Monitoring a Molecule

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INTRODUCTION

I think science is downright fascinating. I am thankful beyond words for the adults in my life who passed that fascination on to me. My aunt Pearl was a naturalist, conservationist, schoolteacher and otherwise interesting person. We used to go on long walks in the woods of Pennsylvania during which we would find things that she would then identify and make a big fuss over. If we found a rare fungal growth or a yellow Lady Slipper orchid or a beautifully formed pine knot, she would gloat over it with as much enthusiasm as a forty-niner might have for a pure vein. I caught something from her.

My biology teacher was like Aunt Pearl. He was taking some courses, working on an advanced degree, and he gave us the same notes he was getting in his classes. He explained everything so plainly and thoroughly because he was really trying to explain everything to himself so he could pass his course work. One time the administration gave him permission to teach a genetics class. Of course I took the class and we had so much fun in there working the problems. Sometimes we got the problems right before he did and that was rather thrilling. But basically we were all discovering together and he was able to be a leader without being a dictator.

That was when the government was shelling out big bucks for those who would take up science and when I was sixteen my teacher got me signed up for a free summer at Penn State doing research with real live scientists. I'll never forget it. We went in the woods and cut down trees and took samples from the bark of young maples in an attempt to find out in which part of the tree a certain fungus that threatened the maples might be residing. We brought the samples back to the lab, cultured them, read the agar plates and generally were detectives in a murder case. Microscopic organisms were murdering maples and we were bound to find out how to stop them.

I was fortunate to be around people who were aware of how wonderful it is to discover things. Better yet I was around people who knew how to help young people catch the fever. That is what I want to do for my students. I want to pass on to others the excitement that I caught from the adults who influenced me.

There is a trick to that. Science has to be presented for what it is. Science is a way of answering questions. It is one way. I always make very sure that my students understand that there are other ways to answer questions. When a person falls in love for instance, it is not always possible to apply the scientific method. It is not always the objective evidence that rules the day. But when one goes to the hospital for treatment, it is a minor point if the doctor loves the patient. The important thing is to have a doctor who has spent a great deal of time in the realm of experience preparing for the surgery, or whatever is on the agenda.

Science is not the only game in town. It is vastly important sometimes and then at other times it is not so important. Since that is true, it would be wrong of us to try to squeeze the romance out of any aspect of being human, including the teaching of science. Without minimizing the importance of limiting ourselves to the five senses in a scientific investigation, we can, I think, recognize that the thrill of science is the sense of discovery about existence, our existence, human existence in a universe which is not only stranger than we know, but stranger than we can know with the five physical senses.

I don't have the hills of Pennsylvania available to me as a teaching tool; more's the pity. All I have is my enthusiasm for a fascinating discipline and in this unit I intend to do what I am constantly doing anyway which is to figure out ways to inspire my students to love science. Yep. I said it; you heard it. *Love* science.

Concurrently I must accomplish another task which is to prepare my students for a largely objective test which will weigh heavily on the likelihood of them ever obtaining their diplomas. To spur me on in this aspect of my intentions I will have administrative personnel checking periodically to make certain that specific items of scientific dogma are being deeply etched in the collective student memory bank in such a way as to be readily retrieved on test day.

Since science is a way of answering questions, in order for the love of science not to be lost, dogma must be presented as a means to an end, the end being the answering of questions. And, since dogma is not the end but the means it makes perfect sense to serve it up as palatably as possible.

For example, when I teach the steps in the scientific method I do it in the form of a song that I call the Science National Anthem. I make students stand (in military fashion with their hands on their hearts) and sing lustily from their toes. It is rather silly and they laugh about it but they learn the steps in the method. Singing songs is evidently a good way to memorize. It is how we remember to drink Coca Cola. Which came first, the song or the taste? The song, of course. The song made us want to taste and it helps us remember to taste.

You may say, "Well, high school students will not want to sing silly songs. They will consider it to be a childish endeavor." Nonsense. Ask the Coca Cola magnates if spending all that money they make from their ads is a childish endeavor. And secondly, since when do we ask teenagers what they want to do?

When I meet my former students at the grocery store or in the bank they invariably tell me, "Whatever you do, do not stop teaching those stupid songs. I sang them to myself during tests all through school." It's one of those *I'm glad you made me eat my vegetables as a child because now I like them and am the healthier for it* things.

