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Special Issue!

WRITING AT THE RACES

Science Essays in a Public High School

by Dale Worsley

LAST YEAR I WAS SENT INTO THE MANHATTAN Center for Science and Mathematics, a New York City public high school, to represent Teachers & Writers Collaborative in a pilot project to develop science writing skills. My sponsor was the General Electric Foundation, which also supported the General Electric Scholars Program in the school. The school, the Foundation, and the Collaborative agreed that good writing in all fields shares certain qualities and that science essays in particular have not received the attention they deserve. I looked forward to working on the project because I am involved in scientific issues in my own writing (fiction and plays). Also I believe that our society suffers more than ever from the gulf between what C.P. Snow called the "two cultures": the humanities culture and the science culture, and that, theoretically, secondary education is an ideal place to bridge them, while the gap is still relatively narrow. The students at Manhattan Center seemed like good candidates for the project because they were being channeled into technological careers. The school was formed in 1982 to "provide for the technological needs of the nation," as one of its founders put it. Manhattan Center was attractive for other reasons as well: students are admitted on a selective basis; most of them are expected to graduate and go on to college; the attendance rate is above average for a New York City school; there are fewer disciplinary problems than in the city's general high schools.

When I accepted the proposal to conduct the workshops, it was with the following ideas in mind. The world is a remarkable place, filled with wonders, curiosities and mysteries, some of which have been analyzed and codified, others which have been analyzed and codified and put to use, and still others which have yet to be subjected to thorough human scrutiny. Science is the process of the systematic analysis and codification of the world. An essay, according to my *Random House Dictionary,* is "a short literary composition on a particular theme or subject, usually in prose and generally analytic, speculative, or interpretive." Since for an individual the world begins with the self, I thought it appropriate to begin writing science essays about the self, expanding from there as rapidly as knowledge about the rest of the world permits. One writes best about what captures one's interest. Most always one finds oneself a topic of at least some interest. The more one has been taught to respect, trust, and rely upon oneself, the more one has the confidence to explore the world and include it in consideration of oneself. (I picture a baby looking over its shoulder to affirm the steadfastness of its parents before it crawls down the porch steps.) Oneself is as large as the world one is willing to incorporate into it. Beginning with themselves, high school students

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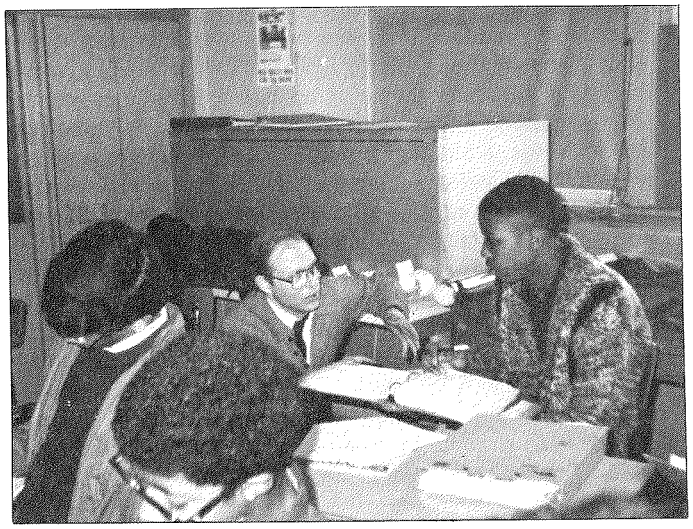
ought to be able to reach out and grasp a considerable amount of interesting and pertinent information. It is at their fingertips, in newspapers, in the library, in the classroom. They ought to be able to take this information and render it into concepts developed along any number of different lines: moving from hypothesis to proposition to theory to proof and back, inductively and deductively, mingling fact, opinion, speculation, example, and observation as need be. They ought to be most motivated to do this if allowed to follow the line of development that interests them most. They are young, full of vitality and intelligence. With encouragement from teachers—their parents on the porch of a larger world—they should be able to overcome their fear of the mysteries inherent in phenomena and explore them with open minds. They should be able to experience satisfaction in the discoveries they make, and to take pleasure in the contemplation and ordering of these discoveries. Finding that others have made the same discoveries before them should be an inspiration. Their writing should reflect this satisfaction, pleasure, and inspiration; its accuracy and thoroughness should be a sign of their experience. It turned out that all these tenets proved true, and to the extent that they were allowed to function, the students' writing grew in volume and quality.

However, the writing (though it was science writing) did not take place in science classrooms, nor did it grow without surmounting obstacles great and small. This article is a chronicle of my experience at Manhattan Center, an essay on the science essay in high school, and a discussion of the hurdles placed on the track that the modern high school student must run, in what is too often a competitive race toward graduation rather than a time to think and learn.



Dale Worsley in class

PREPARATION

Preparations for the project were thorough. A small science library was begun at the Collaborative office. I attended the Bard College Institute for Writing and Thinking's workshop in writing in math and science. Author and teacher Herbert Kohl was engaged to speak. (An edited transcription of his remarks appears elsewhere in this issue.)

At one point he asked the students, "How many of you want to be scientists when you grow up?" Not a single hand was raised. "How many want to be millionaires?" All hands went up. In an aside to me as we left the room Herb said, "Forget science essays. Let these students write anything they want." It is a principle of good education that a student want to learn. It is a principle of good writing that a student want to write. Most of the students were not addicted to the habit of writing, and needed to get a "fix" on the pleasure of it before they could be asked to write "science essays." However, I was determined to have them all wanting to write *and* writing science essays. I believed that with time the two could be simultaneous.

> **Not a science essay:** "I would like to take a long, sharp knife, with a twelve-inch blade, and stick it in your chest, you faggot. Then I would like to turn it around and kill myself with it."
> *—Anonymous, 9th grade*

> **Essay, but not a science essay:** "I believe there is a God. Scientists seem to be atheists, always trying to make every miracle that God did a scientific hypothesis. I believe that God created the planet in 6 days and on the seventh day he rested."
> *—Howard Raymond, 10th grade*

> **Science essay (a beginning):** "As far as I'm concerned I'm a very nice person, all right looking, not exactly Philip Michael Thomas, but I do all right. I like going out with older girls 17 and up because I tend to be mature at times. In school, I like studying zoology. I can't wait until we start dissecting animals. I am 15 years old and my birthday is August 18th, and I am a Leo, which is #1. I am a very good dresser. I like to wear clean clothes, not like the people I know. This is what I think about myself. Although my thoughts in this essay are jumbled, you get the idea."
> *—Same author as above*

I and T&W staff had many meetings with teachers and administrators at the school to set up the workshops. For orientation, I attended classes in the Science, English, and Technology Departments. While I encountered the usual wide variety of teaching styles and student responses, I was consistently disturbed by what I saw in the science classes. Some were fine; the students were bright, polite, and interested. Others were frenetic because of the scheduling (classes last 45 minutes, students attending nine each day), but not overtly chaotic or destructive. Others, however, were frightening, with awful displays of hostility and disrespect overwhelming any activity having to do with learning. Even if the students were behaving themselves, they were often anxious or very hurried. Formulae were dashed onto the board, phenomena displayed on the table, and notes taken, but there was no room for deliberation, contemplation, or exploration. Established facts were being passed from teacher to student as fast as possible, with no context to give them meaning. The students seemed to be racing, some less rebelliously than others, and the teachers were riding their classes, some more steadily than others, but what I'd call learning was not taking place. Nor was there any joy in the teaching.

