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A Hands-on Approach to Environmental Quality

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OBJECTIVES: This unit is designed to acquaint the student with problems of environmental quality and to demonstrate ways by which the student can better cope with problems of pesticide residues and other environmental contaminants.

GOALS: The students will learn to plant, tend and harvest an organic garden. More importantly they will learn about environmental quality and what they as individuals may do about the problem. They will become aware of potential hazards in foods and learn how to partially avoid them.

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INTRODUCTION: As each high school student approaches independent adulthood, it is important that they understand the factors influencing the quality of their own environment and how they may of their own volition modify this environment for a safer, healthier life. In order for students to understand and appreciate the quality of their environment, they must have an understanding of how this environment impacts on their lives, and of how environmental quality is related to health, society and the natural world. This unit assumes that each student will be planting their own garden in a school community garden. The student's plot in the community garden becomes the laboratory in which questions may be posed to the natural community and answers obtained. By so doing, it is anticipated that each student will gain an understanding of the environmental **relationships** necessary to improve the environmental **quality** of their own lives.

The first question to be answered is: What is the composition of a garden and what goes into a garden? This might best be answered with a flow chart as shown in Figure One. A thorough understanding of this chart will greatly increase the student's understanding of what is actually going into plants raised in a garden.

The second question is: What are the benefits to the student in the actual planting of a garden? The answer to this question depends in large part upon the enthusiasm and diligence of the student. Students who have prepared the soil and seedbeds, sewn the seeds, watered, coped with insects and other pests, weeded and harvested their own garden will very quickly and with very little effort grasp a large amount of information concerning environmental quality, and will be able to apply this knowledge to their own lives. In addition, students will benefit from learning to work together effectively in small groups, as well as learning a practical skill that will be with them throughout their lives.

BACKGROUND:

At HSC we have, by design, a mixture of students that is one third each white, Hispanic and Afro-American. Many of our students are from urban environments that are impoverished at best. They have been raised in urban surroundings that are neither healthful, nurturing nor supportive. As a consequence, many of our students believe that they cannot succeed in school and in life and often act out their frustrations with a system that has failed them. One of our goals at HSC is to foster in these students a sense of accomplishment and to teach them that they can succeed and have a successful career as a student both in high school and in college. The community garden is an ideal vehicle through which to bolster student self-confidence and to instill a sense of pride in accomplishing a definite objective. We have found that as students progress with their garden plots, they become more confident, and this carries over into the academic side of the course. Most students show a real improvement in academic grades as they work hands-on in their gardens.

We also try to instill in our students a sense of cooperation. Many of our students are rather distrustful of people in general and of teachers and some classmates in particular. By working together on a community garden most students come to realize that they can cooperate with other people and that there is much to be gained through cooperation. They learn that they can accomplish much more and do tasks that they could never accomplish individually. While each student has their own garden plot, they must work together to clean up the site, rototill, fence the entire garden, plant the flower beds and bring out the hose daily.

Our method of gardening is what is generally termed "organic gardening". This method emphasizes a natural balance in the garden between soil, plants and humans. (This is a very popular method, and there are over 33,000 references on the Internet.) The production and use of compost is taught, as well as companion planting and the use of natural pesticides. I have used rotenone and pyrethrin as my only insecticides for over thirty years. And it is amazing what insects may simply be picked off of plants and disposed of. We have two large compost bins which the students maintain and harvest from year to year. We teach students how to actually plant and maintain the garden plots. I am rather amazed that many students have never planted a seed or watched one grow. The production of a successful garden is very satisfying and a real confidence-booster for students. And it is most importantly a very successful method for making students aware of environmental quality and associated problems.

HISTORICAL BACKGROUND:

Originally, gardens and farms were propagated using all natural additives and methods. This general method has become known in modern times as organic gardening. Organic gardening depends upon the health of the soil to maintain crops. Thus the emphasis originally was upon nurturing the soil through the use of manures and compost. It was thought that if the soil was healthy, the crops that were raised would be healthy. These crop plants would be better able to "fight off" pests, that is, they would show greater resistance and tolerance to pests. For many years the major defense against insect pests was good soil, coupled with good husbandry practices (such as crop rotation, prompt removal and composting of all infected material, picking insects off of crop plants by hand and sometimes burning the contaminated plants). (I have not been able to locate the exact reference, but these ideas occur in the writings of Thomas Jefferson)

Eventually someone discovered that copper and arsenic compounds, such as Paris green, were effective as insecticides. Perhaps these were the first real problem biocides in the environment. Both of these elements are metals. As such, they did not disappear from the environment, but rather persisted and accumulated in the soil. There are reports that some French people could tell the difference in taste of the wines as Bordeaux mixture (a fungicide made of a combination of copper sulphate and lime) became common in the vineyards as a leaf-dusted pesticide.

At the end of the second world war, the use of DDT began the modern era of chemical pesticides. Although promoted as completely harmless to humans, it soon became apparent that DDT and related compounds were causing havoc in all ecosystems, and were in fact extremely toxic (Carson, 1962; Wargo, 1996). But DDT had been a great help at the end of WW II and most people embraced this new technology as being able to save mankind from the scourge of the insect world with no cost to humans. The USDA was particularly enthusiastic and licensed thousands of pesticide compounds in the 1940's and 50's.

