, on average, consume at a rate 100 times that of the Third World). We try to share some of the despair and fear that the population bomb draws from each of us. The most important point for us, however, is that students can have a major impact by promoting changes in life-styles and legislation that reduce Americans' gross over-consumption, thereby reducing America's effective population size. We do not want to leave the bomb ticking with a sense of complete hopelessness. Changes in life-style can be effective now, and careful decisions regarding family size will be effective in the long run.

We achieve an immediate, shared experience of wall-to-wall humanity by scheduling this presentation in one of our school's smaller classrooms. We move from our normal meeting place to a room just large enough to accommodate the whole group if all chairs and tables are removed and everyone sits on the floor, shoulder to shoulder. All windows and doors are shut. During the 45-minute period the effect of over-crowding is readily noticeable as the temperature increases and the air becomes stale. (We monitor these conditions carefully and haven't had anyone faint yet, but there is a good deal of discomfort.) We have not found it necessary to discuss this crowding with the students, there is no need for explanation.

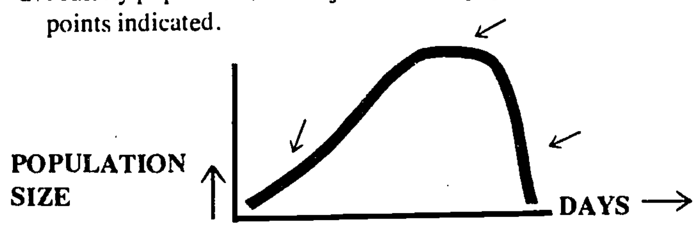
In this room we show a film that we have found to be an excellent introduction to the population problem. It is part of a biology series and takes a laboratory and natural history viewpoint, but nothing in the film is so technical it needs a biological background. *Population Ecology* (17 minutes) is a standard item in most science film libraries. (The film is available from Carl Huether's Population Film Catalog, University of Cincinnati, Cincinnati, Ohio 45221.) Previewing this film and preparing a guide for students greatly enhances its impact, particularly if the guide is distributed to students for the screening, and the film is stopped at appropriate points in order to answer questions and briefly discuss each major idea. Our guide is as follows:

Guide to *Population Ecology*

1. Fruit fly population, 1-liter jar: enter the population size at the points indicated.



2. Fruit fly population, 2-liter jar: enter the population size at the points indicated.



3. What is the meaning of "The population is in equilibrium?"
4. Even though there was unlimited food and water, the mouse population did not grow wall-to-wall. Why?
5. At maximum capacity, how many times the mass of the *grass* would equal the mass of the *rabbits*?
6. What are the major revolutions that have led to rapid human population growth?
7. *Population Ecology* was made in 1963. How many years from *now* should the population be double that of 1963; in the United States; in Africa; in India; in Mexico?
8. The film mentions the energy involved in maintaining the world's food supply. Besides the sun, what is the major source of fuel used today for maintaining that supply?
9. Quickly sketch a potato: how many Calories do you think it has per gram? What does it cost you, retail, per pound? What is the meaning of "Potatoes made of oil?"

10. If all resources were unlimited, what might cause the human population to level off?
11. What major resources are already in short supply?

Following screening of the film we point out the necessary changes since the film was produced in 1963 in growth and total figures for the world and the countries mentioned. We rely on the Population Reference Bureau's *World Population Data Sheet* for current figures. At the close of the period, in the quiet and the stuffy air, we ask everyone to feel his or her wrist pulse. We then consider the fact that the world's population is increasing by 2 individuals with every beat of an average pulse as we leave the room. (Current growth estimates give an increase of about 2.4 per second.)

In discussion sections, we talk over the types of actions that are realistically possible for students. Student support of various population organizations is encouraged. The social impact of personal family decisions is considered.

In recent years we have noticed that an increasing number of students do not take for granted that they will have children, and most of them readily see the need for a 1- to 2-child family maximum.

We never allow the discussion to stop at this point. The most important population decisions for any American concern lifestyle. It is reassuring to think that all American families might, in the future, have no more than one or two children. But no longer can each of those children consume world resources at a rate 100 times that of their brothers and sisters in the Third World.

VII. Understanding What's On The Bill — An Activity

This activity is designed to help decipher the meaning of home utility bills. It emphasizes the many connections between home energy conversion and the larger system of our surroundings. It enables students to begin questioning what is meant by "quality of life."