To provide for the widest range of possibilities, I wanted to work in both English and science classes. I felt it would be useful to find out which shore of the separate cultures provided the firmest base on which to start building a bridge. The English Department and the Science Department heads both welcomed the program and extended their support in the planning.

I was installed in an average tenth-grade English class.

In the sciences I was put into a ninth-grade physical sciences class. I had wanted to work with a higher grade class but it was impossible because the teachers couldn't take any time from their Regents syllabus. (The New York State Board of Regents oversees a curriculum and testing system that is intended to guarantee high educational standards.)

In addition to the 10th-grade class, the 9th grade class (and its later replacement, a non-Regents senior class), I began working in an after-school workshop with the G.E. Scholars, who were juniors. The workshop was organized by the imperturbable Harvey Kaye, chairman of the Technology Department and head of the G.E. Scholars program. These students and I experimented and wrote and discussed and opened a good many possibilities that were never completely realized because the workshops were entirely extra-curricular. At the end, I discussed the situation with Harvey and how it might be planned better the following year, but we could think of no way, within our respective bailiwicks, to introduce a science writing program where it would do the most good: the science classroom.

OBSTACLES

Why the phrase "science *and* the humanities"? Why the distinction, especially on the high school level, between "science" and "non-science" majors? Why are we a "nation at risk" and scientifically illiterate?

—Joseph D. Ciparek, chemistry teacher at Manhattan Center, from his article "Art, History and the Humaneness of Science"

A recent nationwide survey by the National Assessment of Education Progress found that only 2 of every 5 students could draw correct inferences from a set of facts; only 1 of every 7 could write a persuasive essay. "Students may remember dates and facts from a history book," says Bill Honig, California's state superintendent of public instruction, "but they can't stand up and give a five-minute defense of democracy."

—From "Why Johnny Can't Reason" in the "Education" column of Newsweek, *William D. Marbach, 1986*

Dr. Hassler Whitney, a distinguished mathematician at the Institute for Advanced Study in Princeton, says that for several decades mathematics teaching has largely failed. He predicts that the current round of tougher standards and longer hours threatens to "throw great numbers already with great math anxiety into severe crisis". . . . Learning mathematics, Dr. Whitney says, should mean "finding one's way through problems of new sorts, and taking responsibility for the results. This has been completely forgotten in most schools. The pressure is now to pass standardized tests. This means simply to remember the rules for a certain number of standard exercises at the moment of the test and thus 'show achievement.' This is the lowest form of learning, of no use in the outside world."

—From "Learning Math by Thinking" in the "About Education" column of the New York Times, *Fred M. Hechinger, 1986*

Corporate and political leaders have agreed that public schools need to be provided with more resources, such as higher salaries for teachers. Likewise they have agreed to set higher standards for students and teachers, such as competency tests that high school seniors must pass as a condition for receiving a diploma. However, what this political process has not been able to address thus far is how to move from the "input" to the "output," or how the increased resources will be translated into students who can meet the higher standards. Critics, friendly and otherwise, of the school improvement effort frequently note that, sooner or later, the door closes on the classroom and it is individual teachers and students, not business leaders or governors or state legislators, who determine whether learning will occur.

—From "Reform Drive Turns to Classroom Itself" in the "Education" column of the New York Times, *Edward B. Fiske, 1986*

Our lives are controlled by chemicals and computers, not Gothic cathedrals, and science is the "humanities" of our time. [. . .] Nearly everyone agrees that the very best American students are as good as the very best in any other country, but for the 95 percent below that, the vast majority of the population, the situation is far less positive. The average U.S. student is among the lowest of developed countries. And from this larger and less well supported population will come the citizens, the work force, the leaders and the managers of tomorrow's technological society. The cause of the current decline is a lack of public perception of education's importance and insufficient commitment to a more sophisticated (and costly) system. People get what they value."

—From "Some Thoughts on Selling Science to American Students" in the "Education Watch" column of the New York Times, *Dr. George W. Tressel, program director for informal science education at the National Science Foundation*

I want to teach *science.* I want to give my students a vision of what true science is all about, and invoke a sense of wonder and enthusiasm. I want to introduce them to the rigors of science, and try to get them to appreciate the sweat and hard work that scientific research demands. But I can't. In order to cover the 11 or 12 units of the New York State Regents syllabus, I must move on whenever there is an opportunity to treat an interesting topic in depth. Someone has decided that they must learn all the "basics" in their one-year course. More and more after teaching these "basics," I wonder, "Why?"

—Joseph D. Ciparek, chemistry teacher at Manhattan Center, from his article "I'm Tired of Teaching Chemistry"

I'm frustrated both ways. If he's teaching for the Regents, it's not interesting, and if he isn't, I still have to take them.

—Keyai Lee, G.E. scholar

I passed my chemistry class but didn't learn anything. I recommend less procedure (step-by-step lesson plans), more observation, more trips, more hands-on stuff.

—Marcia Valle, G.E. scholar

You could be a 98 student and they say "Regents" and your thoughts go all to pieces.

—Anonymous G.E. scholar

Not being able to work with a Regents science class had major consequences for the science writing project, and the event deserves examination. Apparently, most of the writing in science classes is limited to lab reports. "The communication skills of the students are very low," Science Department head Herb Laden said. After perusing a few of the lab reports, I agreed. Many were nearly incomprehensible. The best were grammatically passable but contained only spit-back information. The situation called for drastic measures not only to improve the literacy of the students, but to provide opportunities for deeper thinking about the subject matter.

"There's no way I can be squeezed into *any* of the Regents classes?" I asked.

"Absolutely not," Herb said. "I agree with you that the students need work with their writing, but the time is too tight."

