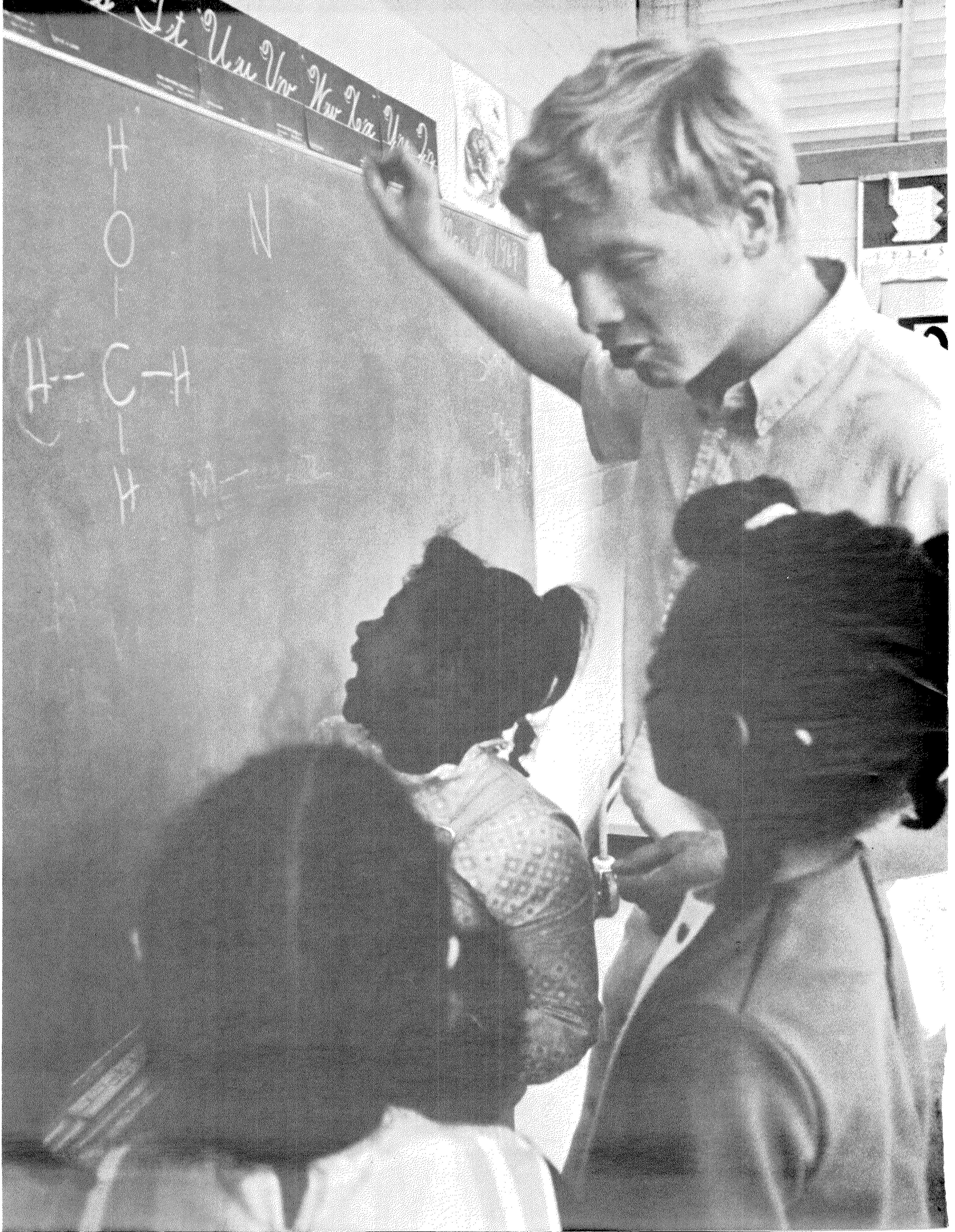


OK, Teacher, What Does Living Mean?

by Gregg Wright

The third grade is a good place to see how much you learned at Caltech; it's also a good place to pick up some of the things you missed.

