Nobel Voices Video History Project, 2000-2001

Interviewee: Manfred Eigen
Interviewer: Neil Hollander
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HOLLANDER:

Professor, could you please give us your name and tell us why you're here?

EIGEN:

My name is Manfred Eigen, and I came here for the fiftieth anniversary of this meeting at Lindau.

HOLLANDER:

If you look at me as not whatever age I am now, but imagine that I'm, say, fifteen, and I come up to you and I say, "Professor, what exactly is it you do?" how would you explain that?

EIGEN:

Well, in the work you are interested in?

HOLLANDER:

Yes.

EIGEN:

I do 80 percent of thinking and 20 percent in earlier times of experimenting and now organizing experimental work.

HOLLANDER:

What I'm trying to get at is, what kind of thinking do you do, and where did you learn to think that way?

EIGEN:

That's a good question. That's what you have to learn during the school and first years of university—to learn how to learn. That's certainly true. When I was at school, I wasn't sure that I would study natural sciences. I thought I would become a musician. I played the piano since my fifth year of age and played a lot of concerts when I was twelve. But it was a wartime, so there the time between my age of fifteen and eighteen were entirely missing. I could not practice, and this is the end of a musical career.

But at the same time, in school I was quite interested in mathematics, physics, chemistry, so I had already the idea to study natural sciences, and when I was a boy, it was clear that the only place I would do it was Göttingen, because Göttingen was the home of mathematics. Quantum mechanics came about from Göttingen. There was a great chemistry at Göttingen, founded by Vindous [phonetic]. So I started my study when I was eighteen, and indeed I found out very soon that what you have to learn when you study is how to learn. You cannot learn all the matter, but you have to learn to be able to handle anything.

So I finished quite early. I finished my doctor thesis in 1950, so after five years, and I was fairly young at that time. I was twenty-two, twenty-three. Then I started to think about problems, and I must say, looking today at the students, they get too old before they start, themselves, to think. All my Ph.D.'s now are near thirty or even above thirty. That's all right, but you are able to think up new ideas when you are twenty, twenty-two, twenty-three, and you should be in that state very early. So you are asking what kind of problems I was interested in. I was mainly a physicist.

HOLLANDER:

Let me move the microphone. I'm sorry to interrupt you. Let's go back to this question. I'm sorry to interrupt you. The question about thinking, which I think is an important one that you were addressing, how, where you learned to think, and how it relates to people today.

EIGEN:

Yes. I was mainly interested in physics, so I started my study really with studying physics. At that time, I had very good teachers at Göttingen, and I did my theoretical physics courses with Heisenberg [phonetic] and with Wicke. When I decided to do a thesis in physical chemistry, my professor was Arnold Eucken, one of the great physical chemists. He was a student of N______. I'm somehow a grandson. [Laughs]

One thing is very typical, because it has to do with a Nobel Prize I finally got. When I was a student, I read in the textbook by Eucken, it was the bible of physical chemists at that time, that there are reactions which are too fast to be measured. What was meant is that when you try to study the proceeding of reactions, the velocity, that you have to mix the partners and by all tricks, putting them under high pressure in a flow device, there's turbulence, and you cannot do that faster than in a millisecond. So by that time it was quite clear there must be reactions, which are faster than having a half time for a thousands of a second, of a millisecond.

So in that book, there's no way, and he called it the immeasurably fast reactions. And I said, "What a nonsense. Everything must be measured. You have to think it up." But I didn't get a solution of that problem.

Then I did my thesis, which involved specific heats of heavy water under a large range of temperatures and pressures, and also electrolyte solutions.

When I gave a lecture after my thesis, I talked about these problems of solvation of ions in solution and interaction among solutions. At the same colloquium were colleagues of mine who talked about an effect they found in seawater. Seawater has a very high ultrasonic absorption, which is of great practical interest because for the echo methods, the sound wave wouldn't travel very far because it's absorbed, especially in the frequency range where they use it. And there was no idea what the cause of this reaction was. It was not the sodium chloride in the—but it turned out that it is the magnesium sulfate. So, seawater is not only salty, it's also bitter. It's the magnesium sulfate, which is called bitter salt. It turns out that it was just the type of interaction with these ion surrounded by water molecules, which I had studied, which gave the explanation then, and I sat down and wrote up a theory, and turned out that this was a correct one.