The more I thought about the situation, the more I was staggered. These students were going to study biology, chemistry, and physics for three critical years of their lives and were not going to have a chance to write or think in depth about what they were doing. There is a provision in Regents science courses that theoretically leaves room for in-depth inquiry after certain basics are covered, but teachers told me that rarely is it used for this purpose. They are often too far behind the syllabus, or they are too concerned about making sure the students have all the facts, so they review. For all intents and purposes, these courses are hermetically sealed from the outside world, the very world they are intended to explain.

There were other, non-Regents courses. In one of them the students had the leisure and the desire to write in depth about science, and in fact were doing so with the guidance of their teacher, Glen Album. I discovered this when I went into the teachers' office to discuss dropping the ninth-grade class with the teacher involved, and Glen overheard us and asked if I could come work with his seniors. I did pick up his class, but there were only six sessions left. Even so it was a pleasure working in his class. He enjoyed teaching and the students enjoyed learning. They were not subject to Regents testing. It was a rare pasture beside the race track. Discovering the world was permitted there.

I picked up his class to replace my ninth-grade science class, which was discontinued after six sessions primarily because there was no discipline in the classroom. Also, the students exhibited extreme prejudice against learning. They said science was boring. "Why do they make us go through this in high school and they don't make us in college?" one asked. I addressed the issue in practical terms for them: if they didn't sense the system respected them, couldn't they nevertheless respect themselves, take their education into their own hands, and try to get ahead within the system, since they couldn't change it? They understood and agreed. Even students who had displayed extraordinarily hostile behavior (the most extreme of which is characterized in the quotation above about the knife) and been kicked out of previous sessions participated brightly. I would rather have been discussing issues more directly related to science, but under the circumstances this *was* a science discussion. It was about them and their world, how they could understand it and gain the power to thrive within it, just as science is.

Initially I met with much of the same disregard and hostility in the 10th-grade English class. My free-writing exercises intrigued the students momentarily, and some issues interested them enough to result in short papers, but the overall response was grudging. Also, I needed to learn how to work with their teacher, and she with me. Our mistakes were merely tactical, however, and held us back only temporarily. Strength of ideas, simple perseverance, and respect for the students win out in any classroom.

One product of our success was that certain educational realities of the students' lives became visible in their writing. I have referred to these realities, especially as they apply to science, as a race track. I mention it again here, before addressing the subject of the essays themselves, because of how strongly it defines the world of learning for the high school student in New York, and, presumably, wherever similar systems are to be found. This system is reflected in both the students' attitudes toward science and their abilities to write scientifically. The track, ineluctable, became either the content or the context of the essays that were written in my workshops at Manhattan Center.

The errors in most of the examples in this article have been corrected, but here is an uncorrected one (including the use of capital letters) that illustrates my point:

> "I AM A NICE PERSON AND I GET ALONG GREAT WITH PEOPLE. BUT THERE ARE TIMES WHEN I GET ON PEOPLES NERVES AND TALK TO MUCH. AS A STUDENT I TRY TO DO RIGHT BUT WHEN TEACHERS GIVE AN ANSWER THAT MAKES NO SENSE.... I REALLY ENJOY WRITING, BUT THE ASSIGNMENT MUST BE ENJOYABLE.... SCIENCE IS A SUBJECT I LIKE BUT AGAIN ONLY WHEN ITS ENJOYABLE BUT I DISLIKE THE TEACHER AT TIMES BECAUSE IF I TRY TO DO HER LAB SHEET AND SOMETIME ARE DIFFICULT AND ARE HOT IN THE READING REALLY UPSETS ME BECAUSE SHE STILL EXPECTS US TO GET THE ANSWERS...."
>
> *—Anonymous, 10th grade*

The track is evident here in the student's frustration with his science class. It is but one of many such papers. It should be kept in mind that almost all the progress made started from such beginnings, this student's paper being better than average.

THE ESSAY

> What can you learn by rote?
> You can commit to memory the names of stars, flowers, and parts of the body,
> Just as you can become a baseball fan by perusing stats,
> But you won't learn so well as under the blanketing sky at camp,
> On a ramble in the jungle, butchering a hog,
> Or relaying to the plate a dying quail thrown by your uncle.
>
> You can learn the axioms of geometry and rudiments of chemistry
> Though you're liable to remember the ripped seam in the Periodic Chart
> More than how the art transmutes petroleum into pants
> Or corn into dance via moonshine.
>
> *—From "The Army for Kids" by Gary Lenhart, poet and Associate Director at T&W*

I am difficult to explain. No one understands the complex thoughts which are dissolved in my actions. I feel that I exist in an airtight bubble. No one can be permitted beyond the guards that hold the secret to my true existence.

I'm just a character. I've been placed in a setting with confusion and turmoil. When problems arise I find myself dealing with them as a character. It's hard to break away from this, so I search for myself. I look into a reflecting glass and stare deep into my eyes trying to find the definitions of my personality, the window of my soul.

The only time I'm one with myself is when I'm asleep. I fall out of the world which holds me to reality. I go away with my soul on an adventurous journey. I see things through my own eyes and deal with conflicts that way. I do not care about others and what they think of me, but of myself. What I think: no dramatic flaws or careless errors, no undermined feelings or confusing thoughts, just myself.

When I come back to reality and face the world the way it was forced upon me and I handle my next problems, I realize that a character is something that you define, you name. You

navigate the feelings and you set up its environment.

How can I play a character that I don't know?

I can't, so I see that I find the subtext for my own character in myself on my thoughts, on a dream.

A dream defines our behavior in reality....

—From "Dreams and Forces," an essay by Nicole Olitt, 10th grade

Teaching *for* thinking involves the restructuring of classroom environments, teacher attitudes, teaching techniques. That may involve not lecturing, but rather concentrating on questioning in the classroom. It might involve bringing into classrooms unresolved issues in the sciences that the teacher admits he or she doesn't know much about.

Teaching *about* thinking can be very rigid. Simply teaching about the scientific method without giving kids the chance to use and develop these skills can be very sterile.

—Dr. Robert Swartz in the "Education Watch" column of the New York Times, *1985*

What type of people watch comedy shows? Are they comedians themselves looking for someone to laugh at, or are they humorless people trying to loosen up and gain a sense of humor?

What type of people watch documentaries? Do kids watch them because they have to for school, or do they watch them out of curiosity?

Who watches nature films? Teachers? Students? People who want to learn what makes animals tick? Just nature lovers? Some people watch nature films for the scenery?