A week prior to carrying out the activity, all students are asked to locate stubs from their various home energy bills: electricity, natural gas, fuel oil, and automobile gasoline. We have found some resistance among our families to letting these stubs and bills get out of the house — in some cases even resistance to having the students see them. Emphasize that the bills are not to be kept, the teacher isn't prying, and hope for the best. Originals are best since they enable you to deal with slogans, pictures, and logos, as well as numbers. It is advisable to hold up your own bills as examples when the assignment is made.

A. The bills themselves are worthy of group inspection before analysis of the numbers begins. What utility companies are represented? From what are their names derived? Which are private, which public? How do they choose to symbolize themselves? What pictures, what slogans are used? ("Power for Progress — Water for Life," etc.)

B. Now, working either as a group or individually, follow the procedure outlined here with each bill. The advantage of working through this as a group is that many opportunities for productive discussion arise en route, and figures from different bills are more meaningful as they are compared. We wrote the procedure out on a ditto, so that each student could keep a record of his own calculations and eventually have a take-home energy profile of his household.

1. Electricity

a. How many days are covered by the bill?

b. What is the difference between the meter readings shown?

c. What are the measurement units for this difference?

d. What is your household's average electricity use per day?

2. Natural Gas

It has been our experience that natural gas bills are anything but clear. Gas meters read in 100's of cubic feet, which may or may not be indicated on the bill. A meter difference of 40, for example, actually means 40 times

100 cubic feet, or 4,000 cu. ft. Once you have established the number of cubic feet you can complete steps (c) and (d) below. (There is more information provided on the bill, but it is so hidden that it is too confusing to deal with as a class. Very briefly: The energy content of a cubic foot of natural gas is about 1,000 British Thermal Units (BTU's). A "billing factor" indicates the number of 1,000's of BTU's in a cubic foot of the specific gas provided. For example, a billing factor of 1.03 or 1/03 indicates each cubic foot of gas contains 1,030 BTU's. Sometimes "Thermal Units" are also shown. A gas company's Thermal Unit is actually 10,000 BTU's. For example, a bill showing 50 Thermal Units means 50 times 10,000 BTU's, or 500,000 BTU's.)

a. How many days are covered by the bill?

b. What is the difference between the meter readings shown?

c. What are the measurement units for this difference?

d. What is your household's average natural gas consumption per day?

3. Fuel Oil

Oil is at least as much a problem as natural gas. You may find nothing but a price on the bill. The oil may be measured in inches, in which case you have to so some nifty solid geometry after discovering the dimensions of the tank involved. If you are going to deal with home heating oil, call up a local supplier first and work out a way to deal with the bills the students will be bringing in. (A barrel is 42 gallons when dealing with oils.)

a. How many days are covered by the bill?

b. What is the difference in readings shown?

c. What are the measurements for this difference?

d. What is your household's average oil consumption per day?

4. Gasoline

If all is going smoothly, doing automobile fuel consumption here is appropriate. If not, stick to "in-house" energy use for now.

a. How many days are covered by the bill (credit stub)?

b. What is the dollar value of gasoline shown?

c. What is the approximate cost per gallon of the gasoline used?

d. How many gallons of gasoline were consumed? (b divided by c)

e. What is your household's average gasoline consumption per day?

C. Using the above figures, the next step is to develop a *total* household energy use figure. This requires converting to a common energy unit. The math involved can be simple and elegant, easy for 10th graders to master if it is approached clearly and methodically. Our choice of a unit is the Calorie. We want to be able to make comparisons to food energy systems in subsequent parts of this unit. We also want to get away from "all-electric" thinking, even to the extent of choosing an alternative to the commonly used kilowatt-hour for this very reason. The conversions to Calories are as follows:

1. Electricity
Kilowatt-hours/day X 860 Calories/kwhr = Calories/day
2. Natural Gas
Cu. ft/day X 260 Calories/cu. ft. = Calories/day(*derived from a BTU content of 1,030 per cubic foot.)*
3. Fuel oil
Gallons/day X 34,000 Calories/gal = Calories/day, *or,*
Barrels/day X 1,400,000 Calories/bbl = Calories/day
4. Gasoline
Gallons/day X 32,000 Calories/gal = Calories/day
5. Add the total Calories/day from all the above sources to arrive at the total household Calories/day.

D. To standardize this information further, we proceed to derive the *per capita* power rating for the household. This is obtained by dividing the total Calories/day figure obtained above by the number of individuals living in the house.