So what have we got here? The asking of questions (the discovery of answers), the preparation for which being done in the most effective least offensive manner (songs, games, hands-on projects, skits or the hills of Pennsylvania if available).

STRATEGY: HOW?

It may seem a little strange to get into the *how* of teaching before getting into the *what* but bear with me because there is a method here (somewhere carefully hidden).

When I start the teaching year I begin by assigning a question to each table. Typically I stick to an area I know a little bit about, *ants*. Yes I choose ants for a number of reasons. For one thing ants are the most successful animals (other than humans) on the planet. We can learn a lot from an organism that is not only surviving but thriving. For another thing, ants do not arouse a lot of comment from the animals rights activists. Experimentation using ants has yet to be picketed. Lastly, ants are readily available all year round in Houston and they don't cost anything (an important consideration at my school).

Most science rooms have tables, which means at least four people (or more) regularly sit together. This arrangement lends itself nicely to the asking of questions that require experimentation to obtain an answer. So this year, in each class, the students at the first table were asking the question "Can ants withstand repeated disruption of the environment?" Now if I had been teaching Biology everything would have been peachy, but I was teaching Integrated Physics and Chemistry. So all year I felt like a thief when I spent class time imparting the necessary dogma for the answering of this question.

So, let's talk about next year. Next year I won't have to sneak around teaching about ants in an IPC class. Next year I can have table one students asking the question, "What might be in my drinking water besides the traditional H_2O?" Then I can spend at least the chemistry part of the year helping them gain the knowledge necessary to intelligently attack that very important question. Then when science fairs roll around the students at table one have at least one very clear option. They can all do a project titled "What is in my drinking water?" or a variation thereof. They could ask another drinking water question, like "Does the content of tap water vary over time?" Or, "Do the students drinking out of the 1st floor fountains get the same product as the students drinking out of the 3rd floor fountains?" Or, "Is there a difference in the water that comes out of the tap in the new part of the school as compared to the water that comes out of the tap in the (very, very) old part of the school?" The list is potentially endless.

Another table could ask the question, “Could a microwave oven be used to test water purity?” Another table could ask, “How could a broken water pipe be fixed without contamination of the water supply?”

Once each table has a question, then the learning of dogma becomes a means to an end. It becomes one more tool in the answering of a question. When we take notes they can go directly into the logbook because they will relate to the question being asked. And when science fair time looms up large as it inevitably does, what do we have? We have a question (which is Step One of the method). And we have information, dogma (which is a big part of Step Two: Collect Information). All that is left is the formulation of a hypothesis and the designing of an experiment that will test the hypothesis. Shazzam! Add a backboard and we are off.

CONTENT: WHAT?

Now let’s talk about the *what*. The *what* is water and this wonderful substance can be the subject of much questioning. This year as I went through the IPC dogma I noticed that water kept turning up during each unit I taught. Each unit is already prescribed by the HISD course requirements. The order in which the units are taught has to be agreed upon by all the members of the team of teachers teaching the subject on a given semester which means that there is a chance that I could influence the order in which the units are presented to the students.

Of course the first unit is always the same in any science course. We review the scientific method and go over lab safety and measurement. It would be during this unit that each table would accept the assignment of a problem. Usually during this time I pick out six or seven problems ahead of time that I am interested in. (It is vitally important to be *interested* in these problems. You cannot convey excitement you don’t have.) Armed with these already thought-out problems I then preside over a brainstorming session in each class during which time I give the students an opportunity to come up with problems they are interested in. This brainstorming is done after parameters are set.

For example, this year the parameters were: the project must deal with an organism no one cares about, as in *animal rights* caring. The problem must deal with an organism that is available all year long. The problem must be solvable using scientific experimentation. This lead to ants with me steering the vehicle, although some snail projects slipped through which I didn’t mind although I wasn’t able to help the people who did snail projects as much as I was able to help the ant people. I already have in my classroom a very impressive bibliography for ants, including the Pulitzer Prize winning book by the world’s two leading myrmecologists.

During this assigning of problems an attempt is made to be democratic and allowances are made for those independent workers who really don't need or want too much supervision, but most students need and want direction in the selection of a year long investigation and for those students it is just a matter of steering them to the problems you have already thought out and prepared. As an example, this year I preselected problems. Can ants withstand repeated disruption of the environment? How do ants select organic nutrients? How does pollution affect survival behavior in ants? What social units do ants recognize and tolerate? Colonies, species, or both? How do ants maintain mounds that are mold and bacteria-free?