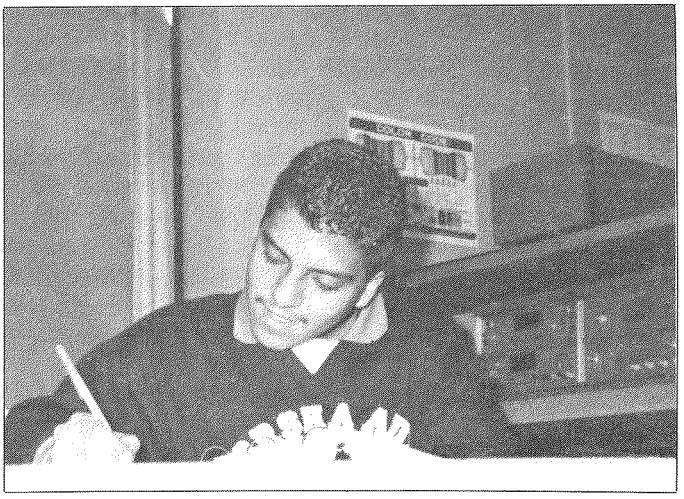
What type of people buy cable TV? Are they people who don't want to pay money to see a movie? Are they disabled and can't make it to the movies? Are they deaf and have to wait until closed caption films come on TV? If so, what do they watch on cable TV?

Haven't you ever wondered how TV shows are rated? Of course, it's by the Nielsen ratings, but how does the Nielsen company place the ratings boxes? Who thought up the system of letting one family provide the rating of a couple thousand?

—From "Television in Society," an essay by Diane Spann, G.E. scholar

To develop essays with the students, I moved through several phases. Below I will analyze the elements of each phase chronologically and in detail. Before doing so, however, I would like to focus on perhaps the most important discovery I made in the course of my work: the importance of discussion. Under any circumstances good essays, particularly those in the professional world, do not consist simply of reportage. They are created at the vortex of various currents of thought and activity. Many different points of view may have to be considered before an essay can be considered thorough. Whether in glacial movements through scientific journals or in caroms through the halls of a conference, ideas, opinions, and information of all kinds flow from mind to mind. Essays are the products of such interchange. It so happens that high school students love to talk. They think a lot and need to talk about their ideas among themselves.

Considering how important and useful the discussions turned out to be, I should have had them earlier in the workshops. Instead I stressed writing first. The consequence was that it took a bit longer to make writing truly comfortable for those who were anxious about it. The disaffected might also have become engaged sooner, knowing that their thoughts and opinions would have an impact on others. Here



A student at Manhattan Center

are comments written by 10th-grade students after the class' first major discussion, six weeks into the program:

When Mr. Worsley asked questions, hysteria broke out. The question was about life and everyone had a different response.

—Angela Maxwell

This is the first time I was interested in Mr. Worsley's class. Usually I found it boring, but not today. I was really tired today. I went to bed at 4:00 a.m. last night studying for my biology test. I didn't want to do anything when I came in class, but little by little I was waking up.

—James Ambert

I think instead of having a writing workshop they should have a talking workshop where the students can discuss their feelings about the environment they live in and the problems teens of their own age go through. I think that before you get down and write your thoughts on a piece of paper you have to know what you want to think about.

—Wanda Lucca

What stressing writing first did do is demonstrate how important it is to thinking, and how it can become an organic part of learning. For this I used freewriting, directed freewriting, and summary writing exercises. At the beginning of most classes there were three minutes of either freewriting or directed freewriting. In directed freewriting one writes any thoughts and associations one has about a particular subject. For example, I wrote on the board several terms relating to the theory of evolution: Evolution, Natural Selection, and The Struggle for Existence. In response to the last notion, one student wrote:

One day I was coming home from school and there was a gang fight going on. In some orderly way I had to go past this brawl. In order not to get involved, I had to cross the street. It was a very frightening experience.

—Bernell Hollis, 10th grade

Another student's response:

Evolution. There are two theories. One theory is that we evolved from apes. The other is that GOD is our maker. I really don't know what to believe. There are many theories in which to believe.

—Aquanetta Joe, 10th grade

Directed freewriting is a good way to focus the mind and raise questions. It works best if not used artificially. The more practice I had using it with students, the more discerning I got about when to use it. It became an organic part of the process of molding ideas into the shape of essays. I believe teachers could find this and the other exercises useful in a wide variety of situations. I use them in my own work without ever thinking anything like "Now I am doing directed freewriting."

Besides freewriting and directed freewriting, I used summary writing. Summarizing one's thoughts can be useful at the end of any class. If there is no rush, one may be able to frame the thoughts in a number of different ways to prepare better for doing homework, reviewing, noting unanswered questions, stating plans for solving problems, etc. If there is a rush (as there always was in the 45-minute classes at Manhattan Center), it may prove useful as a net to catch ideas that might otherwise slip away, and a bridge to the next week's session. Some of the students' greatest discoveries occurred during the summary writing, and either did or could have appeared in more formal essays later.

Here is an example of how directed freewriting, followed by discussion, followed by summary writing, can work:

> **Directed freewriting:** Evolution to me really doesn't exist. My feelings towards it are none. I feel that some superior being put us on this earth, that superior being meaning "God," to many a supervisory state of mind, to others a feeling of respect. I don't believe man came from a non-existing cell. It is said that the earth before this time was a dead structure, so how can something like life come along from something that has no life itself?
>
> **Summary writing after discussion:** Evolution didn't evolve from some non-living species. These are my opinions, but scientific studies and observations have put a bit of doubt in my mind. Maybe humans derived from apes and monkeys, but then again, they are very different in culture, appearance and intelligence. They are somewhat intelligent but still have not reached the brain's ability to suck in more and more information. Humans have not yet done that either, but they are more civilized and in control of their daily behavior.
>
> —*Wanda Lucca, 10th grade*

"Scientific studies have put a bit of doubt in my mind" is revealing. In the 10th grade, scientific studies should not be just beginning to put doubt in one's mind, but should by now also be putting wonder and curiosity in it.

Essays revolve around ideas. Without ideas there can be no essays. One can have essays that aren't on paper. I played one on tape to the class, "Voices of the Loon," written and produced by William Barklow, narrated by Robert J. Lurtsema, and published by the North American Loon Fund and the National Audubon Society. When the eerie sounds of the loon first wafted out of my "beat-box," the natural sounds seeming out of place in the noisy classroom of scarred desks and peeling walls, the students' ears perked up, and they hushed each other. But one cannot have essays without ideas. An idea is not a fact. An idea is to a fact as the sun is to the moon.

