A Serious Chemist –with a Light Touch

Whatever the game–research, teaching, tennis, or tomfoolery– Harry Gray has always played to win

"Gray's Stable" in Noyes Lab isn't what it used to be. It's been almost a year now since Harry came back from a year's study in Europe, and nobody's been spraying his office with plastic cobwebs or stuffing it full of computer cards. Even Harry hasn't appeared in any costume more exotic than sport shirt and slacks. What's up? Well, everybody—and especially Harry Barkus Gray, professor of chemistry—is concentrating on research.

Of course, even in the heydey of the hijinks, plenty of hard work was going on. Whatever the game—research, teaching, tennis, bridge, Monopoly, or tomfoolery—Harry Gray has always played to win. And at 38, the list of his accolades reads like a what's what in chemistry: numerous awards (election to the National Academy of Sciences at a mere 35, the American Chemical Society Award in Pure Chemistry, and the Harrison Howe and Fresenius awards for research achievement, for example); ten books at the latest count (his publishers feted him with a special award four years ago when sales approached 100,000 copies); and more than 175 scientific papers. His energy, drive, zest—and accomplishments—are the envy and despair of a lot of his colleagues.

"If I knew what motivates him," says John Roberts, Institute Professor of Chemistry and no mean achiever himself, "I'd try to buy a quart."

Nevertheless, in the past a lot of Harry's high visibility on the campus has been due less to his 6′ 3″ height than to his ways of expressing his exuberance. His taste for fast cars, breezy language, and joyous conviviality are justly famous. For instance, his office was named "Gray's Stable" after he retaliated for a student prank by wearing a horse costume to one of his classes. And he was christened "Harry the Horse" at the same time. Once he imported a drum-beating Hari Krishna group to stir up a class full of sleepers. Not too long ago, bored with being a spectator, he impulsively jumped into the middle of the Mudeo with a Caltech coed on his shoulders. And more recently, when a group of belly dancers finished their act by offering instruction in the ancient art, who was the first volunteer to bound onto the floor?

Harry has been the butt of some outstanding student pranks too, most of which he's enjoyed as much as the students. For publication, his comment about finding his smiling face pasted onto a centerfold-nude photo slipped into several thousand of Caltech's current catalogs was a tongue-in-cheek, "I wish they'd used my body too."

The fact that students delight in hazing Harry is a measure of his rapport with them. "We work *with* him," say the students in his research group—"not *for* him." He has a straightforward way of making that relationship clear from the beginning. "Dr. Gray?" he says incredulously. "Call me Harry."

Informality is as much a part of Harry Gray's personality as his sense of humor—but it also serves a very basic purpose. "What I'm trying to do," he says, "is to teach more chemistry, to keep them coming back to class, to drill a little science into their heads."

Doing chemistry has been Harry's pleasure as well as his vocation for a long time. Deciding at age ten that the subject looked interesting, he promoted a shopping trip with his father for the materials to do some experiments he had in mind. After three or four weeks, he emerged from his basement lab and announced his intention to become a chemist. It is probably significant that nobody doubted him, though his mother admitted later that it was a little hard in those years to explain to his friends why Harry didn't come out and play.

Even then, Harry's energy and motivation belied the classic stereotypes of both "only child" and "Southerner" that he had a right to claim. There are a fair number of Gray kinfolk, but his immediate family consisted of his mother and father. And though his home state of Kentucky is usually referred to as a border state, Harry points out that Bowling Green, where he grew up, is in *southern* Kentucky. Being a Southerner may, in fact, account for some of his strongly competitive nature. "I hate to be anything but the best," he says, "and if you're from the South, people tend to assume that you're a little backward. So I learned early to try harder."

Trying could have sprung from other factors too. Myopic from birth, bantam-sized until late adolescence (he's still referred to as "little Harry Gray" in Bowling Green), and studious by choice, he worried about being accepted by his peers. Once, in the eighth grade, he deliberately flunked a test to remove the stigma of straight A's—and found the experience so painful that he worked twice as hard to make up for it.