At this point we have found it profitable to pause and broaden our view. Here are some per capita Calorie/day ratings for other nations for purposes of comparison with the students' own households:

Afghanistan	600 Cal/day	Philippines	6,300 Cal/day
Bolivia	4,200 Cal/day	Spain	34,000 Cal/day
China	11,000 Cal/day	Uganda	1,500 Cal/day
Ethiopia	800 Cal/day	U.K.	110,000 Cal/day
France	80,000 Cal/day	U.S.	230,000 Cal/day
Guatemala	4,200 Cal/day	U.S.S.R.	92,000 Cal/day
India	4,200 Cal/day	World	40,000 Cal/day
Japan	65,000 Cal/day	World without U.S.	27,000 Cal/day
Mexico	25,000 Cal/day		
Nepal	200 Cal/day		

(Figures derived from Ritsch and Castleman's "Lifestyle Index.")

While student averages are generally well above the level of the less consumptive countries shown, there is bound to be some consternation at how far the students' averages fall short of the United States' average. The reasons for this begin to become apparent in the next section. For now it is a puzzle worth leaving unsolved.

E. Remember the Laws of Energy and Order: The system that provides energy to the home uses vast amounts of energy itself! We extend our energy analysis to include the energy required to supply the energy used in the home and the automobile. Good statistics for calculating the full energy cost of energy supply, including mining, refining, construction, transportation, plant efficiency, and even industry employee energy consumption are simply not available. The essential science of energy accounting is in its infancy. The size of the electricity system conversion factor given below is due primarily to plant operating efficiencies of only 30 percent when fossil fuels are used. If electricity is delivered from hydroelectric sources, this figure may be wide of the mark; we have no reliable data, which would have to include the construction and maintenance costs fo the dams, the energy cost of beach erosion from lack of silt, and transmission networks.

For fossil fuels used directly in the home or automobile, conversion factors are lower and apply to the operating efficiency of refining the fuels and, with considerably less accuracy, to the energy costs of mining and transporting the fuels. (The conversion factors below are derived from Ritsch and Castleman.) The totals give total system energy use for each category.

1. Electricity (Coal) Calories/day X 3.6 = Calories/day total
Electricity (Oil) Calories/day X 2.8 = Calories/day total
Electricity (Nat. Gas) Calories/day X 3.1 = Calories/day total
Electricity (Source unknown) Calories/day X 3 = Calories/day total

2. Natural Gas, Fuel Oil, and Gasoline Calories/day X 1.1 = Calories/day total

3. Add the Calories/day totals from all the above sources to arrive at the Total System per capital Calories/day.

The per capita Calorie/day rating obtained in step 5 is now appropriate for comparison with the world and national figures for per capita Calories/day given in the previous section. The world and national figures were obtained by taking a nation's total energy conversion and dividing by its population. This total energy figure obviously includes the system energy involved in bringing energy to households. Again, consternation is likely, when it is seen that class figures *still* fall substantially lower than the US average. But the picture should become clearer when you add in the non-direct-household energy uses in the United States which contribute to fattening our total so much. There are many good departure points for discussion, including manufacture of all goods; all construction; all private and public services; the military; and all branches of the food industry. An attempt to assess the role of each sector of activity in the United States in energy terms can be found in Makhijani and Lichtenberg. It is particularly appropriate for the discussion to end on the subject of agriculture. While the figures do not include the actual Caloric value of food grown, they do include all branches of the food *industry*, including "production," processing, packaging, shipping, retailing, advertising, and so forth. This subject will be explored in greater detail in a later presentation on the Green Revolution.

F. Remember the Laws of Energy and Order: they tell us that all energy conversion ultimately degrades energy into heat. The Calorie/day figures also express per capita daily contributions of heat to the environment.

To illuminate this process it is useful to recall activities carried out in "Understanding Energy and Order." Where did the heat from the light bulb go? What happened to the light from the bulb, eventually? After heat entered the water from the hot plate did it remain in the water? As the automobiles found their way through the concrete jungle, did they contribute heat to the surroundings? What parts of an automobile can easily be shown to give off heat?

Another interesting exercise is to take the average per capita US heat figure, which is 230,000 Calories/day, multiply by a round total population figure, 200,000,000, and compare this to other countries' total heat production per day. What do these figures suggest about relative environmental disruption?

G. To complete this series of activities, a home assignment is in order: namely, to take an energy inventory of the household. This can be outlined in different ways, depending on the time available. Essential activities are: location of household energy meters; a wattage survey of all appliances; some experimentation, with family cooperation of course, with altering rates of energy use, keeping close check on the meter(s). The same activities can be carried our in the classroom or school building. (Remember that every time the rate of use goes down by one kilowatt [electric], the total system use has been reduced by at least 3 times as much!)

H.The tedium of the above calculations is made well worthwhile by the exciting conclusion to this activity, the follow-up discussions. *Is* energy use a direct measure of quality of life?