The first step in writing an essay is to have an idea. It must be one's own idea. On the track, students rarely have time to develop their own ideas, but they must if they are going to write essays. Moreover, they must be permitted to have *wrong* ideas. If they own their ideas, the compulsion to express them will generate not only writing, but the will to write well, and the qualities of good writing will become inherently interesting. One great quality of good writing is its ability to express the truth. The truth doesn't necessarily come easy, but it is attractive enough to draw students through several drafts to get at it. Their wrong ideas can be left behind in a draft, but there's almost no time for drafting on the race track. Perhaps that's one reason why high school writing and thinking skills alike are so abysmal.

My experience at Manhattan Center was sad because I had imagined being able to start with the initial ideas of the students and, through drafts, to guide the ideas to their logical conclusions using principles of science, but it turned out that I had to spend too much time dissolving the massive anxieties associated with the race track to get beyond the first couple of drafts. For example, if a student hypothesizes that humans could not have evolved from apes because apes do not have the ability to "suck in more and more information" (why did this student not say "think"?), then give that student time to go ask how evolution works. She was studying meiosis and mitosis in her biology class that year, but there was no relation in her mind between these processes and evolution. Let her make the link and write about it and draw whatever new conclusions she wishes. Let her discuss her hypothesis, her research, and her conclusions with her peers, so she isn't writing in a vacuum. Students are excellent critics, and will put each other right with the same fervor as bonafide scientists. To teach science, treat students as scientists. To teach writing, treat students as writers. How could these premises possibly be wrong? In my previous school residencies, some as short as ten sessions' duration, most of my students were able to write at least two drafts of well-developed stories. The students at Manhattan Center had the intelligence to do the same with science essays, but were too alienated not only from the expression and development of ideas, but ideas themselves.

Though the students' anxieties were onerous problems, and it took some time to dissolve them, the solution was near at hand. Solid ideas are like healthy, living entities, with the power to charm, attract, defy, elude, elucidate. Put them in a room full of curious teenagers, and they will do all of these things. Also, like living entities, they will produce offspring. After several sessions warming the 10th-grade students up to writing, using the exercises mentioned above, and trying to promote a sense of trust and collaboration among them by revealing myself to them and discussing issues that preyed on their minds (such as grades, success, and what significance their attitudes toward learning will have in the marketplace), I began to introduce rather commonplace ideas to stimulate them to have ideas of their own.

Rather than march the ideas in like invading soldiers, I thought it politic to sneak them in the back door under cover of night, so to speak: by putting them on a piece of paper in the form of a test. That way, I figured, they would come in disguised as facts and not create defensive reactions. I asked the students to answer four or five of twenty questions. (Or fewer. Or more. If students needed guidelines, they could go for four or five. If not, then, well, maybe they were having their own ideas that could lead to essays.) The questions concerned either popular topics or current issues. One question was: "Do you believe extra-terrestrial life exists? If so, what should we tell about ourselves?" Here is a good answer:

> If I were to write a letter to alien life forms, this is what I would say: Greetings, aliens. I am an Earthling and I come

from Earth. I came here to explain my existence and how I and my race came to be. It all started millions of years ago. A devastating explosion called the "Big Bang" brought all the planets together. By chance, up until now, our planet was the only one which housed living organisms which advanced throughout the ages. My race was once said to be an inferior race of sub-humans called apes. This, of course, was all a theory. Maybe we can collaborate all our knowledge and create a superior race which can rule throughout the universe. Together, Alien and Human can reach the end of the cosmos.

—Rafael Fernandez, 10th grade

Another question was: "Should athletes be subjected to mandatory drug testing?"

I believe mandatory drug testing should be accepted only if everyone else who has a job that affects the public has to be tested. To me athletes shouldn't have to bother taking them because not many people do. Athletes are just people who have jobs playing sports. I feel the real people who should take drug tests are the politicians. They have a greater effect on the public than athletes.

The reason that pro-drug testing groups give is that athletes affect the young public. I feel that politicians are looked up to more than athletes. If a politician is under the influence (it doesn't have to show very much) while passing or vetoing a bill it could affect the public much more and to a larger extent than a team losing a game or a man dropping a ball.

In all my years of life I've never heard of mandatory drug testing for politicians even though there have been more arrests than you hear about with athletes. I feel what the president does with his life if he uses drugs will have a much greater effect than an athlete found selling drugs to an under-cover cop.

—John Batson, 10th grade

Both of the above essays contain either wrong ideas or unsubstantiated claims, but both are good starts toward science essays. If the topic in either were to prove compelling for its author, it would justify research, discussion, and further drafts. Both could go toward a discussion of natural laws, as well, laws being discussed in their science classes. Under ideal circumstances, there would be a possibility of collaboration between English and science classes to provide substantiating facts and background information for further writing. Whatever direction the student might want to take, whether it be to abandon the effort and start another essay, to take something from the effort to seed another essay, or to develop the writing already begun, the next steps in the writing should be taken with greater scientific proficiency. The first glaring need is for objectivity. Apes, for instance, are not "sub-humans." Their evolution from a common ancestor is parallel to human evolution, and they are different, perhaps less intelligent, but not, objectively speaking, "sub" human. And, objectively speaking, can one say for sure that politicians are looked up to more than athletes? Granted, the author does disclaim the information with the statement "I feel," but the essay would be stronger if there were some

KEY PHASES IN THE DEVELOPMENT OF AN ESSAY

1. **Freewriting**
   A period of nonstop writing, perhaps three minutes, in which all thoughts are jotted down as they occur. For the writer's eyes only. Repeat as often as desired, usually at the beginning of each class.
2. **Inspiration**
   An interesting example that has inspired the teacher or a student is presented. More examples may be presented as necessary throughout the development of the essay. Examples may be selected to illustrate points. One may be chosen for its descriptive words, another for its factual substantiation, another for the excitement of the issues involved, and so forth.
3. **Exercises**
   For a brief period, perhaps five minutes, students write their opinions on a subject, objective observations on a subject, or speculations on a subject.
4. **Topic Selection**
   Students select a topic of interest to them and, with help from teacher and/or fellow students, find a slant on it that narrows it to manageable proportions.
5. **Topic Evaluation**
   Students write for a period of time, perhaps five minutes, about how much their topic can be explored and still retain interest.
6. **Research**
   Students find information related to their topic and spend time in class noting their reactions to the information.
7. **Discussion**
   Authors introduce their topics to the rest of the class for open discussions, during which they take notes.
8. **Rough Draft**
   Authors assemble their thoughts and notes as coherently as possible.
9. **Peer Criticism**
   Authors trade their rough drafts and respectfully evaluate each other's work, making suggestions for improvement.
10. **Summary Writing**
    Whenever possible and/or necessary, all write summaries of what has occurred in the classroom and make plans toward the improvement of their essays.
11. **More Drafts or No Drafts**
    If the author is still compelled by the subject, more drafts are written until the essay is fully developed to the author's satisfaction. Under most classroom situations, one more draft will be produced. If a subject has not proved to be compelling, the author may wish to write an essay on the experience of attempting the essay. Under any circumstances, the author should be permitted to write anything.
12. **Publishing or Reading**
    The essays are published or read to an audience, which may be the class.
13. **Evaluation**
    Students write evaluations of the process of developing their essays, so the teacher may have the satisfaction of knowing their opinions on its merits.

objective substantiation.