At age 11, Harry got a job as a newspaper carrier, and by the time he was 17, he was assistant circulation manager (and occasional sports writer) for a paper with a press run of about 20,000. His job entailed doing all the circulation accounting, handling subscriptions, dealing with customer complaints, and supervising the carriers. In addition to a daily 4-hour stint, he worked a straight 20- to 24-hour shift on weekends, during which time he had to assemble the Sunday paper—slipping the comics inside the magazine, the magazine into the social section, and so on until the whole edition was together. He was, he recalls with some pride, an expert at it.

He also became an expert at juggling his time. He held the newspaper job through high school and college, went to school, played tennis (he was college conference champion at age 19), and led an active social life. It all added up to a week of 60 or 70 hours of frenetic activity.

Harry is the first to point out that he couldn't have done it if Western Kentucky University, in which he enrolled in 1953, had been a really tough school. Fortunately for someone who had to earn his way, it wasn't "an academic crunch like Caltech," and—typically—Harry made a good thing of the situation. He graduated in 1957, second in his class, with three majors—chemistry, physics, and mathematics—and a surplus of credits. He also had some money in the bank, a scholarship, admission to the graduate school of his choice, and a fiancée.

Shirley Barnes was a mathematics major at WKU, and she finished college in three years in order to graduate (with honors) along with Harry. They were married that summer and set out for Illinois in the fall—Harry to do graduate work at Northwestern University and Shirley to teach mathematics in a Chicago school. Harry looks back on

Northwestern as a "terrific, fantastic place." The conjunction of its small, friendly graduate group in chemistry, the exciting things opening up in Harry's chosen field of inorganic chemistry, and the stimulation of two extraordinary professors—Fred Basolo and Ralph Pearson—added up to what he calls a lucky break for him.

Enthusiasm, ability, and the financial pressure of a growing family got Harry through graduate school in record time. In just three years he was able to take his new PhD, Shirley, and one-year-old Vicki to Copenhagen where as a National Science Foundation Postdoctoral Fellow he studied for a year with Dr. Carl J. Ballhausen.

In 1961, the Grays—now including Andrew—returned to the United States and a teaching job at Columbia University. In the next five years Harry made both a place and a name for himself there. At the age of 29, in 1965 he became the youngest full professor in the 200-year history of the university, and when he left in 1966 to come to Caltech, the student newspaper announced his departure in a black-bordered story.

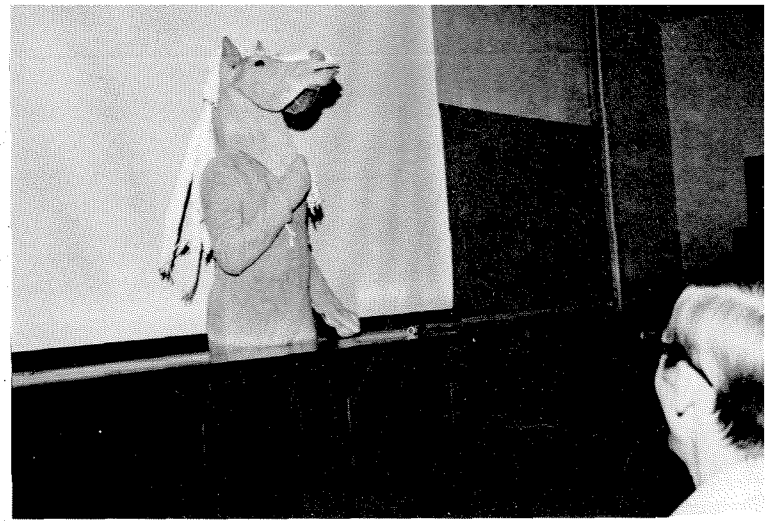
Harry still feels some compunctions about the rightness of his decision to leave Columbia. ("They took me in when I didn't have any reputation.") But he also recognizes that Caltech was much the best place for his scientific progress. In those terms, he says, the move has paid off beyond his wildest dreams.