But even as far back as the 1940's many people were alarmed at the effects of the new pesticides on the environment. Rodale's *Organic Gardening* became a popular magazine. Yet there were many people who ridiculed the ideas put forth in this publication. Rodale was thought of as a crackpot. The only people who took him seriously were those gardeners who were reluctant to put any more persistent man-made pesticides on their soil. It is somewhat ironic to me that the methods espoused by Rodale in the 1950's are so widely accepted today. They surely were not acceptable when first brought to the public's attention.

But what did mankind do before the availability of all these wonderful chemical pesticides that are now slowly poisoning the world? Were we all in a semi-starved state until 1947? No, of course not. But farming was conducted in a rather different manner. Crops were rotated so that non-migrating pests did not have a chance to become well established. Fields were cultivated so that weeds were not able to flourish. Fields were contoured-plowed. Fields were well-manured and limed when needed so that crops had good soil to grow in and were healthy to start with. And farmers were not afraid to do a little old-fashioned hand weeding and hoeing. I spent many June afternoons as a boy cutting morning glories and bindweed out of corn fields. Not a pleasant chore, but it did the job with no harm to the soil or crops.

As a young boy and later as a teenager, I had a chance to experience farming first -hand in Ohio in the late 40's and the 50's. I saw the change in our area from careful husbandry of the land to chemical pesticide and fertilizer use. My family did not willingly embrace this new chemical culture. We continued until the 60's using classic methods of husbandry, doing most of the work with teams of horses, making loose hay instead of baling it, threshing wheat instead of combining, manuring the fields in late summer, and generally using older, labor-intensive techniques. Finally, as I was in graduate school and others were retired, we sold our farms. The new owners took no time in drenching the land with pesticides and chemical fertilizers and getting rid of all of the livestock. And the interesting thing to me was that crop yields actually decreased over the next several years.

If you drive from Canton, Ohio down towards Columbus on routes 30 and 83 through Millersburg Ohio, you pass through country farmed by the Amish. Their religious beliefs prevent them from using almost all modern farming methods. They use no electricity or the internal combustion engine. They farm with horses, milk their cows by hand, and cling stubbornly to a way of life that is very hard to adhere to. They are often called the "simple people" although their lives are anything but simple. They are very private people, and would not open up to me at all until I had explained that I grew up on a farm working horses and tilling the land much in the same manner that they do. Then one of their elders spent three full hours answering my questions and explaining their farming methods.

The Amish are basically organic farmers. They farm some of the best farm-land in central Ohio, land that continuously is extremely productive. Why? Because the Amish maintain and improve the land. They use classic methods of crop rotation, weed control by cultivation, and manure their land each year. They do not use pesticides that I know of, and yet they have some of the most productive farm lands in the entire country. This has to raise a very basic question. Just how effective are all of these pesticides, anyway? In 1945, when pesticide use was minimal, only 3.5% of the corn crop was lost to insect predation. In 1990, there was a 12% loss of the corn crop to insects. This does not sound like the extensive use of pesticides is all that effective.(Pimentel and Pimentel, 1979; see also Wade et al, 1994, pg 297)

COMPOSTING:

One of the most basic and fundamental aspects of organic gardening is the use of compost. Adding compost to the soil increases the organic content of the soil, improves the structure of the soil, permits better water retention in the soil and facilitates mineral uptake by plants. It may also add a small amount of nitrogen to the soil, but it is not a fertilizer in the common sense. Excessive amounts of compost may actually result in nitrogen deficiency. If you are going to have an organic garden you must understand what compost is and how it is made.

Compost is partially decomposed organic material, mostly derived from plants. Compost is usually not purchased, but rather made at the garden site. If you do purchase compost, it is often sold as "humus" or "loam". But it is so easy to prepare that there is little advantage to buying it, other than time. Compost is prepared by simply piling scrap vegetable materials together. These can be grass clippings, leaves, waste foods (but vegetables only!), weeds and any other plant materials you can think of. A small amount of soil is mixed in to furnish the correct microbes, some water is added to dampen the entire pile and then you just let the pile sit until it has partly decomposed or "composted". Sounds simple, right? But there are a few other considerations that we had best mention.

If you just leave the pile sitting there, it may blow away or be disturbed in some other way. You need to make a compost bin to contain the materials. We have a store near our school that is only too glad to give away pallets. Pallets are ideal for a compost bin because they have large slits that let air into the compost. We have obtained materials for several bins and it has not cost us anything. All we did was to lash four pallets together with nylon cord to form a bin. You can also buy a number of different kinds of compost bins, but it is good for the class to work together recycling old pallets.

The more finely divided the plant material at the beginning, the quicker the compost will form. We have had good luck with running a rotary lawn mower over a pile of leaves and weeds, and catching the resulting chopped-up materials in the bag. This material is then added to the compost bin.

The one problem you may have with your material is getting it too compacted and/or too wet. If this happens, you do not get compost, you get rotted plants. And this material will not help your garden. So you must aerate the compost. This is why a bin that has slits in the side is ideal. In order to aerate the compost you normally turn the entire mass in the bin over with a spading fork every few days. We arranged our bins so that the front of the bin swung open like a door. This made turning the compost very easy.