To emphasize the need for objectivity, I referred to the way the loons had been studied and I passed out a sheet that defined objectivity ("free from personal feelings or prejudice; based on facts; unbiased") and observation ("the act or instance of viewing or noting a fact for some scientific or other special purpose"). The sheet also contained an assignment, to write a few pages of objective observations about human behavior or, for that matter, anything. I also defined description, behavior, emotion, environment, anecdote, speculation, example, and category, as these concepts seemed relevant to essays intended to cross the "two cultures" gap. One of the great problems confronting science teachers is to get students to make truly objective observations. Students tend to report what they have been told *should* happen in lab experiments rather than what *did* happen, because they will be tested on their knowledge of what should happen. This blinds them to what *does* happen. I ended the assignment sheet by telling them to use any kind of language they wanted and to remember that it was impossible to make any kind of mistake in the beginning.

And so we proceeded to the exercise in writing from objective observation. I encouraged the accurate use of metaphor and simile, concepts familiar to them from English class. These are three examples:

> There is this big black unknown machine in the front of our English room. I wonder what it is. There is a bunch of knobs and plugs piled monotonously on it. There is a big meter. They look like two power meters on a radio. This machine looks very mysterious and it looks like a machine that Frankenstein would have used to make the monster. It is a very mysterious machine.
>
> *—James Amber, 10th grade*

> The expressions of the hands at the party were energetic. The hands of one person were like a dog wagging his tail wildly. The people's hands were waving in the air like a bird when it is flying. Then hands were moving with the help of the music.
>
> *—Bernell Hollis, 10th grade*

> In the computer classroom at least 20 or 30 machines move, with the glare of one machine in the face of another. The keyboards tick. Their faces are blank, as if their hearts were part of the machines.
>
> *—Victor Wright, 10th grade*

Having at last set up conditions I found conducive to really launching the project into the world of ideas, I considered my position. This was an experimental project. There were only a few sessions left. There was no time to build up the momentum necessary to write good essays developed from a wide variety of ideas. What idea could propel us forward quickly? All ideas are connected, and all ideas can tend toward a scientific discussion, but which of the world's great ideas would be the most efficient, under the circumstances? In my mind I scanned a science bookshelf and lit upon Darwin.

I discovered several passages from *The Origin of Species* that seemed to contain the core of Darwin's theories. I quote from two chapters, "Struggle for Existence" and "Natural Selection":

> In looking at Nature, it is most necessary to keep the foregoing considerations always in mind—never to forget that every single organic being around us may be said to be striving to the utmost to increase in numbers; that each lives by a struggle at some period of its life; that the heavy destruction inevitably falls either on the young or the old, during each generation or at recurrent intervals. Lighten any check, mitigate the destruction ever so little, and the number of the species will almost instantaneously increase to any amount. The face of Nature may be compared to a yielding surface, with ten thousand sharp wedges packed close together and driven inwards by incessant blows, sometimes one wedge being struck, and then another with greater force.

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> It may be said that natural selection is daily and hourly scrutinising, throughout the world, every variation, even the slightest; rejecting that which is bad, preserving and adding up all that is good; silently and insensibly working, whenever opportunity offers, at the improvement of each organic being in relation to its organic and inorganic conditions of life. We see nothing of these slow changes in progress, until the hand of time has marked the long lapses of the ages, and then so imperfect is our view into long past geologic ages, that we only see that the forms of life are now different from what they formerly were.
>
> Although natural selection can act only through and for the good of each being, yet characters and structures, which we are apt to consider as of very trifling importance, may thus be acted on. When we see leaf-eating insects green, and bark-feeders mottled-grey; the alpine ptarmigan white in winter, the red-grouse the colour of heather, and the black-grouse that of peaty earth, we must believe that these tints are of service to these birds and insects in preserving them from danger.

The discussion that arose from these ideas was truly sensational, the climax of the workshops. It was attended by Herb Kohl (his second visit to the school) and by David Spencer, civic leader and pastor of the Chambers Memorial Baptist Church. Spencer could not have come at a better time than when the creationist vs. evolutionist views of the students were coming forth in pitched debate. (When asked what position he took with the members of his congregation, he said, "The members of my congregation disagree about enough things without getting them into arguments about this.") Herb contributed an idea of how two-dimensional creatures would perceive the intervention of three-dimensional ones in their world, which gave us the metaphor necessary to understand that when looked at from within the confines of one world, ideas may seem to be in conflict (as in the religious vs. the scientific view of the origin of human beings), but from a larger perspective, they may be seen as existing simultaneously. The debate brought forth a raging need for facts, figures, studies, and examples, which we could hardly refer to before another student's position had to be considered. I tried to be sure all got floor time.

One student was not satisfied until the end, however. In the course of the debate, someone had mentioned that Homo sapiens was the only species of large animal that murdered its own kind. I said that studies had shown that wasn't true. The discussion surged on to new points, but this student wanted to know which species murdered its own kind, and under what circumstances. I put off his question for the sake of continuity, and he accepted that, but at the end of the class, as we were wrapping up, he demanded an answer. I told him of the studies by Jane Goodall and Dian Fossey. Goodall noted a female chimpanzee that had exhibited what could only be described as criminal tendencies in murdering the infants of other females. Dian Fossey observed that gorilla males sometimes murdered infants after they took over troops, to bring the females into estrus faster. This

information had a visible effect on the student. Ideas sought are ideas retained.