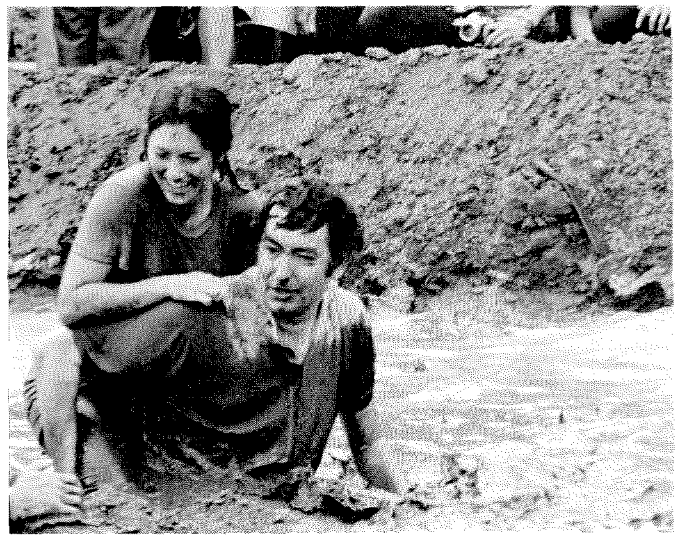
Harry Gray's dream for the eventual outcome of his research is to understand completely how at least one catalytic process in nature works—and then design a better one with simpler chemicals. Chemistry in general, he believes, should try to put itself in a position to improve on nature.

He began his part of this grand design as a graduate student, studying the reaction mechanisms of such transition metals as platinum, palladium, and gold. This research has now become the authoritative work in the field. In fact, at a research conference recently, he asked to have a point clarified and was rather briskly referred to the "classic" literature on the subject—his own.

In his postdoctoral year at Copenhagen and later at Columbia, Harry dug more deeply into the theoretical aspects of transition metal chemistry by working out the quantum mechanical descriptions of the electronic structures of a number of these metals and metal-containing compounds. And he developed a method for doing the necessary calculations that is still in use.

His other work at Columbia involved the investigation of compounds containing transition metals bonded to sulfur