Students automatically put forth the thesis that the amount of energy use directly reflects quality of life, standard of living. More is better. Does this mean that the student whose power rating is twice that of another lives at twice the quality of life? Does the teacher who lives at one-fifth the power rating of many students live at only one-fifth their quality of life? How is "quality of life" related to wattage? As the students more carefully examined disparities within the classroom and among the industrialized nations, their assumptions that energy use is directly related to quality of life weakened. We discussed how it was possible to enjoy life with much reduced energy consumption, and we explained what we have done over the last few years to live, consciously, at a lower level of energy consumption.

We discussed the future as well. Does the projected rate o:

increase in per capita energy use in the United States correspond to any increase in quality of life? If energy use has doubled, per capita, since the 1950's, does that mean everyone in the United States is enjoying life twice as much? Would we be twice as happy if we allowed another doubling? What would be the personal and environmental costs of that?

Students leave this discussion realizing that "quality of life" is very difficult to define and wondering if they and the planet might live even better with a reduced consumption of energy.

VIII. Understanding What's In the Container Container An Activity

This activity is designed to demonstrate how energy and food are interconnnected, in both a technical and an economic sense and to provide some concrete examples of the inefficiency of American agriculture and the scale of the world food situation. "Watch Out, MacDonald's!"

This is to be conducted in a manner parallel to "Understanding What's on the Bill," but does require the use of some simple weighing apparatus. If metric equipment is unavailable, all of your figures can be converted using these equivalents: 0.45 kg/lb; 28g/oz.

Students are asked, in advance of this class period, to bring in one or two packaged foods from home. Emphasis is on examples of over-packaging. An analysis of the foods and their packaging is then conducted. We find it helpful to demonstrate the entire procedure for the whole class using a can of Pringles Potato Chips, our favorite example. (Apparently it is necessary to use paperboard, plastic, and aluminum to raise the price of a pound of potatoes from 10 cents to $1.50.) To avoid wasting any of the food during the activity have various other clean containers handy.

I. Understanding What's *in* the Container

a. What is the net weight of the food?
b. How many Calories/unit of weight does the food contain?
c. How many Calories are provided by the food in the container, total? (Occasionally this information is provided on the package. In other cases it is necessary to weigh the food and to take Calories/gram figures from a Calorie chart.)

II. Understanding What's in *the Container*!

a. What is the nature of each kind of packaging making up the container?
b. What is the weight of each component of the container?
c. What is the energy used per unit of weight for each component?
d. What is the total number of Calories used in manufacturing the container? (Here we rely on figures derived from many sources. See especially *Energy and Food*, Fritsch, *et al.*)

Conversion Factors for Packaging Materials — Throwaways

Paper, Cardboard:	6,000 Calories/kg
Steel, Bi-metal:	12,000 Calories/kg
Aluminum:	64,000 Calories/kg
Glass:	7,500 Calories/kg
Plastic:	3,500 Calories/kg

III. Understanding the Difference

a. Calorie Content of Food, Total ____________
b. Calorie Content of Container, Total ____________
c. Total Calorie Content of Item ____________
d. Fraction Representing Food Calories/Total Calories
e. % of Total Energy in Item that is Food Energy ___

IV. Why Recycle What You Could Return?

a. Recycling of most materials represents about a 10 percent energy savings. If all materials in the container were recycled, what would be the Total Energy Content of the Container?
b. Returnability of glass and some plastics saves as much as 75 percent. Using the chart below, caluclate the Total Energy of the Container if it were made entirely of returnable glass or returnable plastic.

Energy Content of Glass Returnables =
Glass Throwaways X .2
Paper Throwaways X .50
Steel Throwaways X .35
Aluminum Throwaways X .30
Plastic Throwaways X .60
Plastic Returnables = Plastic Throwaways X .40

Discussions following this activity inevitably revolve around the nature of waste, the manner in which tastes are shaped by advertising, and the estrangement of most Americans from the sources of their foods. At this point, we also try to resurrect the Calorie from the ashes of the weight-watchers' fires. There is generally a strong bias against Calories among our students. It is worthwhile to break down this bias and examine its origins. After all, energy in food is essential to life, and Calories are nothing more than units that allow us to measure energy. Why does a society go to such lengths, in fact use so much energy, to fabricate and package materials designed to have no energy content but to be sold as food!? What right does a society have to do this in light of the world food situation?