It's one thing to decide that elementary education is in sad shape and that *you* can do a better job than *they* are doing now. It's another thing to stand in front of 30 kids in a classroom and try to *do* it. But I tried it—and I think Caltech students can, and should, teach science in elementary schools.

At Berkeley, math graduate students are paid to teach abstract algebra in elementary schools with the "discovery method," devised by William Johntz, a high school math teacher in Berkeley. To find out about his techniques, a group of us (Caltech students and students from other colleges working at the ASCIT Research Center) invited Johntz to give a demonstration seminar on campus in October 1968. He impressed most of us with his skill at exciting fifth graders about mathematics, and excited us with the prospect of what we could do.

From this meeting a small group formed to discuss elementary education, and Caltech's role in it. By January, aided by a $500 grant from the ASCIT Research Center, we were ready to try to teach.

The principles and techniques of the discovery method, as I understand it, are these:

> Avoid making more than two statements in a row. Rely heavily on questions.
>
> Move around the class; don't spend all the time up front. Support individual students with a word or a hand on their shoulders.
>
> Write all answers on the board, right or wrong. This validates the answers and encourages participation.
>
> Avoid a pat, "No, that's not right." Each answer is valid to the students. They shouldn't have to feel 100 percent sure of the response the teacher wants before they feel free to respond.
>
> Have students indicate disagreement by waving two hands vigorously in the air. This is an active but non-disruptive way to disagree with a fellow student or the teacher, and the class enjoys it.

Gregg Wright, playing the "molecule game" with third graders at Pasadena's Cleveland School, is a 1969 Caltech graduate now in his first year at Case-Western Reserve Medical School.

Armed with these techniques, we planned to excite kids with the abstract concepts of science. We started by recruiting 60 fifth- and sixth-grade students from Cleveland Elementary School in Pasadena for an after-school class. Shortly after that class started, a third-grade teacher invited us to teach a session of her class twice a week. A few of us accepted her offer. In comparing notes with those who remained with the fifth grade, we found that they had similar teaching experiences.

In our third-grade class we experienced three distinct phases, corresponding to the three teachers we worked with. We began with a teacher on a two-month exchange from her regular school. Because she did not particularly enjoy science, she was content to turn the class over to us and observe. This was the best relationship, because it was clear to the kids that we were in charge when we were teaching. Phase One lasted only three weeks.

February 4, 1969

My plan for the first day was to encourage the kids to ask questions. It seems to me that half of science is being able to ask good questions. Many of these kids are very non-verbal. I hoped to encourage them to notice things around them and then to formulate their vague curiosity into solid questions. After telling them that we were going to study science and introducing the hand-waving convention, I began asking them questions.

"What kinds of questions do you think a scientist might ask?" (No response.)

"Well, how about this one?" and on the board I wrote: HOW DO FROGS GROW? (A few shook their heads, and many looked skeptical.)

"I think some scientists at Caltech are asking questions like that," I said, and I had them take out their science books, open to any page, and see if they got any ideas. The ice was broken, and the questions came in as fast as I could write them on the board. Many of their questions were quite original. I could not trace them either to their books or to anything I had said. They included:

How do babies get in mothers' stummicks?
Why can't we see ourselves grow?
Why do we have brains?
How do brains work? (That's a tough one.)
What makes us laugh and cry?
Why do dogs bark?
How can a space man see in the dark?
Before there were numbers, how did people know how many people in a family?
Is gravity like a magnet?
Why do people have veins?
Why do we send people to the moon?
What is a pencil made of?

What makes boats float?
What is a rock made of?
Who was the first person on earth?
How do people grow teeth?
For real, didn't the Indians discover America?

In retrospect, I am discouraged that, given this material on the first day, we could not do more with it. However, it seemed like a good start.

While we were discussing the questions, one girl asked, "How did the first person to learn about electricity find out about *it*?"

It seemed to be a very important question, and I asked it back to the class.

"He discovered it."

"But what does that mean?"

"Well—he thought about how he thought it might work, and then he tried it to see if he was right."

I was floored. As many times as the scientific method has been drilled into me, I'm not sure that I could have put it that well. I wrote TRY IT on the board, and that became the way we would answer some of the questions that we had asked. They were frustrated at not having the answers. I let that frustration go for now.