I had seven or eight problems that I was anxious to attack. By the end of the brainstorming session, each student had to either come up with an original problem or, pick one of mine although the way I do the brainstorming, the students think they come up with all the problems. In each class a small group of students will come up with completely original problems. These are the students that God rains down from heaven and all you have to do all year is cheer them on until they win the science fairs and then all you have to do is buy them their trophies and everybody is happy. But the majority of students will need lots of help in carrying out a thorough and sustained scientific investigation.

Next year, in my biology classes, I will do ants. But the good thing about next year's IPC classes is that I won't have to do ants. I can do water. I already had a group of problems I was interested in before I started this seminar. What are the differences among bottled waters? Bayou waters? Tap waters? Should you buy spring water, drinking water, or distilled water? Do spring waters differ and if so how do they differ? I want to know what kinds of changes can be observed over time in the various waters. Pick a bayou and monitor the water over time to see what kinds of fluctuations might be observable in things like acidity, dissolved oxygen, contaminants, particulates etc. I mean I am one of those moms who took the kid fishing in the bayou, caught the fish and wouldn't let the kid keep the fish because of what might be in the water. Well, *what is in the water*?

Plus it would be fun to catch the rainwater over a sustained period and see what is in the rainwater. As I participate in the seminar I am compiling a list of the things I am interested in. I am also compiling bibliography so that on Day One next year, I will be ready to steer the IPC students to a project dealing with water.

Now, armed with a problem, the next thing for the students to do is to buy a logbook and get into the habit of bringing it to class so that as we move through the prescribed dogma it gets into their heads first and their logbooks second. Then when it slips out of the head it will be in the logbook for handy reference.

The ideal thing for me would be if the team would agree to do the section on water first. There is a prescribed section dealing specifically with water. Texas Essential

Knowledge and Skills (TEKS) Objective 4: The student will demonstrate an understanding of the structures and properties of matter. IPC Objective 9: The student knows how solution chemistry is a part of every day life. The student is expected to relate the structure of water to its function as the universal solvent.

This would be the time to sew, build, and construct the personal water molecules. (Surrogate teddy bears for IPC). The ones we are going to name and know well. Our friends. Our intimate acquaintances. It would also be time to review protons, electrons, neutrons, nuclei, valence electrons, polarity, bonding and so on.

From there it wouldn't matter what order the objectives for the chemistry part might be introduced. All of them would be necessary for understanding and intelligently attacking the chosen problems. For example, the section in which we identify and investigate the Law of Conservation of Mass, during this time the equations used could *all* have water in them, showing water to be the ubiquitous, interactive wonder that it is. The section where we investigate chemical and physical changes. What a deal! Go in your kitchen and you are surrounded by water in the three common states of matter. The fridge has solid ice cubes; the tap has the liquid; and coming out of the snout of the teakettle, what do we have? Yes the gaseous state, all in one room on a daily basis. Shazzam.

When we investigate pure substances (elements and compounds) versus mixtures, again, what does water do but take center stage? Is distilled water really pure? What other compounds might have distilled right along with the water? Could distilled water really be a mixture? Some in the class will likely be working on the problem *anyway*.

The periodic table could now be merely the family tree for Wanda Water Molecule. Hydrogen is in what family? And what is oxygen's family history? And why did they match up like they did to make water? How is human inheritance different from chemical inheritance? Chemical stability as it relates to water? (How stable is she? I mean, you know, comparatively.) Viscosity, buoyancy, density, and pressure all from the point of view of Wanda?

Even during the physics part of IPC water could easily hog the show. Energy sources, their economic and environmental impact. (Objective). Wilhelm Water Molecule is intimately involved with producing four percent of the nation's energy needs and he does it in a nice, respectful, pollution-free manner, bless his heart.

Convection, ah, and radiation in water? Perhaps? Forms of energy? Have you ever seen that movie they show on the History Channel about the hurricane of 1938 during which time water played a destructive role like you wouldn't believe. Houstonians could relate to that. Only those of us who live in the Heights haven't been flooded or washed out at one time or another.

It doesn't take much imagination to see water as a star in IPC. A real shining star.

PURPOSE: WHY?

After saying that water will be the star of the show, the *what* in general, before we get specific let me also deal with the *why*. Why water?

Water is arguably the most important molecule for living things. True, we have carbon-based life, but that carbon doesn't even get off the ground without water. Waterless environments are lifeless environments. So water is important.