As the compost forms in the bin, the vegetation is decomposing. Soil micro-organisms will feed off of the vegetable matter and this will raise the temperature of the inside of the compost pile to from 120âF to 160âF. This decomposition needs to be aerobic, thus the need for turning the compost. You must supply water but if you over-water you will eliminate the needed air and decomposition will become anaerobic.

Finally, when the compost is finished, it will be black and crumbly. Not quite like soil, but definitely no longer identifiable plant material. Usually at this stage we run the compost through a sieve made of hardware cloth and some 2 X 4's. (Available at any building supply store. They are easily constructed. Do not make the frame too large or the students will have a difficult time shaking it.). The sieved material we add to the garden, the residue we put back as starter material for the next batch of compost.

METHOD OF APPROACH:

Method is Organic Gardening. Organic Gardening (OG) is a system of gardening that depends upon the use of only natural fertilizers, natural insecticides and companion planting to maintain the health of a garden. Any method that teaches environmental quality should be simple and demonstrate a minimum of man-made additives to the natural system being studied. (I am well aware that a garden is not strictly-speaking a natural system and actually does not come anywhere near being so, but it is a system that may be manipulated and studied by high school students with some assurance of success.) The OG movement is rooted historically in the type of agriculture that was practiced in this country and in Europe in the eighteenth and nineteenth centuries.

Method is simple. What exactly is involved in OG? Plants are planted as seeds or set out as seedlings just as in any garden. However, the plants are aided in their growth only with natural products. No man-made chemical insecticides, fungicides, herbicides, rodenticides or fertilizers are used. Pest problems are solved in a number of ways, none of which involve chemicals that are foreign to nature. The simplicity of this method makes it inexpensive, low-tech, and time-intensive.

Method involves minimum of additives to soil and plants. There are basically four categories of garden pests Ð insects, fungi, mammals and birds. Each group of pests is handled in a different way. Below is a partial list of pests and the methods used in their control.

Mammals:

> Rabbits Ð chicken wire around the garden, dog droppings as a repellent used only outside of the garden, blood meal as a repellent used inside of the garden
> Rodents Ð chicken wire, traps
> Birds Ð netting over crops
> Fungi Ð good husbandry, keeping refuse composted
> Insects Ð pyrethrin for flying insects, rotenone for leaf-eating insects, and Bacillus thuringiensis spray. Fly paper is also effective. Others may be picked off by hand. Powdered tobacco is also effective but I do not use it except on non-food varieties of roses and other flowers. Companion plantings of marigolds, nasturtiums and other species are also helpful in repelling insects. And beneficial insects may be purchased and placed in the garden. These include Lady Bug beetles, Trichograma wasps, Green Lacewings and Praying Mantis.

In order to build up the soil, there are a number of other natural additives that may be used. These include:

> Bone meal Ð source of calcium and nitrogen
> Blood meal Ð source of nitrogen, organic material and iron
> Greenstone Ð source of phosphate
> Ashes Ð insect repellent and source of potassium.

Finally, there is the gardener. Most insect pests can be removed by hand. There are not that many of them. I have removed potato beetle larvae, tomato horn worms, cabbage worms and others by hand and disposed of them by simply dropping them into a container of rubbing alcohol or just plain water. The insects die quickly and may then be added as a source of nitrogen to your compost pile. (Kerosene or old anti-freeze are also recommended for this task, but then where do you dispose of the remains? Certainly not in the compost pile.) Plain old-fashioned fly paper is still available and effective, as are mosquito dunks, which slowly release *Bacillus thuringiensis* into ponds or other standing waters.

What is involved? For the students and/or teacher just starting into organic gardening I have prepared four lesson plans that should help students understand much more about soils and plant growth. These are:

Nature and properties of soils Ð Lesson plan #1

Seed germination and growth Ð Lesson plan #2

Composting Ð Lesson plan #3

Natural pest control Ð Lesson plan #4

These are included in a separate Appendix One. There is also included a separate Appendix Two of Teacher's Notes to help in the teacher's preparation of this unit. Appendix Three is a separate bibliography for organic gardening which includes a number of books that can guide a teacher and class through setting up an organic garden.

BASIC ORGANIC GARDENING

What is involved? The following steps are the basic procedure that one follows when starting a community garden. Again, refer to appendix Three for a complete bibliography of materials that will help get you started.

1. Selecting the site for the garden. The site must be within traveling distance from the school. Either the students must walk to the site or be able to get there by bus or other means of transportation. Many cities and towns now have organizations of community gardens. They are usually more than willing to help a school find and set up a garden site. The site must be secure and have water available.
2. Cleaning the site. **If the students can organize themselves into a clean-up crew, the site can usually be cleaned up with no trouble. Students must be extremely careful when cleaning up. Each student must wear sturdy, thick-soled shoes and heavy gloves. The site may have broken glass, nails, scrap metal and discarded hypodermic needles. I cannot stress enough the need for proper protective clothing and common sense. There need to be some parent volunteers who can haul trash away in a truck. When the students are cleaning up the site, they must be aware of any potential hazardous waste that may have contaminated the soil (such as containers of paint, lead paint or chips, oil or anti-freeze). Any bare spots must be noted.**
3. Testing the soil. A sample of soil from various parts of the site should be tested for standard

nutrients by the local extension service lab. Any bare spots should have a soil sample collected and tested separately. If the soil is bare, there are no plants growing. If there are no plants growing, why? Is the soil poisoned? You need to know before you plant there. (This does not include spots that are bare because there was something covering the spot, such as a piece of wood or plywood). It may be necessary to dig out a section of soil if it is visibly contaminated.