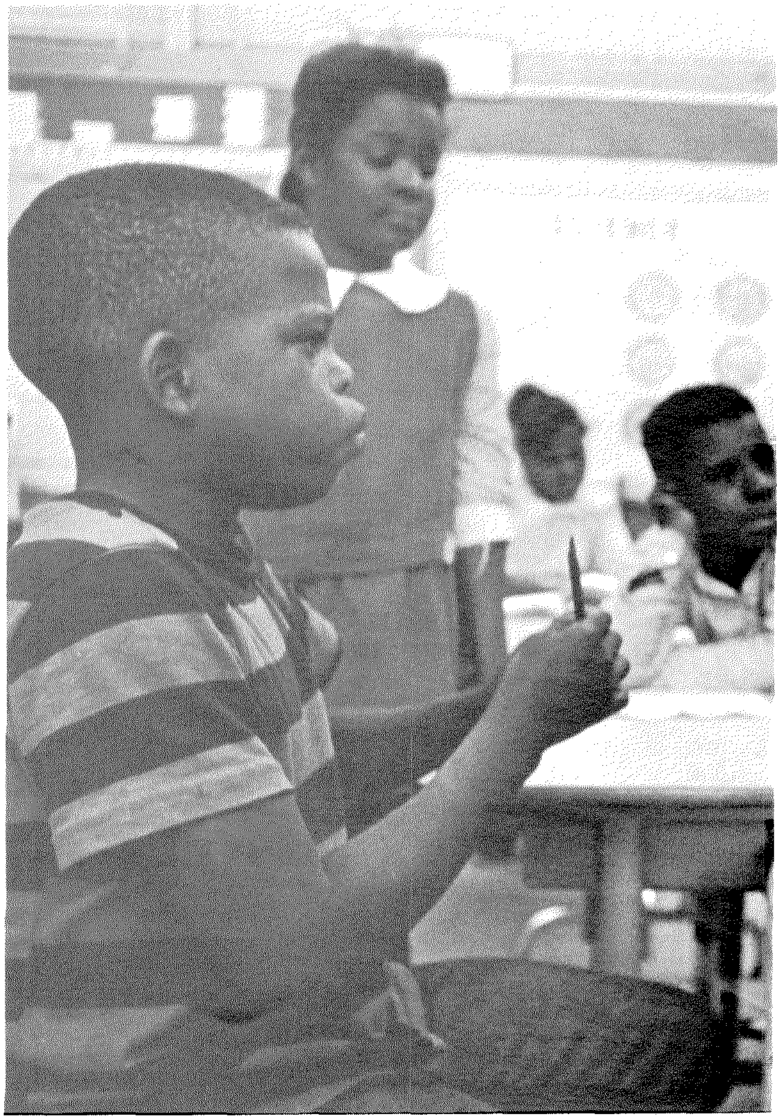
February 6, 1969

The second day was physically exhausting. The level of excitement was high, and perhaps I was working hard at being excited to keep it there.

I wrote some questions from last time on the board, and the students added some new ones. All the biology questions happened to be together on the board, as were the questions about space, and those about weather. I enclosed each group in a circle and named it. Questions about living things were called biology, space questions were astronomy. We also had a weather circle and a physics circle. The kids caught on, and they added questions to each circle.

We began to discuss what qualified a question for the biology circle. What is a living thing? That would keep us busy for a while.

Now—later—I am struck by a contrast. While I was in my home town for a vacation, I visited my own elementary school. In a third-grade class, they were studying science by taking turns reading aloud from their science book. They were studying green plants. When they came to the word chlorophyll, the teacher stopped them to explain, "You know what chlorophyll is, don't you? It is the green stuff that they put into some chewing gum that makes