Now, at that moment, I remembered the textbook of Eucken of the immeasurably fast reactions. Now, sound waves, these are ultrasonic waves, are measured in the megacycle range so the time constant where the equilibrium is disturbed of this is in the microsecond range, and that was far below the millisecond range which was not anything. Now I have the idea of how to study fast reactions, and I went on, and I think within two years the work was done for which I in 1967 then got a Nobel Prize.

So it is often said in science that it is an accident that you get it right. That is not the right word. I would rather say what Napoleon asked from his generals—fortune. In other words, it's somehow accidental that you come across it, but you have to know that there is something where you find a new solution, and that happened.

Now, then, I applied, we worked out this method. We went down to even a billionth of a second, so ten to the minus-nine seconds, and we were the first who started elementary steps of complicated biochemical agents, enzyme reactions, biological reactions, all these control and regulation pulses at which they place it at the molecular level. And there was the time I got the Nobel Prize, and it was that success in studying those important systems.

Now, in biology, reactions are usually fast, because that's why we call them fast reactions. Our perception involves chemical reactions, and we call everything fast which is fast with respect to our perception, and so the reactions have to be faster than what they want to record. And at the same time, we started why is it so, why is everything in biology so well optimized and so well—and then we thought, how did it come about?

I worked out a theory of evolution, which came out in '71, which is a basis of all my further work. So theory of evolution, a real mathematical theory of the principles and what is necessary, turns out that you need self-replication like provided by nucleic acids and that you need a certain error rate, but a certain threshold in the error rate. It's not a whole field of theory, but we thought in sciences a pure theory is a poor theory because our brain doesn't have absolute truth. Our brain can only adapt to the truth, and it's an adaptive organ, so you have to do experiments and you have to start from experiment if you want to learn something which is entirely new.

So at that time on the seventeenth and eighteenth we started to do evolutionary experiment, and we showed that real—the formation of nucleic acids in proteins and the adaptation to certain functional needs can be done within days. First, my colleagues always said, "How can you do experiments on evolution? That took millions to billions of year, and you can't do anything which exceeds the lifetime of a Ph.D." But if you choose the right conditions, you can, and we have shown that. And out of it came a new technology, which now is applied in industry, an evolutionary type of technology.

At the same time, we developed new methods studying the behavior of single molecules and follow-ups in the molecules. Again, in evolution, everything starts with a single mutant, which is amplified then, and if it is of advantage it outgrows the other system. So that's about the type of work I could explain within, I'd say, a few minutes.

HOLLANDER:

I want to go back to this thing about would you consider yourself some kind of inventor or creator [unclear]? Would that be a correct label?

EIGEN:

Yes, that's the only thing which is of interest to me. You see, we left the fast reactions when we thought the essential things we could do with our methods were done. But that would mean that you now can apply it to everything else, but we thought we want to think up something new, and that's exactly what I'm interested in.

HOLLANDER:

If you look back on your life when you were a child, where do you think you got this inquisitive aspect of your personality that pushed you or compelled you so truly in this direction?

EIGEN:

Well, certainly in my parents' home, but, as I said, it was largely dominated then by music. But I was sent to a very good school, gymnasium, humanistic gymnasium, so I was exposed to the Greek and Latin classic.

HOLLANDER:

Is there any particular person or specific book that marked you, that you'd say, "At this point I decided I'm going to be a scientist," that changed your thinking?

EIGEN:

It is true. I thought that the schoolbooks we had were not very good ones in physics. Then I got somehow across about a book which also was used in universities, Grimsell [phonetic] textbook of physics, and that really got me interested in statistical mechanics and that finally—well, chemical reactions is a branch of statistical physics. So, that certainly was one. But I could not say that I was pulled in by a more general book that—

HOLLANDER:

Was there a particular person that influenced you in your life? As you look back on your life, is there one particular man—

EIGEN:

Well, the people who really influenced me in the science, in the area of science, were my professors at Göttingen, and among them I said there was Heisenberg, there was Eucken, there was Wicke, there was Polk [phonetic], there was Kupferman [phonetic], the chemist Vottenbach [phonetic] and Gaboe [phonetic], and so these were all great personalities, and I learned—I got acquainted with three of them, major physical chemists.

