Nobel Voces Video History Project, 2000-2001

Interviewee: Paul Boyer
Interviewer: Neil Hollander
Date: June 29, 2000
Repository: Archives Center, National Museum of American History

[Note: The volume level of the interviewer's microphone is extremely low. At times the interviewer is inaudible.]

HOLLANDER:

Doctor, if you would please introduce yourself to us, and tell us who you are and what you do.

BOYER:

Well, I'm a chemist-biochemist, meaning that I work on biological things. I'm Paul Lee Boyer, professor of biochemistry emeritus from University of California at Los Angeles. Now, most people, when I say UCLA, think of football teams or other things, you see, but it's a very fine place for doing science.

I'm now some eighty years old. I was born in Provo,, Utah, back in 1918, and I at present am what's called an emeritus professor, meaning that I have retired officially from the job of being a university professor, but I still have a keen interest in all things living and all things in science.

HOLLANDER:

Doctor, what exactly was your work, your field of expertise?

BOYER:

Well, I've been in this field of biochemistry for over fifty years, and so I've always had, perhaps, too many interests. But my center of my expertise has been what's called enzymes. Now, you know that there are many chemicals in the living body, and it's a complex system, and these reactions that go on, to make life possible, that are happening in the plants up here, that are happening when I move my arm, all the things that make it so you can have life depend upon catalysts, these catalysts are substances that will make a chemical reaction go faster. So, that the food that you eat has to be digested. They were first studied as digestive enzymes many years ago, that break down the food that you eat into small molecules, and let that come into your body. So, these catalysts are called enzymes, and I'm fundamentally an enzymologist. I love these catalysts. Now, these catalysts are big molecules. Most of you know what water is, and if I ask you what the chemical composition of water is, you would tell me it's F^O. Now, that's a typical molecule of a small molecule, and we assign it a molecular weight, and this is, it has oxygen, sixteen, and two hydrogens, is eighteen. That gives it a molecular weight of eighteen. Now, a typical catalyst, one of these enzymes in the body, would have a molecular weight maybe of 200,000. So, you see, they're much bigger than the water molecule, and they're made much more complex.

So, most of my career dealt with study of these catalysts, how these catalysts are made. And they're such wonderful molecules, that I study this one and I think it's the most wonderful molecule around, and I will start working on glyceraldehydes phosphor dihydrogenase [phonetic] and find out what it does. Oh, that's a wonderful molecule, you see. But there was a process called oxidative phosphorylation. I'll tell you more about that later, perhaps.

The first half of my career I worked, perhaps, on thirty or forty different catalysts. Towards the end of my career, I spent more of my time on just one catalyst, and so I've fundamentally been a person that studied biocatalysts, how catalysis takes place in living systems.

HOLLANDER:

How did you first get drawn into chemistry, as a child? What pulled you in? Was there a book, a person, or event, or something that said, "I'm not going to be a poet"?

BOYER:

Well, I grew up in Utah, and I'm indebted to the Mormon community there for a fine educational system.

HOLLANDER:

You have a truck going by behind you.

BOYER:

Right.

HOLLANDER:

I'm sorry

BOYER:

It's quite all right. I grew up in Utah in the Mormon community there. Although I have not kept with the faith, it did provide me a splendid education system, so that I got, early on, a good education as I went through in mathematics and biology and other things.

My father was a small-town physician. He provided me with a chemistry set that I had in the basement of my house. I can remember, still, monkeying around with this chemistry set, being able to put things together and see them react a bit, and so forth.

But I went to college in this town of Provo, only a few blocks from my house. I was very fortunate, you see. When I grew up, they developed Brigham Young University, a small college then of about 3,500 people. But again, they had excellent teachers. I had a high school chemistry teacher that influenced my life a lot because he took an interest in what I was doing. He helped me set up an exhibit for a student show for a little science exhibit. I had the privilege here some thirty years later, while he was still alive, of going back and visiting my home town and coaxing him to take a little financial gift from me because of the influence he had had on my life.

HOLLANDER:

Was he there when you received the Nobel?

BOYER:

No. He had long since been gone. But, now, that was just straight chemistry. That wasn't chemistry of living things. When I went through my chemistry at Brigham Young University, there was no such class course as biochemistry. My father had hoped I'd become a physician and take in there, but he was by no means directing my career. But he did make me interested in living processes. But I wasn't interested in taking care of living people. I'd seen too many of the problems that a small-town physician has. [Laughs] These things. So I was interested in living processes, and that's how I got started in chemistry, not how I got started in biochemistry.