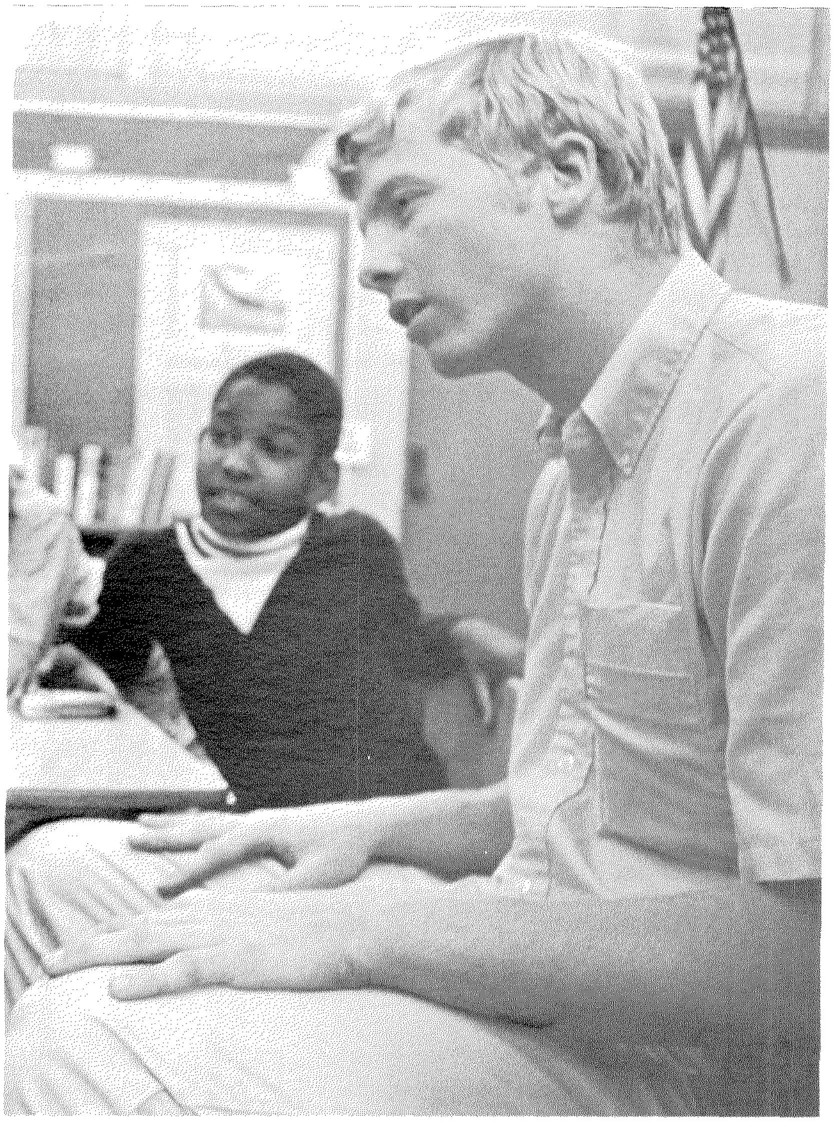
your breath sweet." The class nodded in agreement. The striking thing is not the teacher's explanation of chlorophyll. She has a hard job, many areas to teach, and science was just not her best subject. What was amazing, and upsetting, was that not one of the kids thought to ask, "But what does that have to do with green plants?" There was no response, and they continued their reading.

February 11, 1969

We spent today in confusion. How can we tell what is a living thing? Last time a boy suggested that living things grow, and most of the class was satisfied with this answer. Without thoroughly comprehending the consequences, I had come prepared to completely confuse them.

I brought a balloon and a package of "magic rocks," which are small seed crystals. When they are dropped in a super-saturated solution, the crystals "grow." First I asked, "How do we know what is living?"

"Living things grow."



"Oh? Watch—" and I blew up the balloon.

"Well, living things move."

I let the balloon go, and it flew around the room.

"Well, living things grow by themselves."

But a classmate objected. "No, we don't grow by ourselves; we need food and water."

Then I showed them the magic rocks, which most agreed were not living. In the solution, they grew. Now we were all confused. I had these doubts instinctively, and I hadn't thought about what I would do with the confusion that I produced.