In addition to that I noticed as I taught chemistry units in IPC this year, water was on the agenda more often than any other issue. Every unit required an understanding of water. This fact led to my saddest moment. Early on in the year I had each student construct a Bohr model of water. I invested considerable supplies in this three dimensional project and I felt really good about the learning experience I thought the students were having. I would often refer to the models as water was discussed throughout the semester. I remembered the models. I really liked the models. We didn't keep the models but I labored under the impression that every child had been marked for life by the experience of researching and building the models.

I was less than tickled then, when towards the end of the semester I asked the students to draw a Bohr model of water, and instead of the quick response I expected, very, very few students were able to draw it. I was deeply horrified by this state of affairs and vowed to remedy the situation before the year was out. I also committed to rectifying the situation through a change in plans for next year. If water is the most important chemical, and arguably it is, then my students are going to be able to elaborate its merits as readily as they recount the plot of *The Lion King*. (They all know that movie by heart, having watched it at nauseam when they were little kids).

To this end I will redo the water molecules but this time they will be durable, possibly cloth items which we will then name (Wilhelm, Walter and Wanda), construct a history for ("I did time in Napoleon's colon"; possibly an interdisciplinary assignment) and treasure daily as we get to know our personal water molecules more and more intimately. High school students for the most part have been forced to relinquish their teddy bears because of image problems so this will give them a legitimate reason to revert.

The personal water molecules will not be put away but will be available in sight all year, possibly suspended from the ceiling, and their ever present message will be enhanced and reinforced by a water molecule human-sized, which will be worn whenever a skit about water is done. This large costume will always be on display possibly hanging on the wall, with all protons, electrons and neutrons boldly visible for immediate use when the need arises.

We all believe that repetition is a vital part of learning, but finding ways to make repetition tolerable can be a full time job. It is a job that has to be done however if we are to avoid painful experiences like the one I endured.

TARGET AUDIENCE: WHO?

Now for the all-important question: Whom are we teaching? Well for the first time next year I will be teaching the right students. For those purists who might be mentally objecting to what might be considered a too light-hearted approach to a ponderous subject matter, get this. Our school will be taking an historic step. In fact we are mid-stride. We are breaking up a 2900 student monolith into Small Learning Communities (SLCs) sort of like the universities that have different colleges. Instead of one big mish mash, next year we will have the Performing Arts Academy, the Visual Arts Academy, the Megatechs, the Business Community, the Medicine-Health Community, the Law Enforcement Community and so on.

I will be in the Performing Arts Academy. I will be legitimate for the first time. I have always taught the sciences using the performing arts. Next year, I will for the first time be driving with a license. I have always used songs, skits, and games to sell dogma, as any good advertiser would. I have done whole musicals with science as the subject matter. I am now in the process of writing a musical about water. Yep. Some of it is ready to go but that doesn't mean it might not change drastically before the fall. My intention is to have a song, rap or skit for every IPC objective that in any way deals with water. The star of the show might end up wearing that human-sized water costume but then again I may decide to have a whodunit drama in which a group of sleuths find out what happened to a defiled water supply for a town. But the purpose of any show would be to dig the cranial grooves a bit deeper with each practice and then the show, whatever it is, could be performed for parents, peers, or perhaps a traveling group could entertain and teach grade schoolers. I mean, what else would you expect from students attending a Performing Arts Academy?

For example, let's say we did a show about Wanda Water Molecule (or Walter). The theme song might be:

> Water! Water! It's mighty important to me.
> I just love to talk about it,
> And I sure can't live without it. (repeat) (tune available upon request)

Rap: I met a water molecule the other day.
He was older than dirt

And his feelings were hurt.
"Nobody understands me."
(Least that's what he said.)
"I'm so misunderstood
I'd be better off dead."

(Solids, liquids, and gases)

"I'm an emotional guy;
You know I can't take the heat.
As long as it's cold
I can kind of keep my seat.
But whenever the temperature begins to rise,
I rise up on my water wings and take to the skies."

(Internal structure)

I was swimming at the beach
Enjoying a wave
When a water molecule jumped out at me and started to rave
"It's obvious that you don't care a thing about me!
You're just swimmin' and a floatin' in the deep blue sea
Never recognizing what a complex guy I really am.
Shut up and listen bud cause I'm about to jam…

"Protons!
Look inside me
Protons!

"They have a positive charge and they're not very large.

"Electrons!
See them go.
Electrons!
See them flow.