IX. The Green Revolution — Presentation

We now try to involve students emotionally as well as intellectually in an understanding of world hunger, food in the United States, and the common misconceptions about the Green Revolution. We schedule this presentation for about 90 minutes, working the school lunch period in as the beginning of the class. The day before the presentation, we announce that the students need not bring a lunch; lunch will be served in our class.

At the door the following day, students are greeted by us in our best Ugly American Tourist outfits — loud shirts, dark glasses, hats, and so forth. One lab assistant comes as a photographer, another as a nurse. And each student is handed a "nation card" as a meal ticket. These are not explained until later.

We quickly settle down to a formal presentation before lunch. This presentation reviews, initially, the food requirements of the average person, (dependent, of course, on age, weight, activity levels): 2,000-3,000 Calories per day; 40 grams of protein per day (on an animal protein diet); 60 grams of protein per day (on a plant protein diet). The subtleties of protein complementarity are mentioned, but not explained in any detail. (Lappé).

Next comes a brief review of energy transmission in food chains. Students are reminded of the energy loss at every level. We use the rough figure of 10 percent transmission of energy from one level to the next. And we tie this concept to world diets by explaining why many people can't eat meat. (Lappé)

We move next to a discussion of the nature of agriculture in the United States. Potatoes really are made of oil, we point out. The figures below are displayed on an overhead projector. Only a short explanation is needed, for although the concept is new it is not difficult.

Per capita calories expended per day in some agricultural activities in the United States:

Tractor operation: 3,5000
Fertilizer porduction: 2,800
Farm electricity: 520
Farm machinery production: 360
Food processing: 3,500
Farm Industry Total: 11,000

These rough figures are, on the whole, conservative; they don't take into account many aspects of transportation and maintenance throughout the industry. The energy expenditure involved in trips to the supermarket, for instance, is not included. Nor is advertising. At a *minimum*, then, 11,000 Calories are used in the provision of food in the United States, each day, for each individual. (Hirst; Pimentel, *et al.*; Perelman)

To show how potatoes need not be made with oil, we present the following data from a group of New Guinea Highlanders (Rappaport).

Per capita calories expended per day in all agricultural activities in Tsembaga culture (New Guinea)

Clearing: 110
Fencing: 50
Planting and weeding: 270
General maintenance: 80
Harvesting: 90
Carrying: 160
Agricultural Total: 760

The above figures are not conservative, in the sense that they *do* include *all* aspects of the agricultural system.

The US uses 11,000 Calories per person per day, the Tsembaga use 760! The real meaning of these figures becomes clear when one looks at the number of Calories *grown* per capita per day. In the United States, the figure is 3,330 Calories per person per day. Among the Tsembaga in New Guinea the figure is 13,400 Calories per person per day! In other words, 11,000 Calories of input yields 3,330 Calories return in the US; 760 Calories provides 13,400 Calories return in the Tsembaga culture.

Since they, like us, need only 2,000-3,000 Calories per day, the Tsembaga regularly give a large portion of their food output to their pigs, insuring an annual intake of animal protein to supplement the daily protein derived from their vegetable sources. Their diet is varied and exceptionally nutritious.

To bring this matter into better focus we give a copy of the following graph to all students.

It shows dramatically how the "efficiency" of US agriculture is a false efficiency, resting on the well-head of fossil fuel

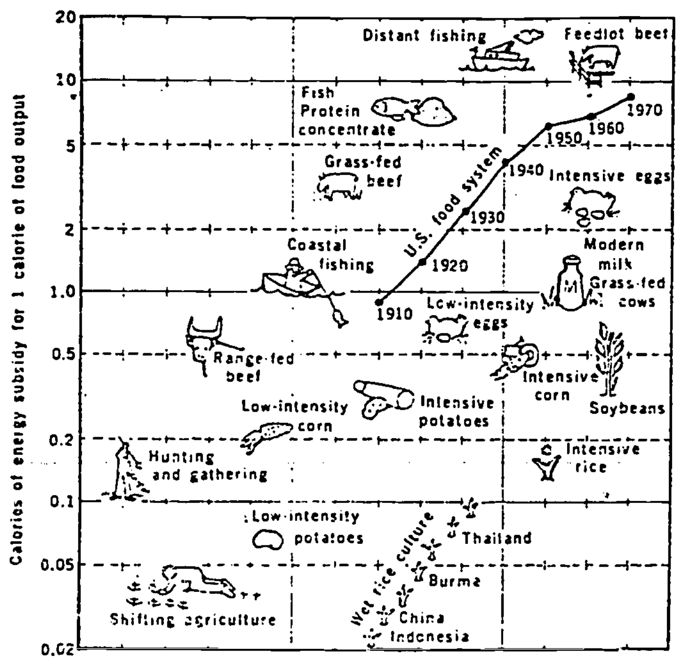


Fig. 5. Energy subsidies for various food crops. The energy history of the U.S. food system is shown for comparison.