We tried to isolate some things we knew were living and look at their properties. But the class was too confused. About ten voted that trees were not alive. They don't move much. I asked them to tell me on their papers why a balloon was not alive but a tree was. Some described some properties of balloons. Some asked me new questions. The best answer was probably from a boy who said that it doesn't matter. Another said, "I can think of something, but I don't want to." To finish things off, a boy insisted that in Arkansas there are rocks that grow; then they split in half and grow some more.

OK, teacher, what does *living* mean? I knew that at their age I had a three- or four-point definition of living things. I could not recall it, and I think that in good conscience I could not teach it. It isn't that simple.

We tabled the question until next time, and I went home wondering what I would do.

February 13, 1969

I wanted to work on the idea of TRY IT. The method is to dream up a statement about living things that might be true, and then try it somehow and see if it *is* true.

As the first statement the class suggested, "All living things breathe." They quickly changed this to, "Some living things breathe," and we were ready for our first experiment.

"What living things should we use?"

"The tadpoles!"

"Well, is there a better living thing around?"

They were stumped, but only for a minute.

"Oh . . . Oh! . . . US!"

They were happy and excited. One girl volunteered to come up in front and breathe for the class. We were all satisfied. Some living things breathe, sure enough. Then some of them wanted to try, "All living things breathe." But this caused a dispute. There seemed to be two factions in the class. Two spokesmen from each side debated in the front of the room.

"All living things breathe, because they would die if they didn't."

"No, some living things are so small that you can't tell if they are breathing."

"But, they would die if they didn't."

"OK. How about an ant? How do you know an ant breathes? You can't see him breathe."

We decided to make "Ants breathe" the next statement, and the time was up.

Now, I wondered—how in the hell are we going to show that an ant breathes?

February 18, 1969

I was surprised by the class. They had asked their teacher what "alive" meant, and together they had looked in their science books for the answer. Living things grow. Living things change. Living things reproduce. So now they knew. I was glad that they had taken the initiative

to follow up in their regular class. I'm still not sure of the value of a three-point description of life, but I'm sure it is better that they learned it on their own initiative. They were proud and happy.

Over the weekend, and with their new decision about living things, the group lost interest in ants. That was the end of our TRY IT technique. I think it could have been very successful.

I passed out some *Scientific Americans,* and it was one of the most rewarding days for me. The class was very disorganized, but the interest was high. Each one had a different issue of the magazine, and they kept running around to show someone else a picture. I walked around and answered their questions. It was a challenge to explain a three-dimensional model of a protein, or a chart of the elementary particles and their properties, but they asked. When I used big or new words, I wrote them in the margins next to the pictures. They especially liked the pictures of lab equipment, spaceships, and strange animals.

Because it was so successful, I brought the magazines in the next time also. This time I let the kids keep them. The high interest of a few turned out to be a desire to accumulate something—an I-have-more-than-you reflex.

This was the last day of Phase One. We had started orderly and moved toward disorder, but I feel that there was learning in the disorder. In the disorder of Phase Two, we who were teaching did most of the learning. We came to refer to Phase Two as our biweekly third-grade riot.

February 25, 1969

I had a series of slides about the Mariner Mars shot that included some comparative pictures of Earth and Mars. They were beautiful, and the comparison was quite striking. I wondered whether the kids would ask questions about them. Showing them that day was a mistake.

It was the third day of a substitute teacher, and she was having trouble keeping the kids quiet. It was also a rainy day, and she had cancelled their recess. They were overflowing with energy. As soon as the lights were out, kids were all over the room—chasing pencils, under tables, over desks. The substitute teacher was no help; those who were running around were questioning her authority as well as ours.

I moved the projector close to the screen so that the six or seven who were interested could watch with the lights on. In the face of this, thoughts of discovering science were far away. I tried to stop everything and institute one rule: DON'T BOTHER OTHERS. If they would follow this, things might be chaotic, but learning could take place.

For four more weeks there was no recess, hyperactive kids, and no control. For many reasons, I feel that this was a valuable aspect of the program. We saw a part of the kids that is blocked out and covered up by our traditional discipline.

Schools are governed by two guidelines. Children must sit and look interested, even if they are not; and children must not worry about the relevance or importance of a subject, because they will realize its value later. I think this is wrong. I think that the time we were able to spend outside these guidelines became a valuable learning experience.