In Göttingen, first Eucken was my teacher, but he died just after I'd finished my thesis, but before I took my examination. Then I was invited by Karl Friedrich Bonhoeffer to join the Max-Planck Institute, then originated at Göttingen. It was before Imbellion [phonetic]. He was a wonderful personality. The Bonhoeffer family is, of course, well known to everyone in Germany by resistance during the Hitler regime. But he was a wonderful personality that really was—and that's what, a princely character, that man. Then when Bonhoeffer died, Karl Wagner [phonetic] came in, and, again, he was a completely different kind, but again a very admirable person. And that's what forms you.

HOLLANDER:

Let me jump to a totally different subject.

EIGEN:

Yes.

HOLLANDER:

Do you have a favorite science joke?

EIGEN:

Favorite science joke. Oh, there's so many. Yes, I have one. It's not a joke. It's a true story.

HOLLANDER:

Even better.

EIGEN:

When I had already the Nobel Prize, some burglars broke into my home and stole various things, among them the gold medal of the Nobel Prize, the Nobel medal. The next day, the *Bilt Zeitung*, German big annual newspaper, phoned me and said, "Professor, we heard they stole your Nobel Prize."

And I said, "No, look, this is not really true. The Nobel Prize, I have three things. The first is the acknowledgement of what you have done, and that you can't steal. The second is a sum of money," which at that time was a tenth of what is given nowadays. [Laughs] "And the third is a nice gold medal, and that medal was stolen, that's all." Then there was a silence.

And then I heard the man saying, "But this is a shame, Professor. All your work now was done for nothing." It's a nice joke, isn't it? I used to tell that story, and whatever you do, it's not done for nothing.

HOLLANDER:

Let me ask you another question. If someone were to come to you, say, I'm age fifteen, I come to you and I say, "Professor, what should I do?"

EIGEN: Yes, I tell you another story, which answers that question. You know there's a man with a violin running along 42nd Street in New York City, in Manhattan, asking one of the passing people, "Can you show me the way to Carnegie Hall?" A man stopped and looked at him and said, "Practice, practice, practice." That's what I would tell. [Laughs]

HOLLANDER:

We've been talking quite a bit about thinking. How does one learn to think?

EIGEN:

Being curious, asking questions. A friend of mine who was one day President of Israel, Ephraim Katchalski Katzir, a good friend, he told me once when he was a boy and he came from school, his mother asked him first, "Did you have a good question?" That's not what you expect in the German school. [Laughs] So I think that's how you learn to think, asking questions and then trying to collate them. It's the same as if you ask the question of [Yasha] Haifitz, "How did you learn to play the violin?" Well, he would tell you, "Practice, practice, practice," but there's a lot of other things you also have to do.

HOLLANDER:

If we could draw a line from your work to something very practical, where would that line be, to what?

EIGEN:

Let me first say that science has not only the goal to find out something which is practical. We never know what is practical and when it will be practical. You have to get a complete view of nature, and that sometimes forces you not to think about what could be the practical application of it. So if I look at my later work on—well, first work on fast reactions finally was done to understand complicate reaction behavior which determine living beings' biochemical reactions. Then if we worked on molecular evolution, on origin of life, I wanted to understand how did it come about. What is the essential point? Is it the origin of information? It's not. Information did not originate in our brains. It originated four billion years ago in the genetic code, and that was the basis of evolution in which finally the brain came out, which again originates information on a new level and then getting cultural evolution and that.

So, all these things, if you get enthusiastic about answering those questions and so on, you don't think of the practical application. But we had a big practical application after we understood how molecular evolution, how nature managed to solve problems which are so complicated that you can't construct the solution. In other words, evolution solves the problem without knowing the problem. But it solves it.