4. Preparing the soil for planting. Most often you will need to rototill a new site in order to prepare it for planting. Rototilling is a very effective method of loosening the soil and killing weeds so that the seeds may be planted. It is also an effective method of adding compost and fertilizers into the soil. However, rototilling also may kill some of the earthworms present in the soil. Earthworms are terrific natural aerators and mixing agents.

5. Planting and Planting **the garden (see below). Since not all seeds and plants are placed in the garden at the same time, it is a good idea to plan out the garden and have a calendar of planting dates. Students also need to know how deep and how far apart to plant each variety of vegetables.**

6. Weeding and Maintenance (pest control and water). Each student needs to learn to weed their garden and water if necessary. If there are many insects, the use of rotenone and pyrethrin is allowable. Unfortunately, by the time that the plants are up and doing well many schools are letting out for the summer. I have been fortunate in that there have been students who were eager to continue their gardens over the summer. The summer work must be on a volunteer basis.

7. Harvesting. Students may of course harvest their gardens any time during the summer. Most of the harvesting will be the next fall. This can be done in a separate class or with the same students, depending upon circumstance.

8. Preparing for next year. This involves work on the garden in the fall for the coming spring. It might include sowing winter rye, planting spinach and cleaning the garden of old vegetation that may harbor pests.

It would be impossible for me to write all that is needed in order for one to produce a successful garden. That is a separate book. (But see the section entitled BASIC GARDEN PLANNING below) There are many good basic gardening books that will guide both student and teacher through the joys and trials of organic gardening. Rodale’s *All New Encyclopedia of Organic Gardening* (Bradley and Ellis, 1992) is excellent. I have included a number of very good books on organic gardening in a separate bibliography (see Appendix Three). However, some specific suggestions here on seed selection and planting are in order.

BASIC GARDEN PLANNING:

Gardens are mainly a systematic way of raising particular plants so that each plant grows to its optimum in the time frame of one garden season. There are some basic suggestions that may be followed to produce a respectable garden with very little effort.

If you enter a store that sells seeds, you may be overwhelmed by the number of varieties of vegetables offered for sale. If you are shopping in a super-market, you are on your own, and can only be guided by the label information on the packets. But in a real seed store, you should be able to ask which varieties are dependable, relatively trouble-free and have a good track record. While seeds for everything are on the shelves, you must be aware that some types of vegetables do much better in certain climates. For example, collard greens are southern while kale is northern. Okra does not do well in the north. Many varieties of vegetables have too long a growing season to be usable in the north.

I have included a list of the seeds and plants that we are currently using in our program at HSC (Table I). I have also included a sample lay-out of a student garden plot to show how the seeds and plants might fit together as a whole. One of the early student assignments is the construction of a master plan for their garden plot. You might very well ask how large the individual plots are, to be able to plant so many different kinds of vegetables. Our plots are all 12’ x 15’. The dimensions of the plots vary some from year to year, depending upon the number of students enrolled in the course.The answer to why so many kinds of plants is that not all students plant every vegetable or flower. One student was almost rude when I suggested that he plant beets. Another told me that she was allergic to egg plant and did not want it in her garden. Most students try most of the vegetables, but very few try them all.

So no student could plant everything. But the way in which we ask them to lay out some areas in their plots for the natural pest control experiment partly dictates how the garden will shape up. I usually award a prize to the student who designs the best garden, and often give an additional prize for the most imaginative lay-out. If you examine a typical garden lay-out (Fig. 2), you will see that I have not included all of the plants.

Table 1. Seeds and Plants used at HSC, Spring 1997

SEEDS

Radish	Turnips
Kale	Chinese cabbage
Peas	Snap Peas
Green beans	Yellow wax beans
Beets	Cucumbers
Summer squash	Winter squash
Pumpkins	Sweet Corn
Lettuce	Romaine

PLANTS

Tomatoes	Marigolds
Green Bell Peppers	Basil
Egg plant	Oregano
Cabbage	Onions

ParsleyLemon	Balm
Sage	Alyssum
Ageratum	Salvia
Portulaca	Petunias

THE GARDEN AT FRUITION:

Just as plants need to be planted in a time sequence, so they are ready to harvest at different times. The first plants normally ready are the radishes (for which I usually give a prize for the largest). These are followed sometime later by the peas, then beans and lettuce and parsley. Later still, during the summer, cucumbers, tomatoes, peppers, corn, etc. are ripe. There are also plants that ripen in the fall, such as winter squash and pumpkins. Some plants, such as kale, may be harvested up until frost.