"They're charged negatively.
So small you never could see

"Them,
Neutrons!
Big and lazy.
Neutrons!

Drive ya crazy.

"They don't have a charge;
They're disgustingly large.

"My electrons are moving at the speed of light.
They travel in pairs cause they're not very bright.

"But unless you can completely understand what they do.
You'll never understand me cause they act like the glue.

"That holds my little hydrogens firmly in place.
My hydrogens you know are what put eyes on my face." (Et cetera)

When our SLC met the last of school we decided to put on a musical as a project. I'm hoping to get a water musical at least considered. It would be a way for the math and science to get a fair hearing in the project. But either way it goes, I can have my classes do a musical or a drama and thus reap the benefits of having all the senses involved in learning. Of course science lends itself readily to the senses and the labs we do are good but I'm sure you came through the schools like I did and you have forgotten more labs than you remember. The goal here with whatever students we are teaching is to have something memorable.

TIME LINE

Most curriculum units are written for two or three weeks of class. As we can see, what we are dealing with here is more like an envelope into which we plan to insert an entire semester of work, so the trick is to figure a projected time line, or series of events. What we need is an extended lesson plan.

Week One

Explain that science is a way of answering questions. Explain that the way scientists answer questions is by applying the scientific method. Introduce the method via the Science National Anthem:

Define the problem!
Collect information!
Form a hypothesis!
And test it with an experiment!
Accept or reject your hypothesis based on the experiment you have done!
Then communicate the results to everyone!
That is science!

That is science!
If you can't see it, touch it, taste it, hear it, smell it, then it's not science!
Accept or reject your hypothesis based on the experiment you have done then communicate the results to everyone! (Tune available on request.)

Immediately apply the method to a question. Last year I bought mealworms at Academy and let the kids answer the question, How do mealworms respond to oatmeal?
The purpose of this is to allow them to try the method on something simple that will cause a lot of interest. Holding wormy, crawly things is always exciting. Sing the song as much as possible and give extra credit to those who attempt to sing along. Have each student turn in a lab report which is exactly like the song except add four steps under experiment:

Define the Problem.
How do mealworms respond to oatmeal?

Collect Information.
Mealworms and all other organisms have adaptations that allow them to carry out their life cycles successfully in the habitat that supports each form of life (or whatever they want to say here as long as it leads into a hypothesis).

Form a Hypothesis (a statement).
(This hypothesis must be based on the information collected.) Mealworms have adaptations that allow them to function successfully in meal.

Test Hypothesis with Experiment.

Problem:	(State the hypothesis as a question.) Do mealworms have adaptations that allow them to function successfully in meal?
Procedure:	(What you physically do.) Get a sampling of mealworms from the supply table. Get a beaker of oatmeal from the supply table. Put the mealworms into the oatmeal. Observe and record behaviors. Repeat three times.
Observations:	(Use charts and graphs whenever possible.) In all three tries the mealworms should burrow immediately into the oatmeal demonstrating their structural adaptations for this purpose. Have the students report these findings in a chart with times for tries one, two, and three.)
Conclusions:	(Based on the observations, what can be concluded? Caution students against making too grand conclusions. Explain that under different conditions, different results might be obtained, so until all those conditions are tested, conclusions should not me drawn.)

Accept or Reject Hypothesis.

Communicate Results (lab write-up).

Continue applying the method to simple interesting problems for the next two weeks. After two weeks of becoming familiar with the method, explain to students that they are full-fledged scientists. Students should by now know the song by heart and they should have had science demystified in a very big way. Applying the method should be as easy for them as falling off a log.

Week Three

Now it is time to alert the students to the fact that science books are just reference books. They are really nothing but a report on what other scientists have done. Explain to students that taking a course in science is not reading a book and learning facts. Science is a way of answering questions so to do science one must be about the business of answering questions and it is at this point the brainstorming for the science project begins. Here is where students are guided into the asking of questions to which the answer is not known. At this point the students must find the questions that will shape a whole year of study. And at this point in IPC classes I will be selling water to my students. Just like last year I sold them ants, next year I will sell them water. And to make the sale I will need a tidy little arsenal of questions that are answerable given our lab limitations and of course the parameters that are set by the Scientific Review Committee (SRC). I have begun, under the tutelage of our seminar leader, to amass my little fortune of wonderful questions for the water investigations but hopefully, the ones I have, will serve as a spring board for the students who will be able to think of creative variations and of course some totally original questions. That is what happened this year with ants. In fact the student who went the farthest this year, winning the Urban Structural Entomology Award for the ninth grade at the Houston Science and Engineering Fair, thought up his own completely original ant project.