HOLLANDER:

What exactly was the Nobel for?

BOYER:

Oh. Well, let me go back just a little bit here. What exactly was the Nobel for? It was because I did work on an unusual one of these catalysts.

But let me tell you just a bit more about these catalysts. When I had this opportunity at this university, there was a notice on the bulletin board, of a scholarship at the University of Wisconsin in biochemistry, and I was fortunate that the University of Wisconsin biochemistry department there was very good. I applied for the scholarship, went there, and one of the things that happened during the first—while I was there, was they had a symposium on what's called respiratory enzymes. At this symposium on respiratory enzymes—these are catalysts that are concerned with what you do with the oxygen you breathe—at that point they described the occurrence of a very important metabolic process called oxidative phosphorylation. Now, that's a big mouthful in a way, but it's the oxygen that you breathe now. The oxygen you breathe, you capture energy from it, because out here, if we burn these things, burn some wood, it gives off a lot of heat or energy. The oxygen in your breathing gives off energy in the body, and it's captured by making a compound called adenosine triphosphate, ATP, and the process is called oxidative phosphorylation. And that's the first time I'd heard about oxidative phosphorylation.

The discovery of the process was a very important thing. Now, I'd finally finished studying, and the Nobel Prize was for recognizing how an enzyme that makes the ATP functions. That came later in my career. I've worked on other enzymes, other catalysts, but then it came to how ATP functions. If you want, I can tell you more details on that or more other aspects of enzymology, but it was about ATP synththase [phonetic] that makes adenosine triphosphate.

HOLLANDER:

What I'd like to ask you now, Doctor, is what do you think is the significance of the Nobel?

BOYER:

The significance of my Nobel, or the Nobel Prizes in more general?

Which?

HOLLANDER:

More general.

BOYER:

Yes. Well, there's no question, the Nobel Prize has become a household word. Whenever it's mentioned, people think this is the acme of science, and as such, it carries with it the prestige of a scientific accomplishment, and for the science field, with the field of chemistry and physics and so forth, it defines really what has been important. In a sense, the Nobel Committee is in one way both writing the history of science by what they choose for this, as well as bringing the—

[Tape interruption.]

BOYER:

The Nobel Committee is essentially writing the history of science when they choose it, because this is going to be a record of what have been scientific accomplishments, but it brings science to the public. It makes for the public attention of scientists, gives us the opportunity for scientists and science to tell the public about accomplishment, and to why science is important, as well as to explain to the public what new things have been discovered. There's a beautiful public interest in science on the thing, so the Nobel Prize serves to recognize a few individuals and give them much more recognition than they deserve in terms of the field as a whole, because many people contribute to the thing.

HOLLANDER:

What was the other side of this matter—the significance of your Nobel?

BOYER:

Well, I'm very fortunate to have had, much as my Nobel come late in my career, the research work that I did to give an understanding of this catalyst was mostly done in the seventies and the eighties, nearly a quarter of a century ago. At that stage it was controversial, and until my co-recipient in a phase of the Prize, John Walker, did his work, it wasn't accepted in the field. But it turned out that his work verified mine, and so, in terms of significance, of course it's satisfying to have what you had postulated and have it done.

I sometimes say I've been fortunate because I've had life, luck, and longevity. I've had an interesting life in living processes. I've had luck as I chose what turned out to be a very unusual and important enzyme to study, and longevity that I've been around long enough after I did my research and outlived all of my competitors to have it, and I got the recognition, you see.

Now, there's another fortunate thing about my Nobel Prize at this stage. It comes at the end of my career, and so I don't face the problem that some other people with Nobel Prize do. You win a Nobel Prize when you're forty or fifty years old, they pat you on the back, and then they say, "Now what are you going to do next?" you see. This way I can enjoy coming to meetings like Lindau [phonetic] and talking about it.

I would admit I was pleased in terms of my relationships with colleagues and family, that they had a recognition, perhaps, of accomplishment that they didn't realize before, that the hours and the time I had spent away, I was doing something down the line. [Laughs] So, I'm fortunate, you see, in that aspect. Of course I was pleased to receive the Nobel. I recognize, though, that there's many others that did it, and it's really a recognition of the field as a whole, the science, the accomplishment, and I'm just a little more fortunate than the other ones to have the recognition.