We were forced to face the question of discipline. How much should we impose? Why do we impose it? Why is it necessary? Is education really so foreign to human beings that they must be made to endure it for their own good?

February 27, 1969

The day just started out wrong. When we came in, there were kids doing cartwheels in the aisle. Again they had had no recess. Jan Streiff, a Grinnell College student affiliated with the Research Center, tried to teach today. She had good success getting them to sit down, and the first 20 minutes were spent peacefully playing a 20-questions game about living things. Then they put on a play that a few of them had made up to celebrate a birthday. It had a rambling plot involving an accident, a fight, a hospital, doctors and nurses, and an operation. I couldn't follow it, but they were completely involved.

With this start, Jan tried to direct a play about living things. Kids were to play the parts of seeds, wind, rain, dirt—everything needed to make the seeds grow. They enjoyed it at first. There was not enough room, however, and the seeds started pushing with the dirt, and fighting with each other. The class ended in confusion.

March 4, 1969

When we came in today, the class was really wild. The teacher had taken a troublemaker to the office and had left the class alone for 15 minutes. As soon as we came in, there was a muffled, "Oh! Oh!" A group quickly formed around us.

"Billy dumped my plant on the floor."

"She put dirt in my book."

"They aren't supposed to be playing the record player."

"Hey, come on and dance."

"Are you going to get the teacher?"

The rest of the hour was general chaos. That day I think we witnessed the pressures that made the schools what they are today. It is easier to say, "Sit down. Learn this. Repeat this back." But I still can't believe that it is right.

This was Phase Two. I've called it a riot and general chaos. I don't want to give the wrong impression. Hyperactive is a good term. My goal was to solve the discipline problem by bringing in something that was more interesting than running around in class.

During this phase, I introduced several new activities. I brought in a set of space-filling molecular models. These are plastic oxygen, carbon, nitrogen, and hydrogen atoms that snap together. When a group began playing with these, I told them the correct name for each piece, and if I could, I named the completed molecules. Their first reaction to the models was to build them into molecules with an axis of symmetry. They would then spin like a top. I could hardly object to this. I remember a biochemistry seminar at Caltech where we spent half an hour building bigger and better tops. This activity could probably pass as a study in spatial relationships and symmetry, and it is probably worthwhile.

Others played another game, at the board or on paper at their desks. The game consists of alternately adding carbon, nitrogen, oxygen, or hydrogen atoms to a basic structure. The winner is the one who completes a molecule. Of course, it is possible to continue the game forever by adding carbon atoms, so I occasionally sprinkled hydrogens in the structure to cut down the possibilities. A few students made the connection between the game and the models, and could draw the structure of a molecule that they had built.

Another activity that we periodically tried was to talk about the state of the class. They voted 25-2 that DON'T *BOTHER OTHERS* was a good rule. However, I don't trust that vote much. One day that wasn't particularly bad (for Phase Two anyway), I asked how many thought that it was too noisy. Many raised their hands. When I asked how many thought it was OK, I raised my hand. I thought that that much noise was all right. This caused an interesting reaction. Five or six of those voting for more quiet became very uncertain, and some changed their vote. Perhaps it had not been too noisy after all. I wonder how many answers in school are calculated to agree with the teacher.

March 13, 1969

Today something happened that reinforced my feelings about relevance and discipline. Tony Searcy, a black student at Caltech working with the Research Center, taught the class, and I observed. As he walked in, he had an immediate rapport with the kids, troublemakers and all. The boys were excited that he had a natural comb like theirs, and he was relevant to them. He spoke their language.

They spent the time talking about what soul is. I was relieved and encouraged that they accepted me without question, and several wanted me to help them with the meaning of soul. Their answers were good. "Soul is holding hands and dancing. Soul is I'm black and I'm proud. Soul is together. Soul father, soul mother, soul grandmother." I was convinced that the students aren't intrinsically troublemakers. They aren't uninterested; the material in school is uninteresting. Something is wrong with our presentation.

"Now I wondered—how in hell are we going to show that an ant breathes?"