The problem is, that no one ever seems to say much about how you harvest the produce. There are some suggestions in the organic gardening books (see Appendix 3) but no really good and complete instructions. This leaves the students on their own. They must use their own judgment. In addition, most things will ripen after school is let out for the summer.

The best solution is to have some kind of organized summer activity that will help the students to tend and harvest their own gardens. If this is not possible, students may still work on their gardens on a volunteer basis and on their own. But there must be some thought given to security. Is the garden site a place where students may safely go alone? If it is not, then a group activity is needed.

Fall plants may be harvested either by the original students or by a subsequent class given in the fall. Classes that are working in the fall can prepare the site for winter and harvest the fall produce. We are trying a program this fall where all of the produce harvested will be weighed and measured. The class will then calculate yields of various plants.

ENVIRONMENTAL QUALITY AND AWARENESS:

We have learned some bitter lessons concerning pesticides over the last fifty years. Our scientists have found that chlorinated hydrocarbons, PCB's and dioxins all have persisted in the environment long after their manufacture and use was banned (Carson, 1962; Colborn *et al* , 1996; Tschirley, 1986). Yet we continue to use an enormous array of over 10,000 poisonous chemical formulations as pesticides to this day. And more of these toxic compounds are being approved for use each year. (Wargo, 1996) We have learned that these compounds are toxic in large doses, and that many of them are carcinogenic at much lower, sub-toxic levels. Recently we have begun to realize that many of these persistent chemicals also may act as hormone disruptors at low levels, causing abnormal development especially of the nervous, reproductive and immune systems (Colborn *et al* , 1996).

The fact is that we **all** have pesticide residues in our bodies, particularly in fatty tissue. There is virtually nothing that we eat that is not contaminated with these residues. The rational for permitting these toxins in our foods is that they are present at levels that are tolerated by our bodies. Thus there are tolerance levels assigned to almost all residues in foods. These are levels that have been calculated as “safe” by the FDA and EPA. Unfortunately they do not seem to have taken into account accumulation of these toxins in fatty tissues or the hormonal disruptions that may occur at very low levels (Wargo,1996; Colborn *et al* , 1996).

If we examine Figure One again, we can obtain a better sense of the methods by which many of these contaminants reach our food. Metals may be present in the soil naturally, or they may have been introduced from contaminated water, in pesticides or as air-borne particulates. Water may be contaminated from run-off, from inadequate sewage treatment and from absorbing particulates from the atmosphere. Some atmospheric contaminants are present naturally, such as turpenes and ozone, while others are the products of man, such as acid rain. Many organic compounds in the soil are deliberately introduced as pesticides, while others come from the atmosphere and are deposited by rain.

Environmental text books often show accumulation of contaminants in the food chain (Miller, 1990), but they seldom seem to show what happens in cultivated ground. And this is extremely important because it is from cultivated fields that we obtain almost all of our foods. These same contaminants are present both in vegetables and fruits, and also in meats. All of our commonly eaten meat animals, including cattle, swine, sheep and poultry, derive all of their food materials from plants.

There are a great number of pesticides used on crops, and they are often used frequently. Some crops are sprayed up to twenty times a growing season. Why? For two reasons. First of all, they are sprayed to minimize loss to insects and other pests. Secondly, they are sprayed for cosmetic reasons. Each plant crop has cosmetic criteria, including color, surface appearance and blemishes. Many fungicides are sprayed to minimize surface blemishes. But these blemishes have nothing to do with the wholesomeness of the fruit or vegetable, only with the surface appearance. So why use them? Because all produce is graded, and the producer is paid based on the grade of his produce. Have you ever peeled a nice orange orange, only to find that the color comes off on your fingers? A cosmetic dye was used on that orange, and it probably was a carcinogenic aniline dye. How much got into the part that you ate?

One other serious problem that we have not discussed is what happens to these toxic residues once they are in garden produce. These residues are taken up by the plant along with water and minerals from the soil (Fig. 1). As such they are incorporated into the cells and tissues of the plant. They cannot be washed off, as can some air-borne residues. Thus we ingest these residues directly when we eat plants and secondarily when we eat animals (Wargo, 1996). And our bodies must deal with these residues as best they can. We have already seen that these residues may be both carcinogenic and act as hormone disruptors (Wargo,1996; Colborn *et al* , 1996). Unfortunately, even with the knowledge that we have, it is very difficult to get the government to act to eliminate the use of the pesticides in question.

In 1962 Rachel Carson alerted the country and the world to the dangers of chlorinated hydrocarbons, especially DDT. Wargo and Colborn have raised the same cry in 1996 with regard to pesticide residues of all types, especially their accumulation in children. But to this date the government has not responded in any decisive manner. Part of the problem is the fact that responsibilities for monitoring and regulating pesticides fall under the jurisdiction of three separate federal agencies Ð the USDA, the EPA and the FDA. These agencies use different sampling procedures, different analytical procedures and different statistical methods. The end result is that it is very difficult to obtain action from any of these agencies.