HOLLANDER:

You mentioned also, a minute ago, your competitors. Is this really a very competitive field?

BOYER:

Oh. [Laughs] Yes, definitely. When you have a problem of this major importance. You see, this compound adenosine triphosphate is made throughout nature. In fact, I estimate it's the most prominent chemical reaction in all of nature, of all the world, that there's more of this chemical reaction go on that anything else. You see, an active person will turn over their body weight of ATP a day, if they're active. They'll make him break it down. Anytime my muscle contracts, or my nerve thinks, or my kidney functions, or I make some new compounds, it uses ATP. So, the problem has attracted a lot of attention, and since it was first described, it's remained as a major problem of biochemistry. So, the many people that worked on this to find out—there are a lot of others—it had lots of people working towards the mechanism.

So, yes, it was a competitive field, and it was I was fortunate in that we developed a methodology that others didn't have and appreciate. We could see the power of this methodology, but the field as a whole didn't, because it was a little bit complicated. But it allowed us to get at the heart of the enzyme in a way that others couldn't, and when I was in that heart of that enzyme, I could see that it was different than had been described for any other catalyst. So, this catalyst turned out to be unusual, so that gave me the step beyond the others in the field.

HOLLANDER:

[unclear] competition, a person sort of on the outside a little bit subjective, trying to fight its way towards acceptance.

BOYER:

Well, I had not quite that. See, working on these other enzymes, one of my favorite sayings sometimes is what to do in a research field is, most of it is the coal that you mine while you're looking for diamonds. Now, I had mined a lot of coal with these other enzymes. I had mined enough coal to get elected to the National Academy of Sciences before I started on this line of research that was productive. When I did start on this line of research that was productive, though, when we first recognized this new way, a paradigm that was different than others had thought about, it was different in the field, I tried to get it published in the leading journal in biochemistry, and they declined the opportunity to publish it.

At that time, though, I'd been elected to the National Academy of Sciences from other work, and one of the privileges of being a member of the National Academy of Sciences is you can publish a paper in the Proceedings without all these referees getting in the way, you see. So, my first paper on this was published. Now, it was controversial then, and since that time we added other things to it, and gradually I was convincing and so were other workers that came along and did contributions to the field to this, so that over a period of fifteen years, we convinced most people we were correct.

HOLLANDER:

Doctor, you mentioned that you had left the faith, the Mormon faith, [unclear] life sciences? Has the study of biochemistry led you [unclear]?

BOYER:

It's my study of science, not just the life sciences. I'm afraid that also my father was already not a strict—didn't have a firm belief in the religion, so early in my—before I even got into biochemistry, I had felt that the tenets of this religious faith or other religious faith didn't correlate with the way that I saw the world around me. So I have a great respect for many facets of the

Mormon religion, but the theology and the monotheistic deity are elements that I don't agree with. I was interested, when you mentioned biochemistry, there's an article in the *Scientific American* assessing the attitude of scientists towards religion, and they asked a question about who believes in a god, a single god, and found that this hadn't changed in the last forty or fifty years a fraction of scientists. They also, though, tried to ascertain the level of attainment and the belief in a deity, and they used as that such things as membership in National Academy of Sciences. And when they did that, the higher the level of scientific attainment, the less the belief in a monotheistic deity. And I was pleased that among the scientists, they then did the classifications, and the physicists and the mathematicians were more likely to believe in a monotheistic deity, next the chemists, and last, the ones who had the least belief were the molecular biologists, biochemists. So, I've been part of that group, I'm afraid, that my beliefs that I had in being with the church, there's no question my biochemistry and study of life processes took me to feeling that nature has a different way of achieving this.

HOLLANDER:

Where do you look for ethical guidance?

BOYER:

I feel that one of the fine products of the human existence is to bring what may be called a humanist now, viewpoint, which we have developed from our original needs for social interaction to survive. Early mankind couldn't survive as an individual. In order to survive, he needed a tribe. He needed more than this, so man, through evolution, became a social animal in this sense, which meant that he had to have other people he interacts with, and out of this comes the feelings of dependency, of love and concern, you see. As soon as you have these feelings, you have now the makings of setting up a type of philosophy that is the humanistic type of philosophy for this common good. So I turned to the way that nature is organized, and the evolution of mankind, and his background as being a source of this type of ethic guidance.