That was the end of Phase Two. Tony taught one more day, and I left for spring vacation. While I was away, the regular teacher returned and kept a firm control on the class.

April 10, 1969

By the time I returned, the third graders were interested in the microscopes that our fifth-grade class had been using. I promised that we could use them today, and then found out that they had all been taken back to Caltech. One small dissecting microscope was left, and we spent the day looking at hands, paper, pencils, and so on. They continued to play the games with molecules, build the models, draw, and look at *Scientific American.* Arguing and running around have shown a remarkable decrease.

April 16, 1969

With enough microscopes now available, I introduced the concept of cells to the class. Then we looked at onion skins, cork, hair, and pieces of chipped paint from the wall. Except for the paint, the class did not suggest new things to look at, but they seemed to enjoy this activity.

April 17, 1969

Today I learned that I was at a dead end. I had assumed that the concept of a cell was both important and interesting. I am not sure of either.

The exposure to the microscopes was probably good, especially since they had asked for it, but I definitely think that I shouldn't have said anything about cells before they had seen them. They could have asked about them if they noticed. As it was, where was there to go? I told them that they would see cells in some things, and they did. Big deal.

April 23, 1969

I introduced two new activities today. I left about 20 batteries, light bulbs, wires, and switches on a side table, without saying anything about them except that they were available, and I wired one simple circuit. From then on the electricity table kept many kids interested for hours.

Following an idea developed in our fifth-grade class, I brought in a tape recorder. The teacher helped operate it, and the kids were encouraged to tape stories about science so that we could write a science book.

April 30, 1969

Many are interested in the batteries and wires. One boy just likes to short a battery out and hold it while it heats up. Perhaps he will ask why. Another boy was fascinated by a switch he had made. He could turn the light off by connecting up a new wire. This shorted it out, and he ran to me to show me.

A few like to look at the *Scientific Americans* that I bring in, and a group of girls consistently plays with the models. Once I showed them a ring structure, and they built several others with different atoms. It is hard to pinpoint what they are learning. Sharing is still a big problem. If I haven't brought enough of something, it usually disrupts things a bit.

Today I brought in a five-ball pendulum, of the kind that is popular now. They liked it but didn't ask a lot of questions. I showed them my favorite modes, and they invented a few new ones themselves.

My function has become to walk around between the various activities, ask questions, answer questions, and join in the activities. I often make deals with students who haven't found an activity. I tell them that they can ask me any question that they like, or I will ask them a question. With one group of three, I described respiration using models of O_2 and CO_2. Then one of them explained it to a fourth person.