There are so many possibilities for water investigations. A student could ask the question, What variations in dissolved oxygen can be observed in the bayou behind our school over a period of three months? In order to carry out that investigation a proposal would have to immediately be submitted to the SRC and approval would have to be obtained before even the first water sample could be analyzed. (This is a necessary safety precaution for any type of experimentation that might end up at a science fair.) So…now we begin the serious study of water. Now we have a reason to ingest the dogma in the science book. Now we need to know as much as possible as fast as possible about the vital chemical we have chosen to study so *now* we make our durable, three-dimensional water molecules that will be our friends all year and *now* we begin our log book into which we put all information relevant to the study of water. That is the same log book that will eventually accompany us to the first science fair we enter (after Christmas) which will be our classroom fair which of course precedes our school fair which is followed by our district fair which is then of course followed by the Science and Engineering Fair (regional fair)…then the state the nationals...yea right…well, I can dream can't I? Like all good scientists we intend to publish, which is why we go to the fairs. We intend to communicate our results. That is what honorable scientists do. They share what they have learned for the good of humanity.

Week Four

By Week Four all students must have either decided on or agreed to a question to answer using the scientific method. Every day in class should include some progress. All labs should be done for the purpose primarily of boosting the understanding necessary for the solving of water problems. They should all be written up exactly as the one above with the mealworms. (Secondary purpose being the passing of standardized tests.) Ideally the students sitting at a table will all be working on either the same problem or very closely related problems. A rubric (sample attached at the end of this section) can be handed out so that students will be able to understand ahead of time how their scientific efforts will be assessed and evaluated.

The advantage of having students work on the same or a closely related problem is that one teacher is therefore not stretched too thin. It becomes mentally manageable to stay on top of research efforts so that the maximum amount of coaching and collaboration can take place. Besides it is instructive for students to see similar projects getting quite dissimilar results. The necessity for repeating experiments soon becomes more than apparent.

Students will now begin to pull away from the pack and get out in front. Some students love this sort of thing and are uniquely suited to scientific endeavors. They play a vital roll in leading the other students along the path of discovery. They are a vital part of a successful classroom. The pace of instruction is of course variable, fortunately, and can be adjusted to suit the needs of the entire team of teachers teaching IPC. After all, the classroom instruction is now just another tool in the young scientist's hand. Some students may need to jump ahead in the book and others may need to jump around in the book but all the students will need all the information in the book because none can afford time to reinvent the wheel.

THE MUSICAL

How can a musical fit into a time line? Again, it can be another variable, because it is just a way of reinforcing taught dogma. I have found that the last few minutes of class are best spent singing, doing drama or playing a game. Many times it is a way to lift the spirits of the students. That becomes necessary in my classes. I tend to be a little too goal-oriented and sometimes I think I really push my students too hard. I have found that at some points it is more advantageous to just stop and sing or dance or play, as long as, of course, you are reinforcing dogma.

I like to give students a chance to play a part in composing. Young people are more open-minded and creative and tend to be able to make fun happen. Some of my favorite times are when students have written and performed amusing skits. I'm currently teaching summer school and the other day I asked the kids to write a script about a dialogue between a virus and a bacteria. Viruses are rather pushy and rude guests so I thought it would be fun to see what they would come up with. I loved the kid whose virus knocked politely at the Host Hotel and said he was visiting from down Blood Stream Lane. I thought it was great. Especially since there is a Host Hotel for real right here in Houston.

MONITORING

I am planning to get involved with Texas Watch, the website given to me by the seminar leader. I hope that a number of the projects this year will be related to the kind of work citizens involved with this group are doing. I think it is entirely appropriate to have scientific investigation presented as a tool for human habitat preservation.

Texas Watch is a part of Clean Texas 2000, a statewide environmental partnership program designed to reduce the pollution generated in Texas and to provide citizens, industry, and public agencies with the information they need to improve and preserve Texas' natural resources. Students are citizens. They qualify for participation in this program.

It is a matter of record that science research done by the very young has great merit. A number of years ago it was noted that farmers on the east coast were contracting a lung disease that very much resembled the problems associated with asbestos inhalation but there was no asbestos. A high school science project cracked the case while analyzing soil. Tiny microscopic pieces of what amounted to sharp glass were found and directly related to the problem. Junior high students first found the famous deformed frogs in Minnesota. Young people have sharp eyes and questioning minds. They make productive scientists. They can be taught to care about monitoring our precious water resources.