[Off-tape conversation with videographer.]

HOLLANDER:

With this kind of humanistic perspective based on essentially natural sciences, what about the life force, the mystery of life? Why? Where? What do we do with that one?

BOYER:

With the mystery of life.

HOLLANDER:

Yes. In other words, if you take the Big Bang Theory and so forth, and come back to a point, whatever, why?

BOYER:

There are some kinds of questions that I don't think you should spend time worrying about, because there's no way you're going to be able to find answers. Now, if you ask about the Big Bang Theory and the start of the universe, what preceded that, you see. Now, this is a question that I don't think that there is a method yet for us to answer, and to now try to do it from superstition or other kinds of things, to me is not an answer to the question, you see.
I appreciate the approaches to that question. I would, for example, think it is, although a little bit of an answer, the idea of a steady-state universe that has gone through a series of big bangs over the time, could be appealing to me, you see, because I think that after we had the Big Bang, that life itself is a probable event to come out of the compositions of matter and its organization into planets and suns and rotating things like the Earth, and these conditions. I think, then, that life is not an unusual event, but one that's happened many times.

HOLLANDER:

You're looking at the life at the molecular level now and the life processes at the molecular level. Do you think there's anything still—is there a life force that needs to be explained yet or is it only explainable by the origin of life itself and the life processes? They're all explained?

BOYER:

Yes, I'm looking at life at a molecular level in terms of this part. But now, you ask such questions as consciousness. I should think that what we call conscious has its explanation in terms of the billions of neurons in our head and their connections, and what we have stored in there from information, and the information that we would hear, that we felt this yesterday. We have a time consciousness. We have that ability to do that. So, I think these things are—I don't think there's anything beyond the molecular explanation, so that there is not a necessary additional explanation. Mankind has always sought to have other explanations and has devised many things. I could surely see why early man looking at the Northern Lights would be mystified, utterly mystified by the Northern Lights, and wants to attribute supernatural powers to them. There now again, he's making the mistake of trying to explain something that he doesn't have the information to explain.

One thing that science, I think, in the scientific mode of thinking comes, is you explain those things that you can find a means of getting insight into. Don't try to explain those things that you can't find a means to get the insight into. I don't know if I've answered your question or not.

HOLLANDER:

Yes, you have, quite well, as a matter of fact. Let's go to another subject.

BOYER:

[Laughs] Yes, only for a moment or two.

HOLLANDER:

Okay. Doctor, outside of—we'll come back to the thing you want to say about your enzyme in a second. Outside of your work, is there any other field of interest that you've pursued actively?

BOYER:

Yes. Family. No question. Family relationships are extremely important to me, and I've devoted a lot of time, then, to children and family, and so forth on the line. I have eight grandchildren, three children. They all felt that the Nobel Prize was part theirs. [Laughs] So they all went with me to Stockholm to receive it. I have an active interest in sports. I play a fair game of tennis, all my life. I still do. So, I like physical activity outside the laboratory. So, my interests have been that. I have some in different community services of types, and Planned Parenthood and others; I'll devote time to these over a period to try to do a little bit of more than financial contribution to them.

But I'm afraid that outside of family and science, I didn't have time for other things. My science, I was too interested in it. It's just this wonderful opportunity to go at things that you want to do, but it is time-consuming. So, that's where my life has been.

HOLLANDER:

Before you go, you wanted to ask something about that enzyme.

BOYER:

Oh, yes. I forgot to tell you when you asked me about ATP synthase, when I said luck. These big molecules all have ways of assembling in a three-dimensional structure to do a catalysis, but this one that we were studying turned out to have a very unusual mechanism, that it had, instead of just one, three components that made the catalysis, and a central component that we postulated rotated like a little molecular machine. It was acting like a little motor that turned around.

Now, my work only let me say this is the best way I can explain that data. The subsequent work is showing that this explanation was utterly correct, and this became the first known molecular machine at that time. So, it's attracted a considerable interest outside of biochemistry, even, because of the unusual nature of the catalyst. That's part of my luck, because I could have worked just as hard on some other problems that didn't turn out to have an unusual answer. So, the reason I'm here today is that luck, and the then other one, longevity, so I can still be here.

HOLLANDER:

Thank you very much.

[End of interview]