exploitation that opened for this country in this century. (Graph from Steinhart and Steinhart)

By this point in the presentation we're all rather hungry. Next, then, we prepare for lunch. While lunch preparations go on behind, one of us draws attention to and explains the nation cards handed out at the beginning of the presentation. An example of one is shown below:

CENTRAL AFRICAN REPUBLIC

1. 2,000,000 — 4. Sudan
2. 300 — Zaire
3. 33 years

1. Population. 2. Number of Calories per person per day *below* the world average. 3. Number of years to double the population at current growth rates. (We write this figure in red.) 4. Names of bordering nationswith shortages of at least 300 Calories per capita per day. o Indicates one of the 15 fastest growing nations in the world. oo Indicates the presence of one or more of the 25 largest metropolitan areas in the world. ooo Indicates one of the 15 largest populations in the world. We used, for this exercise, the nations that are lowest in food resources. These statistics, in

conjunction with the lunch itself, should serve to emphasize the political and international ramifications of what might seem at first to be merely gloomy statistics of malnutrition.

Meanwhile, lunch has been readied. A picnic basket has been set on a table in front of the group. A tablecloth, candles, wine goblets, a decanter, fruit, and other delicacies are produced. (A lttle light piano dinner music is the correct background.) We (teachers and lab assistants) proceed then to tread a thin line between an elegant picnic and the eating scene from "Tom Jones."

After settling into a pattern of savoring, discarding, and chatting, we let the table talk drift into a consideration of the myths behind the Green Revolution. One of us proposes a myth, for example — that the oceans will soon provide all the food we need, and another points out the problems and contradictions until the myth recedes before some other proposition. Almost as a script for this little drama, we use section 6-4 of G. Tyler Miller's excellent book, *Replenish the Earth*. Miller outlines the following series of food myths: The Land Myth; The Water Myth; The Ocean Myth; The Synthetic-Food Myth; The Education Myth; The Evolution Myth; The Space Myth. Eventually all these have been exhausted, and one of us turns to the need for some immediate action.

We look out across the sea of students and see them as the Third World. In our class *we* happen to be just about 6 percent of *them*. The decision is made to set up an aid program on the spot. Donning paper "CARE" hats we bring out a pail of water, powdered milk, dried bread, and enough bowls to go around. The bowls are passed out. The milk is mixed. And we pass out milk and break to those that ask for it among the needy.

The students are restless, indecisive, and hungry. Some want the food. Others are repulsed by the whole idea. With as straight faces as we can maintain amid the confusion, we continue to call out, asking who wants the nutritious milk and ladling it into bowls. Some throw the bread back. A few students, either to play our game or quite seriously to get the food, plot to take the table behind us. We ask them to sit down, and they do. There is no doubt that this presentation creates confusion and some emotional discomfort during the class. There has been no lunch of the style expected — except for the few.

It is essential that discussions follow this presentation. Under no circumstances should it be attempted when no classes will be held the next day. Some students are angry and feel tricked. We ask them to explore this in light of their generally well-fed condition. How is the anger they feel different from the anger of someone experiencing starvation? Some feel guilty about the waste they saw. How can they promote the reduction of waste in their lives? Some are disgusted about the way others acted around them, "like animals." How *do* animals act? What sorts of food shortages do they face, and how are they dealt with?

Some were disgusted by the powdered milk, specifically. What is the nutritional value of powdered milk? How does a taste develop? How can milk be transported efficiently? Some were just too hungry to do anything. How did it feel?

In the short term, primarily the first day following this presentation, there is a good deal of resentment and a disruption of class feeling. In the long term, our discussions are exceptionally productive, and we have had many students come back a year later to tell us of their continuing consciousness of the food problem, their memory of the presentation, and their growing commitment to act to solve the problem. We feel that such an experience can be of great value to people who frequently see the faces of the world's starving on television screens and in magazines and are used to shaking their heads in response. This immediate experience sharpens their awareness and awakens their sensitivity. In many classrooms, we can imagine that such a drama should not be attempted. To a great degree, its success hangs on the rapport established up to this point in the class. In our own course, we have the confidence of knowing that what is to follow is a week of constructive discussion of alternatives, a time in which we build on our understanding of the problems.