After we learned that trick, we said by this way you can make any compound you want to. You can adapt any pharmican to its optimal action. And now we have founded a company which is flourishing, and it's a whole field now in biotechnology where you produce compounds. But this was not our aim to do so. This just comes out, and when it comes out, then you should say, “Yes, it has to be done,” because it is of benefit, and but it was not started by that idea.

HOLLANDER:

What is your company?

EIGEN:

It’s a company at Hamburg where 300 people work, and it’s doing very well in the biotechnology.

HOLLANDER:

I’ll ask you one last question, if you don’t mind. What was your most embarrassing moment as a scientist?

EIGEN:

Can’t tell you. I had many embarrassments where I learned things which I didn’t think to be possible. My biggest embarrassment after the war was learning of how a cultured nation could do such bad things. That was certainly the biggest embarrassment I had. But in my scientific career, many things are different from what you thought first. But these are embarrassments which are part of the job, of the story, so they are well balanced with the positive embarrassments, you see, with the [German]. [Laughs]

HOLLANDER:

What would you say was the happiest moment in your career, personally?

EIGEN:

Again, I can’t tell you which the happiest. Perhaps when I’m a little older still and would think what was the happiest, those happy moments often occurred. When I was younger, I usually worked very late at night. I could tell everybody when birds start singing in the morning, because that was the final signal for me to go to bed. If after some intensive thinking you got a solution, that’s a very happy moment. Or if you carry out an experiment which you think is not very likely to yield a result, and it does so and it proves to be correct, that’s a happy moment. There are many small such happy moments in a life, and I am looking further to think what was the happiest among them.

HOLLANDER:

Was music a help to you in your thinking?

EIGEN:

Oh, yes, I have continued to. When I was student, I still took lessons with Schuldoff [phonetic] Hindemith at Stuyvenhoffen [phonetic] near Munich. He's the brother of Paul Hindemith. He's himself the cellist. His wife, Maria Landers [phonetic], was a pianist at some music academy in Munich. So I went there for a week or two, stayed with them, and played six hours a day. And I played concerts with the Boston Orchestra, with the Basel Orchestra under Paul Zahar [phonetic], and Mozart concertos, piano concertos. That was always a very happy—but when I did that, I really practiced, practiced, practiced. [Laughs]

HOLLANDER:

But what I'm trying to get at, was music in any way to you a catalyst?

EIGEN:

No, no, it was entirely palliative, and my scientific ideas I did not get from music, and vice versa when—

HOLLANDER:

Do you think it helped in your personal life?

EIGEN:

Oh, yes, it was wonderful, wonderful rest and wonderful—even if I practiced very hard that was, because it was so different from what I do. But there is no direct linkage. It's often said that mathematicians are good musicians, too. It's said that Einstein was a good musician. I always say it's an insult for Einstein to say that, because he was such a great scientist, and his music was that of any music student who finishes his courses on a music school. That was fine, but he was not a real musician in the way he was a great scientist. He was a unique, and one should not say that. But it meant much to Einstein, and it meant much to Planck, who was a very excellent pianist in Heisenberg. I played with him, four hands, the piano. But they were great scientists, and they enjoyed music.

I know only one scientist who was also great musician. That was [Alexander] Borodin. It's a Russian composer. He was as great a chemist as he was a composer.

HOLLANDER:

Did you play Borodin [unclear]?

EIGEN:

No. There's no so much for the piano, and also that would require more time than I had usually at hand.

HOLLANDER:

What kind of things did you play with [unclear]? What music?

EIGEN:

Oh, we all loved Mozart, of course. I played Bach, of course. I played Beethoven sonatas, piano trios and quartets, and Schubert, Schumann, Brahms. I tried also Shostakovich and I tried the Hindemith *Ludus Tonalis,* but this was really, I realized that this requires quite a bit of time, which I usually don't have.

HOLLANDER:

One last thing, and then I really will quit. If you're addressing young people today, is there anything you would want to say to them?

EIGEN:

Well, yes. I want to convey to them my enthusiasm about science, and I can do that only by talking about it, not giving wise advices. I want to show them how much fun it can be.

HOLLANDER:

Thank you very much, Professor.

[End of interview]