Another problem is one of human nature. It is very difficult for any of these federal agencies to admit that they made a mistake. Instead of admitting that their knowledge was imperfect ten years ago, they mostly hold to their original position regarding any pesticide. If they approved it, it must be OK to use it. (Wargo, 1996). A classic example is the mercury poisoning at Minimata, Japan. These victims are still, to this day, trying to get the Japanese government to admit that they were negligent (Smith and Smith, 1975). And it is virtually impossible to get a corporation to admit to culpability in these types of cases (Harr, 1995).

While the United States prohibits the sale and use of a number of pesticides, we are often the world's largest producer of a prohibited pesticide (DDT is a good example). We export tons of these pesticides, mostly to third-world countries. And we get these pesticides back in imported produce, in what is called the "Boomerang Effect". Each year we import more and more fresh produce from abroad. The cantaloupe you buy in the supermarket in February were not produced in this country, but probably came from Ecuador, Costa Rica or Mexico. And in these countries, they use pesticides that are prohibited in the United States, and some that have never even been registered in this country. So this is another way in which the residue level in our bodies is increased.

Is there any way by which the pesticide levels in our bodies can be lowered or at least held at present levels? Yes, there is. People can raise more of their own food, and do it pesticide-free. And this has been the entire point of this paper. I have attempted to show how growing your own crops in an organic garden can minimize the amount of pesticide residue that is entering your body. You may not be able to do much about those residues found in produce in the supermarkets, but you can cut down on residue intake if you use foods raised in your own garden. You may also buy produce raised pesticide-free, so-called "organic produce". Some states now have requirements for organic certification by producers, and "certified organically-grown" seals on the resulting produce. (Armstrong, 1983; Bergin and Grandon, 1984).

Finally, let me say that most of the students I have taught in our program have become very enthusiastic about gardening the organic way. And most importantly they have gained self-respect and pride in being able to complete a garden of their own. For these reasons and for the health of our children, I urge you to try this unit. It is very rewarding both for students and teachers.

1. Environmental influences on soil and plant. (Note that some contaminants may enter the soil by more than one method).

(figure available in print form)

Figure 2. Simple Layout of garden plot

(figure available in print form)

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Appendix One: Nature and properties of soils Ð Lesson plan #1

For this laboratory you will work in groups and will submit one laboratory report for each group. The format for the lab report is a short hand-out which will be provided. Part of your lab report should be the data sheet that is page three of this paper.

When we discuss soils, we are talking about the abiotic factor that furnished water and minerals to plant roots. Soil type is often the limiting factor in the distribution of plants. How does soil structure influence the availability of water and minerals? The soil has a texture that results from the combination of the **organic matter** in the soil with the **mineral material** present. The organic material results from the **decomposition of plant material** in the soil. The mineral materials are based on the **size of the soil particles** . The finest particles are called clay, the next finest silt, then sand and finally gravel, which is the coarsest. The various combinations of these substances give rise to the various kinds of soils.

How does a soil absorb and hold water? When it rains, the spaces between the soil particles are filled with water, as shown in Fig. 1 below.

Figure 1 Ð Soil saturated with rain water.

(figure available in print form)

All of the dark areas represent water between the soil particles, which are the light areas. In this condition, there is no air present from which the roots may obtain oxygen. After the excess water (called the **gravitational water**) has drained off, what is left is a shell of water around each soil particle. The soil at this point is said to be at **field capacity** . The plant roots absorb this water for plant use. The water is held to the soil particles by hydrogen bonding. See Fig. 2 which shows the soil at field capacity.

Figure 2 Ð Soil at Field Capacity

(figure available in print form)

As the water is absorbed by the roots, the shell of water around each soil particle becomes thinner. And finally, when almost all of the water has been absorbed by the roots, the force needed to remove the water from the surface of the soil particles becomes so great that the roots can no longer absorb the water (Fig. 3).

Figure 3. Ð Soil depleted of water available to plants.

(figure available in print form)

What we will do today is start to measure how much water our soil samples will hold. We will do this by first **wetting** a sample of soil. When the gravitational water has run off we will **weigh the sampl** e and its container. We will then leave the soil to **air-dry over night** . The air-drying approximates the amount of water removed from the soil by the roots. The second day we will **weigh the sample** and then place it **in an oven** . This will remove the remaining water from the soil. The soil will remain in the oven overnight.

The last day we will take the oven-dried soil, **weigh it** , and **heat it** in a crucible to **get rid of** all the **organic material** in the soil. This must be done with caution. Be sure you **wear goggles** and stand well back when you are heating the soil. It will have to be stirred while you heat it. Let the soil **cool thoroughly** and then **weigh it** one last time. This will give you the amount of mineral material in the soil. We will, of course, record these findings (see the attached data and calculation sheet).

The organic material in the soil is important in helping plants absorb minerals. This humus gives the soil a “crumbly” texture and ensures the soil is open and well aerated. A soil without organic material is generally poor and very hard.