X. What's Keeping Us? — Presentation

Our final presentation and end-of-the-year discussions focus on the alternatives that are still available in the face of the problems we have studied. A tape is set up in the background which regularly interrupts us at about 5 minute intervals with Pete Seeger either whistling or singing "Time's a-gettin' hard, boys. . . Money's gettin' scarce. . . ."

We take a final look at common themes or problems underlying global crises utilizing six major headings. The categories we use are:

1. Nature exists for me. . .
2. Growth is good. . .
3. Nationalism and Militarism
4. Technology always saves us. . .
5. Ignorance is bliss — "Not to decide, is to decide."
6. ________(fill in your own)

In each categoy we give examples of the problem using contemporary sources. Corporate reports, newspaper business sections, and the advertising found in *Fortune* provide ample examples of the kind of thinking we need to challenge and to overcome.

We also cite instances where people *have* overcome such attitudes, found alternatives, and made their lives better by the effort. We retell successful community pollution control fights, cases in which "demand" for power gave way to the need for open space, clean air, and water; cases in which technology was set aside that simply was not needed; cases in which informed citizens were able to act for what they believed in. Events that the teachers have had contact with are best, since the idea that the teachers themselves have already been and continue to be involved in the search for alternatives is central to the success of the presentation.

We try to convey a sense of urgency, especially a sense that it is the students' future we are talking about. We try *not* to motivate them by guilt. While people are threatening their own survival, the students did not create this situation. We tell them that once they are aware of the problems, however, they have the responsibility to do whatever they can to change the situation. We point out that there is no guarantee of success. We discuss whether it is worth trying at all. And we open up the question of how to deal with hopelessness, asking how it is that many people find reasons to go on, to try in spite of seemingly insurmountable odds.

This final presentation weaves its way through theory, ethics, analysis, and concrete examples. Although it is a serious presentation, the citing of steps taken toward ecological sanity helps students come to understand that they are not alone and that there are people who *are* standing in the way of further destruction and, ocasionally, even reversing ecological damage.

Beyond specific examples of individual and regional actions, we mention the following developments: the development of solar and wind technology (Clark); the development of environmental accounting through the National Environmental Policy Act and the Impact Statement procedure; the movement toward ascribing legal rights to natural objects (Stone); the movement to make work a healthy, engrossing part of life, rather than stultifying and dehumanizing (Stellman; Schumacher); the movement toward formulation of an economy based on energy currency (Hannon).

Throughout the presentation we use slides and other visual images to underscore ideas. NASA's series of photographs of the earth from space are excellent. At the end, we try to establish a sense of beginning. The last items on our dittoed outline for the day are, *Introduction:* There's nothing like an altered lifestyle to keep you on your toes. . . .*Reading Assignment*: An altered lifestyle does not help unless it is an informed lifestyle. Your reading on each of the above issues (the presentation categories) is due each time you have to make a decision for the rest of your life. Be the first person on your block to have any idea what's going on. . . ! Two recordings are particularly successful to provide the proper musical close to this unit: James Taylor's version of "You've Got a Friend," and Pete Seeger's "My Rainbow Race."

Carrying out this unit with our students is a powerful experience. We are all challenged, and we leave ourselves no excuse for inaction. Some approaches to ecology leave students with their noses to the ground, peering through a hand lens. Others, dealing with pollution and endangered species, only leave students emotionally wrought. Some are merely catalogs of castastrophes and leave students too depressed for action. What is needed is environmental education that brings us to the competence and commitment necessary for informed action. Becoming knowledgeable about current energy and ecological dilemmas is unsettling and scary when one understands the consequences of present trends. But students that have gone through this unit have *not* been paralyzed by the task they see before them. Their enthusiastic response has given us new energy and hope.

* One of 15 fastest-growing nations

● Contains metorpolitan areas among 25 largest population as of 1975

o One of 15 largest populations

1. Population
2. Number of C. per person/per day below world average
3. Number of years population will double
4. Names of bordering nations with 300 C. per capita shortages

BURMA	
1. 31,000,000	4. China o ●
2. 300	India o ●
3. 29 years	Laos

PAKISTAN o ●	
1. 71,000,000	4. Afghanistan
2. 300	China o ●
3. 22 years	India o ●