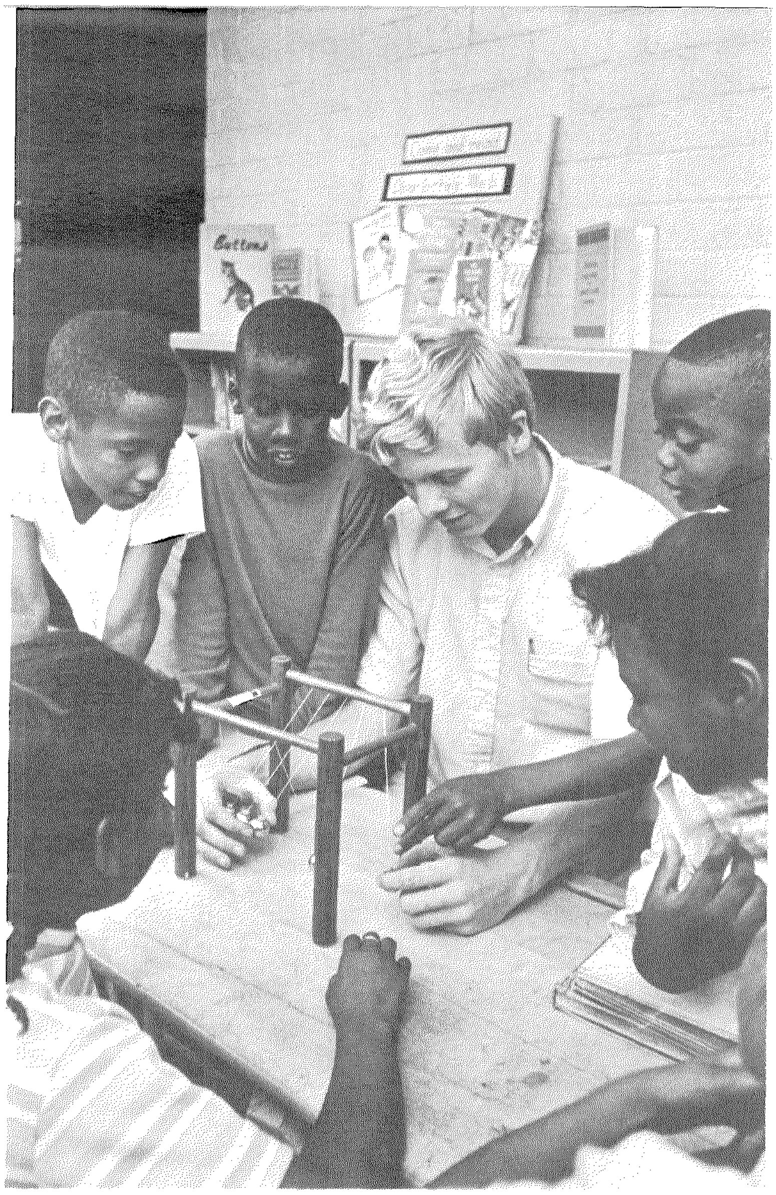
May 1, 1969

Today one of the very shy, quiet girls asked me to help her record a story. To find some topics we looked at the current *Scientific Americans.* She became interested in the pictures and asked some questions. The teacher told me later that she had shown very little interest in anything before and that the tape recorder was a help. A group of three boys hammed it up with a trio version of "Grapevine" at the tape recorder also.

May 5, 1969

I tried to get a group to play a game illustrating how the batteries and lights work. They were to role-play the electric circuit. There were batteries, lights, wires, and electrons. While in theory the game was good, it needed some refinement. First of all, wires should be lines on the floor, and not be played by kids. To be a wire requires standing still, holding hands in a line, while batteries are pushing electrons around. This required a little more restraint than our wires had.

After this class, the pressures of setting up our Summer Institute [page 38] took me out of the classroom. That ended my experiences teaching in the third grade.



One conclusion I came to as a consequence of trying to be a creative teacher is that exposure to the problems of education is a valuable experience for Caltech undergraduates, relevant and important to their professional training.

Many Caltech undergraduates eventually become teachers. Most become teaching assistants as graduate students, and many continue to teach in universities and research institutes. As it is now, they are not confronted with the idea of teaching a group until, as teaching assistants, they are suddenly faced with a section of 20 undergraduates. In this situation, many of them begin teaching in the same manner that they were taught. A TA may do this even if it was completely inadequate for him as a student, because it is familiar, and perhaps easier.

While there may be better ways for him to teach, the pressure of an undergraduate section keeps him from trying other ways. If he is given an opportunity to confront the problems of education before this time, he may become a more dynamic, self-assured teacher, open to change. This is an important part of a Caltech education that has been overlooked.

The questions I was forced to ask about third graders are in many cases the same as those being asked in setting up the experimental biology curriculum at Caltech and in the committee that is reviewing it. In addition, several techniques that I used in the third grade were later used with some success at Caltech. In some ways, an elementary school is an ideal place to develop techniques. Third graders are honest. They do not hesitate to ask, "Are you nervous?" or "Why do you talk so much?" This kind of honest feedback is valuable, and often lacking in a college classroom.

Many of the problems in our schools seem to stem from a manpower problem. Teachers teach unimportant facts to uninterested students as a way of coping. To let the students lead, and switch from facts to creative thinking and learning to learn, a teacher must be confident enough to follow and experienced in both creative thinking and self-education. He, then, can set up the conditions for the students to experience problem solving, experiment with new approaches, and learn to learn.

Universities represent a great untapped potential for public schools. Business and industry are also untapped resources. If the education and experience within these resources were available to the schoolteacher, he could teach the things that he enjoys and act as a coordinator for the other community resources.