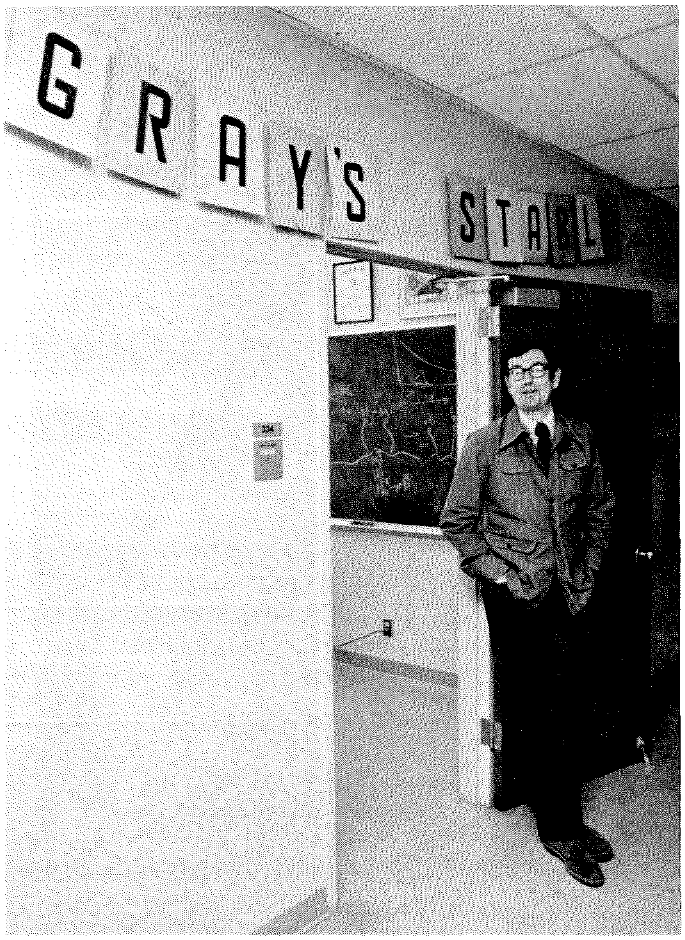


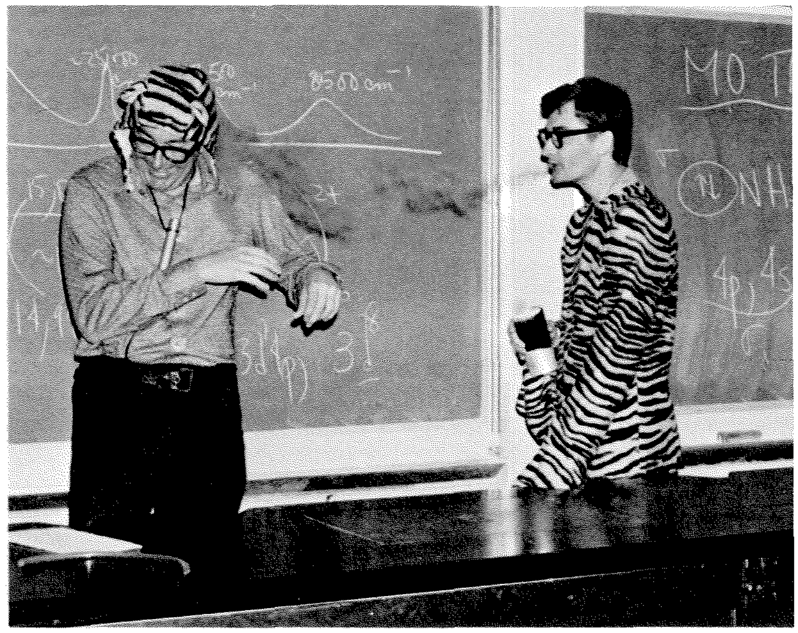


atoms. In trying to understand their reactions and electronic arrangements, he and his group designed a whole new class of molecules with metal atoms carrying charges that do not exist in nature—and thus synthesized materials with properties that do not occur naturally.

This was all basic research, and the manufactured molecules were pretty much curiosities. Harry was happy to be able to predict that these new electron arrangements could be made—and then make them—but he had no idea that any part of it would ever have practical applications. In the serendipitous way that basic research has often been transmuted into applied science, however, his discoveries may become the basis for new technology. Some of the transition metals that are naturally either too reactive or too inert to be used in the body for cancer therapy are being tested now in the intermediate forms that he and his group developed. And a recent physics seminar seriously discussed the possibility of using his synthetic materials for raising the temperature of superconductors.

Harry's philosophy for choosing his research emphasis has always been based less on what to do next than on what to stop doing. This attitude was particularly appropriate when he decided to come to Caltech in 1966. By then, he





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felt that he had contributed most of what he had to offer in the chemistry of simple transition metal compounds, and it seemed a natural time to shift directions. He disclaims ever having abandoned thinking about those problems, though. In fact, he still has one group of students who are working on the electronic structures of inorganic compounds. But two new research problems have claimed most of his attention at the Institute: (1) How metals function in the proteins of living systems (metallo-enzyme catalysis), and (2) What happens to transition metal compounds when light is shined on them.

The first of these research areas is described as biological inorganic chemistry, which may sound like a contradiction in terms. But some of the best examples of efficient chemical reactions occur in biological systems—in the naturally occurring complexes of the transition metals. Harry and his group are trying to find out what is the role of metals (chiefly iron and copper) in large protein molecules and why these molecules are so important in nature.

More specifically, Gray's group is working to discover the mechanisms by which energy is stored to run biological systems. The fixation reduction of oxygen, for example, is one of the most important problems for chemistry to solve, and the group is attacking it by trying to understand the reactions of metals with oxygen in living systems. In the body, for instance, oxygen is picked up in the lungs by an iron protein—hemoglobin—and carried to another iron protein—myoglobin—in the muscles. The myoglobin delivers the oxygen to a third iron protein—cytochrome oxidase—where it reacts with electrons passed down another elaborate chain of proteins from the ingestion of food. The result is the reduction of the oxygen to water and the storage of energy in key molecules in the body's cells. What Harry is trying for is to understand this efficient molecular engine—and then improve on it.