NORTH KOREA	
1. 16,000,000	4. China o ●
2. 300	
3. 29 years	

YEMEN (A. Rep.)	
1. 7,000,000	4. Yemen (People's Rep.)
2. 500	
3. 24 years	

INDONESIA ●	
1. 136,000,000	4. Philippines*
2. 700	
3. 27 years	

CHINA o ●

1. 823,000,000
2. 300
3. 41 years

4. North Korea
   Afghanistan
   Pakistan o ●
   India o ●
   Nepal
   Burma

RWANDA

1. 4,000,000
2. 500
3. 27 years

4. Uganda
   Zaire
   Burundi

PHILIPPINES *

1. 44,000,000
2. 600
3. 21 years

4. Indonesia o ●

BURUNDI

1. 4,000,000
2. 500
3. 30 years

4. Uganda
   Zaire

NIGER

1. 5,000,000
2. 400
3. 26 years

4. Algeria*
   Upper Volta
   Chad
   Mali

CHAD

1. 4,000,000
2. 400
3. 35 years

4 Niger
   Central
   African Rep.
   Sudan

MOROCCO

1. 18,000,000
2. 300
3. 24 years

4. Algeria *

IRAQ *

1. 11,000,000
2. 300
3. 20 years

4. No bordering nations are below the 300 level; but one is Jordan, also one of the 15 fastest-growing nations.

LAOS

1. 3,000,000
2. 500
3. 30 years

4. Burma
China o ●

YEMEN (People's Rep.)

1. 3,000,000
2. 400
3. 32 years

4. Burma
China o ●

SOMALIA

1. 3,000,000
2. 700
3. 27 years

4. Ethiopia

SUDAN

1. 18,000,000
2. 300
3. 23 years

4. Chad
Central African Rep.
Uganda
Ethiopia
Zaire

UPPER VOLTA

1. 6,000,000
2. 800
3. 30 years
4. Mali
   Niger

MALI

1. 6,000,000
2. 400
3. 29 years
4. Algeria*
   Guinea
   Upper Volta
   Niger

ALGERIA *

1. 17,000,000
2. 800
3. 22 years
4. Morocco
   Mali
   Niger

ZAIRE

1. 25,000,000
2. 400
3. 28 years
4. Central
   African Rep.
   Uganda
   Angola
   Sudan

NEPAL

1. 13,000,000
2. 400
3. 32 years
4. India o ●
   China o ●

INDIA o ●

1. 613,000,000
2. 400
3. 29 years
4. Pakistan o ●
   China o ●
   Nepal
   Bangladesh o
   Burma
   Sri Lanka

BANGLADESH o

1. 74,000,000
2. 700
3. 41 years

4. India o ●

BOTSWANA

1. 700,000
2. 500
3. 30 years

4. Angola

GABON

1. 400,000
2. 300
3. 69 years

4. No bordering nation has more than 300 missing C., but Angola, Zaire, and Central African Republic are all within a few hundred miles.

BOLIVIA

1. 5,000,000
2. 600
3. 28 years

4. All bordering countries are above the 300 C. line, one of them is Brazil, one of the 15 largest.

GUINEA

1. 4,000,000
2. 300
3. 29 years

4. Mali
Liberia

UGANDA

1. 11,000,000
2. 400
3. 24 years

4. Sudan
Zaire

HAITI

1. 5,000,000
2. 800
3. 50 years

4. Dominican Rep.*

HONDURAS *

1. 3,000,000
2. 400
3. 20 years

4. Guatemala El Salvador

ECUADOR *

1. 7,000,000
2. 500
3. 22 years

4. Columbia *

COLOMBIA *

1. 26,000,000
2. 300
3. 22 years

4. Ecuador*

ANGOLA

1. 6,000,000
2. 500
3. 30 years

4. Zaire Botswana

ETHIOPIA

1. 28,000,000
2. 300
3. 29 years

4. Sudan Somalia

MALAWI

1. 5,000,000
2. 300
3. 29 years

4. Mozambique

MOZAMBIQUE

1. 9,000,000
2. 400
3. 30 years

4. Malawi

EL SALVADOR

1. 4,000,000
2. 500
3. 22 years

4. Guatemala
Honduras*

AFGHANISTAN

1. 19.000,000
2. 500
3. 28 years

4. China o ●
Pakistan o ●

GUATEMALA

1. 6,000,000
2. 400
3. 24 years

4. Honduras*
El Salvador

DOMINICAN REPUBLIC *

1. 5,000,000
2. 400
3. 21 year

4. Haiti

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3-15-76 — M.T.

Mark Terry and Paul Witt:

Energy & Order

or

If You Can't Trust the Law Of Conservation of Energy, Who Can You Trust?

This is the best energy unit I've ever seen — it's complete, it's interesting, it's fun, it's hands-on, and it doesn't require fancy equipment. Best of all, it should involve students and make a difference in their lives. It was developed for tenth-graders, but I think it could be used at many other levels with success.

— Gabriel Navarre

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