Data Sheet

Weight of wetted soil in container:	SOIL WEIGHTS:
Weight of air-dried soil in container:	Wetted Soil:
Weight of oven-dried soil in container:	Air-dried Soil:
Weight of container:	Oven-dried Soil:
Weight of wetted soil:	Heated Soil:

Weight of air-dried soil:

Weight of oven-dried soil:

Weight of oven-dried soil in crucible:

Weight of heated soil in crucible:

Weight of crucible:

Weight of heated soil:

Calculations

How much water is available to plants? ___________ ml/gram of soil

How much water is present at field capacity? ___________ ml/gram of soil

How much water is not available to plants? ___________ ml/gram of soil

What is the percentage of organic material in the soil? _____________ %

Seed Germination and Growth - Lesson plan #2

This exercise teaches the student a great deal about how a plant grows and is an extremely easy experiment to set up and successfully complete.

MATERIALS: (per pupil)

6 containers Ð small paper cups (4 oz) or 1/2 egg carton
6 cabbage seeds, any type (may be any cabbage relatives, such as broccoli, cauliflower, brussel sprouts, Chinese cabbage, turnips, etc.. Radish is not recommended for this exercise.
6 glass dishes with covers, with wet cotton and black construction paper on the bottom. Plastic Petrie dishes work well if deep enough.
Soil obtained from teacher. Also obtain 2 radish seeds.

PROCEDURE for EACH STUDENT:

1. Label each container with your name or initials. Punch a hole in the bottom of each container with a pencil.
2. Put soil in your cups or egg carton sections until the container is 3/4 full.
3. Place one seed in each cup or compartment of the egg carton. Push the seed down into the soil 1/4 inch and just cover it with soil.
4. Water the soil. Dampen it but do not get it too wet. Excess water will drain from the hole you punched in the bottom of the container.
5. Place your cups of planted seeds on the table under the lights. The lights are set on a fourteen-hour time cycle by an automatic timer.
6. Make daily observations of your container. When you see the plant emerging above ground, make daily pencil sketches of the plant and measure its height. Your initial measurements should be in millimeters, later in centimeters.
7. Graph the height of the plant over a two week period of time. How is the growth rate related to the size of the plant?

PROCEDURE for the ENTIRE CLASS:

1. Work in groups of fours or fives. Obtain a dish prepared by your teacher with black construction paper on the bottom.
2. Place a total of ten radish seeds in the dish, evenly spaced. Place the dish in a dark environment (a drawer works well).
3. Observe your dish daily. Keep a journal. Without opening the dish if possible, observe what happens as the radish seeds germinate. Try to measure the length of the plant each day. Make a sketch.
4. Research what you have seen. What is the white material around the roots? What are the various parts of the emerging plant named?

Composting Ð Lesson plan #3

Compost is basically decayed organic material. When mixed with mineral soil it facilitates mineral uptake by the plant and increases the water-holding capacity of the soil. The organic portion of the soil is extremely important in developing good soil, and is extremely easy to produce.

MATERIALS: (per group)

2 identical plastic containers with lids, with a capacity of at least 2 qts.
A selection of vegetable scraps.
50 worms
6 oz. of raw hamburger

PROCEDURE:

1. Each group should punch or cut six holes in the lids of the containers.
2. Each group will set up the two containers as follows: Shred all of the vegetable scraps and make sure that they are well mixed. Divide them into two equal piles and add 2 oz of hamburger to each pile. Mix each pile separately and place in the two plastic containers. Water each container with the same amount of water. Use enough water to moisten the materials but not enough to produce any liquid in the bottom of the containers. To one container add the 50 earthworms.
3. Place the containers in a cool, dark area such as a closet.
4. Observe the composting vegetation every other day.
5. One group should re-mix their compost once a week.
6. One group should re-mix their compost twice a week.
7. At the end of six weeks, each compost bin should be sifted and the materials that pass through the screen placed back in the container on top of the material that is not fully broken down. (Be gentle when you do this, you do not want to kill your worms).
8. After about two more weeks the compost should be finished.

QUESTIONS for THOUGHT:

1. Why add the hamburger?
2. Why punch the holes in the lid? Why use a lid?
3. Which bin did a better job? Why?
4. Occasionally there is too much water in the bottom. What is the result?

Natural pest control Ð Lesson plan #4

This exercise is done as part of your garden plot. This is a very simple but effective demonstration of the fact that you do not need to use great quantities of man-made insecticides.

MATERIALS: (per pupil)

12 marigold plants

12 tomato plants

6 cabbage plants (raised as part of your study on seed germination)

Other plants as desired, such as potatoes

Pyrethrin spray

Rotenone powder

PROCEDURE for EACH STUDENT:

1. When planting your garden, reserve a plot about 2 by 4 feet in area. Plant in this area the marigolds and tomatoes, with the marigolds evenly distributed around the outside. The tomatoes should be spaced no closer than two feet from one another. There should be just about enough room for six of your tomatoes.
2. Plant the other six tomatoes across the garden as far away as possible from the marigolds (upwind if possible). These will serve as a control for your experiment in companion planting.
3. In two separated portions of your garden plant the six cabbage plants, three to each section. As they grow, watch for any white butterflies in the garden. These are called cabbage butterflies. They lay very small coppery-colored bullet-shaped eggs on the leaves. When the eggs hatch, the resulting caterpillars are called cabbage worms. They eat the leaves of all cabbages and tunnel into the heads of cauliflower and broccoli.