ANNOTATED BIBLIOGRAPHY

Teacher Resources

Biggs, Alton and Laurel Dingrando. *TAKS Science Quick Review Handbook* for grades 10 and 11 TAKS. Columbus, Ohio: Glencoe/McGraw-Hill.
This paperback inexpensive book has a delightfully succinct listing of all that is expected for the new TAKS test students will now be taking instead of the TAAS.

Symons, James M. *Plain Talk About Drinking Water*. Denver, Colo.: American Waterworks Association, 1997.
This book was required reading for the HTI Water Seminar, It is very helpful for the concerned laypersons, like me and my students, who have questions about water. It could also be used as a think tank for manufacturing problems to solve. It is also a paperback and relatively inexpensive.

http://dept.houstonisd.org/curriculum/ProjectCLEAR/CLEAR.htm
Project Clear (HISD**)**
This pamphlet is important to those working for HISD. It gives a detailed treatment of all the required objectives for IPC and includes thoughtful suggestions for how to best present the objectives to the students. It gives alternative source materials and suggested labs.

The professor for our seminar has written an exhaustive book about water which would be awfully nice to have but given its price (in the hundreds) I must wait until I can tap into the school budget when they are having a weak moment. I really need this book for my water projects. It is like the book I bought through Amazon.com about ants. It has everything. Oh well.

Student Resources

The following web links would be helpful as resources for projects dealing with water:

Texas Water Code
Texas Statutes
Texas Water Foundation
EPA Office of Water
Public Drinking Water
Protect yourself
History of Drinking Water
Bottled water quality control
Health effects of water contamination
Buying bottled water

Bottled water recall

Additional sources for project information:

Wilson, R.F. “Analyzing the Daily Risks of Life.” In *Technology Review* 81, no. 4: (1979) 41-46.

U.S. Water Resources Council. *The Nation’s Water Resources, 1975-2000*. Second National Water Assessment. Washington, D.C.: U.S. Water Resources Council, 1978.

Wright, R.F. “Norwegian Models for Surface Water Chemistry: An Overview.” In *Modeling of Total Acid Precipitation Impacts*. Edited by J.L. Schnoor. Boston: Butterworth, 1984.

Cohen, Joel. *How Many People Can the Earth Support?* New York: W.W. Nortin and Co., 1995.

World Resources Institute. *World Resources: A Guide to the Global Environment 1996-97.* New York: Oxford University Press, 1996.

Kaiser, Ronald J. D. *Handbook of Texas Water Law: Problems and Needs*. Texas Water Resources Institute, Texas A & M University, 1987.

Additional websites for use in researching for projects:

www.epa.gov/safewater/protect.html

Provides information to facilitate the protection of source water resources.

www.epa.gov/OWOW/NPS/index.html

Features highlights of Clean Water Act and coastal NPS (nonpoint source) programs and includes a list of enforceable state mechanisms for NPS control.

www.epa.gov/OWOW/NPS/wtrshd.html

Includes dozens of links and information for people interested in protecting their watersheds.

www.cleanwater.gov

Describes Clinton’s effort to address nonpoint source pollution problems.

www.amwa-water.org/

Association of Metropolitan Water Agencies

Provides background on the provisions of the Safe Drinking Water Act that apply to source water protection as well as links to other sources.

www.nrcs.usda.gov

Provides information to help people conserve, improve, and sustain our natural resources and environment.

www.nal.usda.gov/wglc

Agricultural Research Service and the University of Maryland.

A large site with many databases and articles on the relationship between agriculture and water quality.

water.usgs.gov/index.html

U.S. Geological Survey

Contains links to just about everything the USGS is doing in water, including a great site with real-time water flow data from thousands of stations.

www.epa.gov/surf

Describes watershed conditions in over 2000 watersheds nationwide.

www.rivernetwork.org

River Network

Contains information for local watershed protection groups.

www.epa.gov/OWOW/watershed/wacademy/fund.html

Watershed Academy (U.S.EPA)

Lists sources of federal funding to support various watershed protection projects and local watershed projects.

www.epa.gov/OWOW/lessons

Describes the Top Ten lessons learned by watershed practitioners working on watershed protection plans and other watershed work, and provides real-world examples to illustrate each lesson.