Nobel Voices Video History Project, 2000-2001

Interviewee: Jerome Karle
Interviewer: Neil Hollander
Date: June 26, 2000
Repository: Archives Center, National Museum of American History

HOLLANDER:

Would you please give us your name and tell us what you do.

KARLE:

I'm Jerome Karle, and I work at the Naval Research Laboratory in Washington, D.C. My area of interest is best described as structural chemistry. What that means is that, broadly speaking, we're interested in the atomic arrangement in various materials. They may be gases or solids. And solids take different forms. They may be crystalline or may be what's called amorphous. Even though amorphous indicates that there's no real structure, it turns out from our research that even materials like glass have characteristic structures that are different than just a redistribution of molecules as occurs in liquids.

There are many reasons why we consider this an interesting subject. In the first place, atomic arrangements are of significance to many fields of science. It's very important, for example, to know what the atomic arrangements are in chemicals, especially if you're making new ones and you want to know what you really made. If you go beyond that step, you may be interested in making new pharmaceuticals, and that's where health and medicine comes in. It's very important to know atomic arrangements if you have a material that works fairly well, but you'd like to have substances that work better and what might that mean.

You may have something that works fairly well, but it has side effects that make you feel sick or don't do the job as well as you would like it to. If you know the atomic arrangement, you can get some ideas as to how to change this material chemically, in order to achieve a better product.

This goes on all the time. It turns out that the marvelous developments in understanding the DNA and the molecules and the functions of the molecules in humans, combined with this type of structural information, has opened up absolutely new vistas for treating health problems, for example. Now since we work for the navy, and the navy is interested in health problems but it's also interested in other kinds of materials that have various effects, and, in general, there's always this business of wanting to know the details of the structure of interesting materials, and, again, how one might even make them better and perform better. So this covers a very large gamut of fields of science in terms of knowing the structure helps one a great deal to understand the function.

Now, my interest in science has always been in science as a whole. People ask me, "What are you, a chemist?" or so forth. Well, the fact is that I was hired as a physicist, and I've been interested in all science. For example, I taught advanced courses in the university, part of a function at the Naval Research Laboratory, to help people who did not have the Ph.D., but wanted to go for the graduate degree, to do so by having a program that was sponsored by the University of Maryland to give coursework right at the lab. And over the years, about a twenty-year period, although I received a degree in physical chemistry, the courses that I taught were in mathematics and in physics. In all that time, I never taught a chemistry course.

So, structure research gives one the opportunity to have an interest in science as a whole, and the structural science gives one the opportunity to work in the various areas of science, for example, in mathematics and in physics and in chemistry and in biology. This has been my interest, and I seem to have had the good fortune of having very good problems to work on, and we worked on them with some success.

HOLLANDER:

If I ask you what was the problem really that led you to the Nobel Prize, how would you explain that?

KARLE:

Yes. There was a problem that concerned obtaining the atomic arrangements in crystals. The way to explain it is, the data were obtained for doing structural research in crystals by using a technique called x-ray diffraction. It can be rather simply described. What you have is a narrow x-ray beam, and it would have a target. The target was the crystal whose atomic arrangement you would like to know. What happens is that as you strike the crystal with this narrow x-ray beam, it splashes. That splash is called diffraction, and it's recorded. It's like a fingerprint.

Now, you have to do some special things with crystals to collect the entire pattern, and that is, you have to orient the crystal so that different parts of it are exposed to the x-ray beam. What you can record if you're using film are a bunch of dark spots. As I say, it's sort of like a fingerprint, because there's a different set of dark spots, depending upon the crystal unique to the particular type of crystal.

Now here's the problem. The mathematics of the system were such that these dark spots represented half of the information that you needed in order to directly make a calculation to see where the atoms are. All the textbooks and the standard dogma in the field was that you can never do this directly. In general, there are some special techniques when you have such heavy atoms in the structure that the one to two heavy atoms dominate the scattering, and then, of course, you can use that information to more or less directly get an answer. But if you don't have relatively heavy atoms, just roughly the same atomic numbers, then you have nothing to hang the problem on. As I say, the standard dogma was that there was nothing you could do about it but maybe guess and play some games and all that sort of stuff.

Well, one day I had occasion to look at the mathematics. I had been working in a different field, a related field. It was called electron diffraction instead of x-ray diffraction, and it was for gases, gaseous molecules, not for crystals. But as I say, I had occasion to see what the situation was with crystals, and I looked at the mathematics. It was immediately apparent that all the information that you needed was contained in the intensity measurements, and that in fact if you used a compass source of the x-rays, that the amount of information that you had was such that the problem was very greatly overdetermined. So just a simple inspection of the equations indicated that the problem very definitely had a solution just by using the intensity.

That doesn't mean that it was easy to solve the problem, and it took some time. The mathematics was developed in a relatively short time, but going from the mathematics to practical analysis took quite some years. It would have been helpful if in the fifties we had the fancy computers that we have now, but the computing was very different, and it just took some time to clarify the ideas of what you had to do.

You never had equations that were equalities. You had relationships that expressed what we called the phases. These were the unknown quantities in terms of the measured intensities, but there were only probabilistic relationships, and it was necessary to learn how to use the probability theory in order to achieve the solution. The solution—we published the theory in 1950, and I had worked on the mathematics with Herbert [A.] Hauptman, who shared the Prize with me. But then he left the lab.