The second aspect of Harry's current work has to do with photochemistry: adding one new ingredient—light—to transition metal compounds to make them more reactive. At present, energizing a catalytic reaction often involves using a lot of heat and high pressure; Gray's group hopes to be able to substitute light—possibly sunlight—for part of those requirements. The results have been encouraging; they can do several kinds of reactions that can't be done any other way.

The photochemical project is now at about the same point

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that Harry's first work was 15 years ago, with, he feels, even more potential for great impact in the next two decades. Certainly converting light into other kinds of energy is relevant to today's problems. And the work is not too divorced from that of the metallo-enzyme group either, because plants that contain iron and copper can absorb light and convert it by photosynthesis. So the Gray biological and photochemistry groups may eventually merge, and then perhaps complete the circle back to inorganic chemistry and the simple transition metals. "Once back to GO with our new understanding," says Harry, "maybe we can redesign the catalysts."

Understanding the special role of metal ions in chemistry is the thread that has run all through his work, and in that sense he has worked on one problem for 15 years.

Harry hasn't confined his experimentation to the laboratories at Caltech; he's also logged a lot of classroom time. Between 1966 and 1969 he and George Hammond, former chairman of the Division of Chemistry and Chemical Engineering, made a valiant and time-consuming attempt to restructure the chemistry curriculum. It turned out to be a larger bite than they should have tried to chew.

In the first place, their ideas were fairly extreme; and in the second, too much of the implementation depended on the two of them—their colleagues mostly reacting with a mixture of interest in the logic of the concept and doubt of the wisdom of the pedagogy. Students were wildly enthusiastic, though possibly as much because of the personalities of the professors as the content of the ideas. It might have been wiser to propose small changes in the existing courses, but the two crusaders thought that would be a sellout. Harry is philosophical about it now. "Even though all that effort resulted in almost imperceptible changes," he says, "I've never regretted any part of it. If you have a lot of what you think are brilliant ideas, you might as well face it—you're going to have to do most of the hard work yourself, and that's impossible if your scope is too broad. In terms of our 1966 goals, we blew it; but as I look at it now, I see that we got the most we could have hoped for—we stirred people up to think about what they were doing."

The impact of the effort was not by any means lost on the wider educational world either. In 1972 Harry, age 36, was the youngest person ever to receive the Manufacturing Chemists Association award for teaching college chemistry.

His temperate attitude about the possibility of being on the wrong track now and then is part of the maturing Harry feels he's doing these days. He still gives everything he has to following out his own creative ideas, but he tries to be scientifically honest about admitting the validity of contrary evidence.

This is important to him in aspects of his life other than the scientific. For example, he doesn't want to be known as a driver of fast cars any more. The simplicity of his car-free life in Europe last year impressed him so much that he is thinking about moving within walking distance of the campus. Since he often puts in a seven-day week—being constitutionally unable to pigeonhole Friday's ideas until Monday—he could thus spend time at home with his family more easily. The family, which now includes 18-month-old Noah, is a very high-priority item on his agenda.

Another high-priority item—for approximately the next ten years, Harry estimates—is time for concentrated work on research. He feels the need for long quiet periods to study problems from all angles, and he has deliberately cut the size of his research group so that he can give more attention to each of his students. The way he helps them most, they say, is in developing the strategy to attack a research problem, though he leaves it up to them to initiate the investigation and work out the details. But, one graduate student says, "Harry's so full of ideas these days, we practically have to use a filter to figure out which ones will be useful to us."

Since his research group is divided into three sections, Harry probably has to use a filter too—to shut out distractions and concentrate on the student or problem at hand. But he's pretty good at it. And if he is outwardly happy-go-lucky, he is also something of a perfectionist. No sloppy work, no loosely written paper, no incompletely thought-out conclusions—his own or his students'—get past him.

Harry Gray imparts a light touch to chemistry, but no one should assume that he is not also deadly serious about it. In this game, too, he plays to win. If "Gray's Stable" is not what it once was, it is, nevertheless, what Harry wants it to be.

—Jacquelyn Bonner