4. When cabbage butterflies are observed in the garden, dust one group of three cabbages with the rotenone powder. Leave the other group of three as a control.
5. The pyrethrin spray may be used on other vegetables, and is effective against a number of root-eating insects.
6. Other insect pests such as the Colorado potato beetle may be picked off of the plants by hand and disposed of by dropping them in a small amount of rubbing alcohol.

Appendix Two: Teacher's Notes for Lesson Plans

Although somewhat surprising, many students reach high school age without ever having participated in any gardening activity. Thus the teacher must assume total ignorance on the part of most students with regards to preparing the garden, seeding, weeding, cultivating, etc. The four included lesson plans are designed to acquaint students with some of the fundamental aspects of organic gardening.

Lesson plan #1: Nature and properties of soils Ð **This exercise is in the form of a laboratory exercise which can be xeroxed as is. (Just cover the words Appendix One and Lesson Plan). The students are asked to submit a report for each group. This encourages group cooperation and responsibility within each group. The success of the exercise depends largely upon how well the students cooperate. Soil** Ð The teacher will have to supply one or more soil samples for the class. You may ask students to bring in samples of soil from home, but it is a good idea to have at least one sample that you provide. This sample should have at least 15 - 20% organic material. You can make sure of this by adding organic material such as compost to the soil. Students do not need a great deal of soil. Usually samples are too large, rather than too small. Remember, only enough soil is needed to fill a Petrie dish.

Lesson plan #2 **:** Seed Germination and Growth Ð **This exercise is best accomplished during the school year in February and March. You will have to prepare some of the materials for this exercise. Most of the materials are easily obtained and can be purchased locally for much less than from a scientific supply house. Lights** Ð A four-foot fluorescent shop light currently costs about $10.00 and is obtainable at Sear's, Home Depot, and other such building supply stores. The lights come with two short chains from which they may be suspended. It is also desirable to include at least two 100 Watt incandescent bulbs in this bank of lights.

Timer Ð An inexpensive timer, designed to control light circuits, is

generally available for around $5.00. You do not need the heavier units, which are designed to control air-conditioning units.

Table Ð A six-foot rectangular table is all that is needed to place the plants on. If the table is of any value, you should protect the surface from water and soil spills with a layer of plastic.

Light suspension Ð the lights need to be suspended above the table at a height of about 18 inches. You may ask some students to construct a frame, or you may simply rest the ends of the lights on two sturdy cardboard or wooden boxes. You might also suspend the lights from a two by four that rests on the backs of two folding chairs.

Seeds . Ð I have had the most success when I buy seeds in large packages at Agway or other suppliers of that type. I keep the seeds from year-to-year in a large metal canister. Most seeds seem to remain viable for three years, and it is much more convenient to buy them in large quantities, as well as a great deal less expensive.

The one problem with buying seeds is that they almost universally are treated with a fungicide to promote germination. Students need to be sure to wear protective gloves when handling seeds and to wash their hands thoroughly when finished. Fortunately seeds may be saved from the garden each year. Thus you may eliminate this concern entirely.

Lesson plan #3: Composting Ð **This exercise really is designed to be completed before the gardens are started. It can be done any time during the school year, but is probably best attempted during February and March. The vegetable materials to be composted can be collected by the students. Have each student save all of their family's vegetable scraps for one week and then bring them to school. They may be kept in the refrigerator or freezer in a plastic bag while they are being collected.** The plastic bins to compost in are the type of plastic storage boxes that are sold in discount department stores and Woolworth's (about 16"L x 10"W x 8"H). Sometimes these type of plastic boxes may be obtained used from fish stores or from restaurants that sell a lot of fish. I have used these fish boxes a number of times. All they need is a thorough washing to eliminate the fish smell.

Lesson plan #4 : Natural pest control Ð **This exercise can not be done indoors ahead of planting the regular garden, since it uses parts of the garden for the experiment. The principle involved is called companion planting. This involves planting marigolds, which are naturally repellent to insects, next to tomatoes, which insects will readily eat. The theory says that the marigolds will repel the insects, keeping them off of the tomatoes. I have had mixed results with this method.The students will also be using two natural insecticides, rotenone and pyrethrin. Rotenone is derived from the roots of a South American plant called Cube, while pyrethrin is derived from the plant *Pyrethrum* , a member of the Chrysanthemum family. These insecticides may be purchased at a garden supply store. Rotenone comes as a powder, which may be dusted on plants. Pyrethrin is usually a liquid but also comes as a powder. You must be careful, however, that these are the only ingredients. Many products offered have pyrethrin or rotenone as the main ingredient but may have other man-made ingredients added as well. You must read the labels completely and carefully.** Why are we using these two insecticides? Because they are both natural products that are effective against insects in the garden. And because they both break down in nature after about five days and leave no poisonous residue behind. Since they are both natural products, they are handled naturally by bacteria and other decomposers. But they are both extremely effective against insects.
As the students plan their gardens, they must do some research on the space required. Some plants are larger than others and require more room between rows and more room between plants in the rows. I usually try to generate a contest and award prizes to the best garden plan, the most imaginative plan, the most efficient plan etc.

Appendix Three: Organic Gardening Bibliography

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