The practical method for solving centro symmetric and non-centro symmetric crystals—non-centro symmetric ones are the really hard ones. This says something about the kind of symmetry there is in the crystals. That general problem was not solved until about thirteen years later, and in that development, it was a collaboration between my wife and myself.

HOLLANDER:

Is there some way that you can draw a link between the work on crystals and something that is used practically today, something that we will use, that comes from the connection between the two?

KARLE:

Yes, there are major applications in organic chemistry. It's the best way to tell what you have in synthetic processes, intermediate, final products. Another instance, you have natural products and you don't know what the atomic arrangements are. You may have products that come from shining ultraviolet light on substances and making major changes that are unanticipated, and this is what the application is good for.

Now, having this information, as I mentioned earlier, is part of a basic kind of information for making applications in medicine, pharmaceutical industry uses it all the time, and various other applications in improving materials that also may be of interest.

HOLLANDER:

Can you give a specific example [unclear]?

KARLE:

Well, there are so many. For example, the National Institutes of Health, we're working on frog toxins, and one of their interests is the hope that they could develop from them medicine that would be good for heart attacks. We had a small sample of such a material, and we determined the structure. Then it was tested, and it was too dangerous. It had only a very narrow range in which it would operate safely. So it was never used for that purpose.

But it's used in neurophysiological laboratories along with—I don't know if I can instantly remember the name of it. Well, the substance I'm talking about is leutrachotoxin [phonetic], but it's used along with another substance that comes from kind of a puffer fish that is very dangerous to eat in Japan. It's sold in restaurants, and there are very, very well-trained individuals who remove the toxins.

The reason why it's of interest is that in experiments in neurophysiology, these two substances act just opposite of each other. They act reversibly. One of them, as I recall, permits ions to enter into the nerve cells, and the other reverses the process. So, in experiments on the action of nerve cells, these two substances are very useful. That's just one example.

HOLLANDER:

Would you consider yourself some kind of inventor, then, or discoverer? Would that be a correct label?

KARLE:

I don't know quite how to say it, but there are people in this world who can see through the solution to problems, and because I made a point of training myself in several different fields of science, I was prepared, when there was a mathematical problem, to do a mathematical analysis and the various other considerations that would be involved. After you get the mathematics, how do you relate mathematical solutions to real-world solutions? I just think that I work according to scientific principles.

Invention? I would associate the word "invention" more with engineering-type operations, for which I have tremendous respect, incidentally. I think the engineers of this world don't receive the recognition that they should.

HOLLANDER:

Doctor, where did you develop or how did you develop this interest in science? Any particular point in time?

KARLE:

Yes, yes. I was quite a young child, and there was a museum in New York City, at least for a couple years, as I recall, in the *Daily News* building in Manhattan, and it was a marvelous museum because it was hands-on. I must have been about seven or eight years old, maybe. I went there two times, at least, with my mother. She took me there. And I just thoroughly enjoyed making things turn and rotate and do one thing or another with this hands-on application, and I just decided at that point that science interested me.

I didn't have any particular subject in mind, and that's, in affect, the way things developed for me. I have an advanced degree in biology, a master's degree. I have degrees in physical chemistry, and I took a lot of additional courses on math when I was in graduate school, and also some in physics. In fact, if World War II wasn't on, I would have stayed on to get a Ph.D. in math also.

HOLLANDER:

Is there any particular book or person that you would say really marked you?

KARLE:

The closest I could come to a person is that I had the same teacher in high school for chemistry and physics, and he noted my interest and supported it.

So far as a book was concerned, Sir James Jean [phonetic], who was a physicist early in the last century, and an astronomer, wrote popular books on science, and after having been to the museum, I took those books out to read. I could read them with understanding. I graduated the eighth grade before I was eleven years old, so I was far along in school.

HOLLANDER:

Doctor, just to jump to something totally different. Do you have a favorite science joke, or humorous situation, possibly one that happened to yourself?

KARLE:

I can't think of a science joke. I'm usually prepared for the other kind. [Laughs]

HOLLANDER:

Tell one of those if you like, or something humorous that happened to you.

KARLE:

Yes. I can't think of anything that was really, really amusing.

HOLLANDER:

Perhaps an embarrassing moment that happened to you.

KARLE:

If there were, I don't recall.

HOLLANDER:

Suppose I came to you today, being fifteen, and I said, "Doctor, you've been in this business a long time, a lot longer than I have. Where do you suggest I go? What do you suggest I look for? What do you suggest I do?" What would you say?

KARLE:

Well, I think that if you're a youngster who is committed to science, what I tell such folks is that the thing to do is to get as broad a training as you possibly can. Don't worry particularly about what field you're going to be working in. You can do that when you're in graduate school or beyond. But if you want to work in science nowadays, it's very valuable to have a very broad training, because science is not easily divided up anymore. There's a lot of math and physics and biology nowadays, and so forth, and you also give yourself the opportunity for more choices when you get older.

HOLLANDER:

I don't think there's anything else. Oh, one last question. Do you have any regrets?

KARLE:

None whatsoever. I would do this over a hundred times if I had the opportunity. [Laughs]

HOLLANDER:

Thank you, Doctor.

[End of interview]