The last of the workshop sessions came the week after the discussion. Having told the students at the beginning of the workshop that a loosely structured essay about their experiences in the workshop itself would suffice if they weren't working on subjects of their own choosing, I gave them the opportunity to compile their notes and write this type of essay. Many had more particular ones underway, however, and they finished these. Among both categories there were several outstanding essays and many with a great deal of promise. All the students turned in writing that was to some degree successful because at last it contained original, inspired ideas, stated accurately. The writing was done with pleasure, and reflected their satisfaction. Examples of their work and of the work done by the G.E. scholars in the after-school workshops can be found in the T&W booklet *Inquiry: Samples from the General Electric Science Writing Project.*

CONCLUSION

In a sense, the workshop had just begun when it ended, but it ended on a high note, a turn-around from its beginning. In the final minutes of the last session I asked the students to write a critique of the workshop itself and to include any recommendations they might have. For the most part, the critiques praised the workshop, expressed a wish that I had been able to establish order faster, and, in general, indicated a desire to continue the type of writing begun in it. Every evaluation expressed a different attitude in a different way and none can serve to represent all, but I am including this one because it does as well as any to point to both the despair and the hope offered by public education in New York City. I quote the uncorrected paper:

> What happened through the writing that took place in our English class was we got a chance to express our feelings through our writing and we were given very interesting topics to write about and the different controversial ideas each student in their own opinion expressed brought about a lot of fun in the discussions. The topics that were chosen were hard to write on because there were many different thoughts pertaining to them and through listening to others and they're opinions made me think about the topics again and realize that one way or the other they had a good point even though it was vastly different from your own. Each time we were visited it brought out a new concept of thinking about the certain stories and brought to life a better way of Evaluating the actual topic and understand every one else's opinion and where they were coming from.
>
> —*Anonymous, 10th grade*

There is chaos in the schools, and chaos in the minds of the students. That's reason enough for despair. The students want to learn and the teachers want to teach. That's reason enough for hope. Why can't they do it?

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My other project at the Manhattan Center was a series of teacher workshops. Twelve of the eighty or so teachers in the school showed interest, and a time was selected to accommodate ten. The only time they were free was during a lunch period. Consequently they arrived late, and of the 45 minutes, only 25 or 30 were ever used. I felt pressed to pass along specific writing techniques as fast as possible, to cram them in before the bell rang. I jammed the teachers with information, exactly what they feel compelled to do with students. The most interested participants hung on through five sessions, when I at last began to lighten up and promote discussions of their problems. They all complained about the students' writing, not only how bad it was in itself, but how much it affected the students' ability to learn and communicate. "If you are speaking and they are taking notes they can't even understand themselves, how can they learn?" one teacher said. A computer programming teacher said, "If they attempt to explain how the logic of a computer program works, they find themselves at a complete loss. And since they don't understand the importance of punctuation in a sentence, they have a hard time understanding the absolute importance of punctuation in computer languages." We had only begun to address these problems when the teachers had to drop out of the workshop because of hall duty, and paper work, and the approach of exams.

I did manage to introduce a couple of interesting techniques. Herb Laden tried one out with his students. Rather than have the students go into the chemistry lab with the design of the experiment already worked out, I recommended he let the students organize the design themselves, see if it worked or not, and revise it if it didn't, using directed freewriting and summary writing as aids. He reported that the students got excited and learned the concepts better. The risk that the experiment might fail forced them to make their observations objectively. Some, in fact, did fail, and the revisions were made after discussions with the groups whose experiments succeeded. Altogether the technique was a success.

"Wonderful," I said. "Do you think, then, that you could do this again with the next experiment?"

"No," he replied. "There really isn't time if we're going to cover the rest of the work."

I join a growing list of alarmed people who ask, "Why aren't teachers permitted to teach, and students permitted to learn, within the curriculum?" It seems to me there is a gallery of criminal factors that should appear in the line-up for public scrutiny: unwieldy bureaucracy, standardized testing, fact-oriented curricula like the Regents system, paperwork, and the undervaluing of teaching as a profession. More than that, however, I am concerned about another force that may be squeezing the expansive and bright world of learning into the grim confines of a race track: a type of economic and political thinking that is illogical.

Manhattan Center was founded to "provide for the technological needs of the nation." Who is the nation if not the students, whose needs are not technological, but educational? Perhaps the corporate and political leaders who "have agreed that public schools need to be provided with more resources" should visit the nation of the classrooms, which is the nation of the future, to discover how to solve the "output" problem mentioned above. They would discover that teachers and students in public schools need *permission* as much as they need resources, permission to leave a track that runs in useless circles. ●

ON SCIENCE WRITING

by Herbert Kohl

(In 1986 Herbert Kohl, the author of 36 Children, A Book of Puzzlements, *and many other books, gave a talk to students to help inaugurate the T&W/General Electric Science Writing Project at the Manhattan Center for Science and Mathematics, a New York City public school. Excerpted below are some of his remarks.)*

AT THIS POINT IN YOUR LIVES THERE ARE TWO things you have to consider. First: what are the tools you need to get somewhere? And next: who are you? What do you want to do? What do you want to be? Sometimes in school you have to spend so much time studying that you never have time to discover anything, especially about yourself. Who are you? What do you really care about?

If you go into science, a lot of the skills you've acquired —test-taking skills, taking the SAT's—will no longer be useful to you. Because all of a sudden you've got to start *thinking*, not just taking tests. Which is where writing comes in. Writing is a form of thinking, a way of working out ideas in print, out in front of yourself, so you can see them better.

My wife tells me I'm intolerable if I go for two days without writing. I carry pens with me all the time. Sometimes I find myself sort of chewing on the point. It's my weapon, my security blanket. That's ridiculous, but it's the way I am. I have my own way of working. Writers all have different habits. And one of the things you'll eventually have to learn—when you're not in class six hours a day, when you're given the freedom to learn, when you're required to manage your own time—is that you have to develop your own rhythm. Nobody's going to tell you how to do it. You're going to have to develop what's called self-discipline, or you'll fall apart. You'll need to come to terms with who you are as a worker, as a thinker.

I happen to like to write in the morning. And I can't write without music on. My English teachers told me never to write with music on. They said it would distract me, that my mind wouldn't be able to work. But one day I started writing with music on, and I felt so much more comfortable. So now when I'm writing a book, I choose music that has something to do with the mood of the book. Some books are perfect for opera: loud, screaming music. Other books are right for serious jazz, and still others just happen to go with some stupid piece of music that was going around in my head when I started the book. So that's my working habit.

Some writers can't write unless they're in a cafe, surrounded by other people. Others write best in airplanes or on buses, and others need absolute silence in a dark room with only one lightbulb. The main thing is that you have to find the way of working that suits you best.

In college I had trouble writing because I thought you had to get it "right" the first time. I'd write a paper and turn it in and pray for a good grade. I hadn't learned yet that as a writer you don't worry about getting it right the first time, or the second or fourth or even the fifth. In writing essays, you're dealing with ideas first. That is: what you are saying and who are you saying it to?

Who you're writing for has a lot to do with how you write it. If you're writing for yourself, you can scribble notes or just draw a picture. If you're writing an assignment for a professor, you have to figure out what the professor wants from you. The trouble is that sometimes you won't know what is wanted from you until you've already done it and failed! So you have to figure out in advance what the system wants of you.

As a writer, what I try to do is to "psyche out" various publications, to figure out their structures and their styles. For example, take these four science magazines: *The Smithsonian, Scientific American, Science News,* and *Science.* These four different magazines have four different audiences. *Science* magazine, which is the magazine of the American Association for the Advancement of Science, is primarily for scientists. The language is highly technical. It assumes that the reader knows the subject. I can't read this stuff: "half-tide neurotoxins from fish-hunting comb-snails" or something like that. So this magazine is not one that I would write for, and I very much doubt they would invite me to.

Here's *Scientific American.* This magazine is for affluent investors in science and stocks, for sophisticated young scientists, and for knowledgeable citizens who have a tea table in the middle of their living room and want to show off that they're interested in science. Look at these cover designs: they match your furniture! With *Scientific American,* the best thing to do is just to read the captions under the illustrations. That'll help you understand, because you won't understand the articles, unless you're a scientist. And I doubt that there are even many scientists who can understand *all* the articles. So *Scientific American* is an elaborate scientific picture book.

Here's *The Smithsonian.* This is for people who have enough money to help support the Smithsonian Institution. Its style is *very* simple. I wrote an article for them and they

HERBERT KOHL was one of the founders of T&W. He is currently working on a book about children's theater for T&W.

sent it back three times saying it was too technical for their readers.

And here's *Science News: The Weekly News Magazine of Science.* I've never seen it, but just thumbing through I'd say it's for seventh or eighth graders: simple, visual, and... almost no science.

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When you're writing a paper, remember that the first draft is for yourself, not for your teacher. You're writing first to find out what you're going to say. You're making notes. You're exploring your own ideas. Don't worry about being perfect. The second time through, you try to make it decent. Then you get away from it for a while. The hardest thing to do is to read your own writing again. It takes courage to look at it and ask yourself, "Is there anything of value here?"

This is where those other writer's tools come into play: scissors and paste. You cut up your paper and rearrange it. Usually you aren't told you can do this. In most writing classes, you're not shown how writing is made, you're shown a finished product and urged to imitate its perfection. You're not shown the stages it's gone through to get to the final draft.

It is like what happens when a house is built. You put up the 2 x 4's, the studs and the floor joists, and in the last stage all the mistakes are covered over with sheetrock, the walls are painted, and paintings are hung on the walls. You can't see where the boards were sawed a little crooked or the nails were bent over and smashed into the wood. You can't see the various stages that lead up to the finished house. Essay writing is the same.

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Let's say you're walking down the street and you encounter a weird creature from the eighth dimension that has just arrived on earth. And a garbage can comes flying off a roof and crashes onto the sidewalk between you. How are you going to explain gravity to this creature?

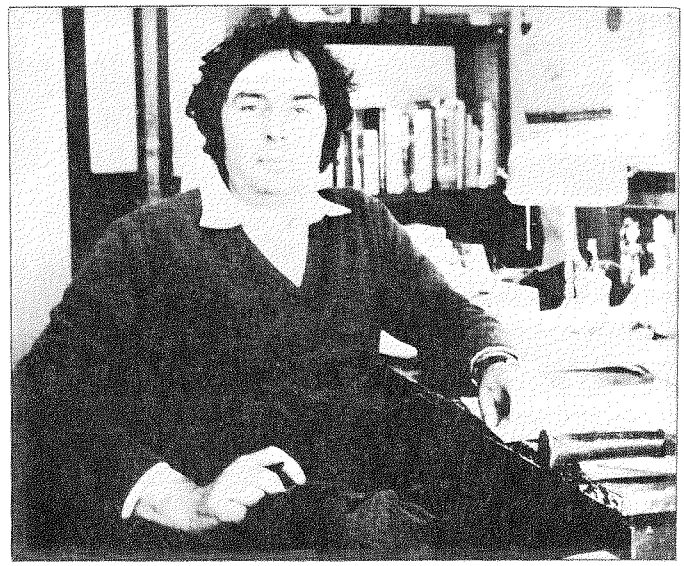
Or let's say there are people living in a two-dimensional world. Totally flat. How would you explain to them what the sun is? How would you explain to them what a three-dimensional object is? This is how science writing is: trying to explain one world to people (readers) from another world. Sometimes it's very difficult, sometimes impossible. That's why science writing can be very similar to poetry: science essays sometimes begin with poetic images.

So, that's enough general talk. I brought along some examples of good science writing that we'll pass out to you now.

The first one is from *The Collapsing Universe* by Isaac Asimov. I chose it because it's a very poetic way of describing what are called "black holes," in other words the *imploding* universe as distinct from the *exploding* universe. It's very difficult to describe something that explodes inwardly, but Asimov does it well.

Mathematical Carnival by Martin Gardner is a wonderfully interesting approach to the idea that there is more than one type of infinity. It's an interesting and important idea, but a very strange one, too. If you have not read Martin Gardner, you ought to. I would suggest that every classroom have a complete set of his books, because I would read them instead of any mathematics textbook.

The Immense Journey by Loren Eiseley is about a journey back through time, the kind of journey you can take by studying rocks. It's a highly poetic book.



Herb Kohl in his think tank

Rachel Carson's *The Edge of the Sea* is about the area that's covered with water when the tide comes in and is out of the water when the tide goes out. That zone houses very special creatures, the ones that have to be able to live both underwater and in the air. It's a beautiful book.

The Binding Curve of Energy by John McPhee is about a man who works on the atomic bomb and then begins to worry about the consequences. It's about the responsibility of the nuclear physicist for what he does, for although he may be working in what is called "pure" science, his work could contribute to the destruction of the world.

I've included an essay by Stephen Jay Gould because he's one of the great science writers in the world today. This essay, "Treasures in a Taxonomic Wastebasket," takes the same scientific story and tells it in three totally different ways. It's a beautiful piece.

Philip Morrison is the best science book reviewer around today. He reviews books for *Scientific American.* I've chosen a couple of his reviews as models for you. If I were going to ask you to write reviews of science books, I'd take one of his reviews, go through it with you, and point out what he does. I'd ask you to follow his example as best you could, although I wouldn't expect you to be perfect unless you were teaching at M.I.T. and had 50 years of science behind you.

Finally, here's part of *The View from the Oak: The Private Worlds of Other Creatures,* which my wife and I wrote. I figured that rather than telling you I had done science writing, I would give you an example, so you could read it sometime and say, "Oh, he was *that* guy." ●