



Nobel Voices Video History Project, 2000-2001

Interviewee: John Polanyi
Interviewer: Neil Hollander
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HOLLANDER:

Doctor, could you please tell us who you are and what it is you've done.

POLANYI:

What I've done?

HOLLANDER:

What you've done.

[Taping interruption]

POLANYI:

My name is John Polanyi, and it's spelled P-O-L-A-N-Y-I. So don't get that "Y" in the wrong place. It's Y-I at the end. I have been at the University of Toronto for over forty years. It's the only honest employment I've ever had, and it's not certain that it's all that honest. But that's where I've been since lecturer, assistant professor, all the way up, and that's where I've done all my research, starting with a research grant of about \$3,000 and now stuck with a research grant of half a million, which is not as much as it seems.

But go ahead.

HOLLANDER:

Why did you win the Nobel [Prize] and [inaudible]?

POLANYI:

Well, I won the Nobel in the way many people do, partly by good fortune, because, as you well know, science is a huge network of interacting people. I, as a student, was trained at Manchester University in England, and people told me that the growing point of my field, which is chemical physics, between chemistry and physics, was the unraveling of the molecular motions of atoms and molecules engaged in simple chemical

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reactions.

[Taping interruption]

HOLLANDER:

I'd like you to tell us [inaudible]

POLANYI:

The origins of the work I was involved in go back to my days as a graduate student, and I was lucky enough to be at Manchester University at a time when people were forecasting what was likely to happen in the field of chemical physics, the boundary between chemistry and physics. They told me that the study of molecules en masse as a group was going to wane, and we were going to study the individual events from now on and unravel the molecular motions, for example, in chemical reactions. And this caught my imagination.

I then went on as a postdoctoral fellow to Ottawa in Canada, as a postdoctoral fellow also to Princeton in the United States, and all the time this was nagging at my mind. How was I to get a foothold on that question?

Through the various things that I saw going on elsewhere, it became pretty clear to me that the way to do it was to carry out a simple chemical reaction, and the one we carried out first was hydrogen atoms reacting with chlorine molecules to form hydrogen chloride, and to let the newly born reaction product, and if you think about it, a hydrogen atom reacting with chlorine will break the bond in the chlorine and will form a new one in hydrogen chloride. That's a chemical reaction. Old bond goes. New bond forms.

The question that we thought we could address was, when that new bond is formed, is it snapping to and fro or is the molecule rotating or is it running around with what is called translational energy? The simplest, most direct, and also cheapest way of tackling that question was to let the newborn molecule vibrating and rotating signal to us its state of vibration and rotation, and the missing element in that description is that molecules which vibrate and rotate emit infrared radiation.

So we set up the most sensitive infrared detector we could find, and we recorded the various colors, the various wavelengths, of the infrared emission. First we had to see it, and we managed to see it from reaction occurring at very low pressure. So then we split it up into its wavelengths, and it turned out that many chemical reactions form products which are snapping to and forward in vibration and rotating a fair amount, too, and that this tells you something about the release of the forces which are released when an old bond breaks and the new one forms.

The technique is called infrared chemiluminescence, and that was mentioned in the Nobel

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citation, even more mentioned for myself and the two other people with whom I shared this prize, who are not people I collaborated with, but people with the same interest. They had their own techniques. They worked elsewhere. One was at Princeton. One was at the University of California, Berkeley. All of us were interested in the motions of atoms and molecules in chemical reactions, and so the heading that covered all our work was molecular dynamics, how do particles move when chemical reactions are occurring.

HOLLANDER:

[inaudible]

POLANYI:

Well, yes. There is a strong link between the fundamental science we did and applications. Had we been asked this in advance, we probably wouldn't have been able to give the link. I think we certainly wouldn't. We most certainly wouldn't have been funded to do the work. The link is this, that if, as it turned out, you can select chemical reactions that love to form molecules going like that [demonstrates], vibrating, then you could put such a chemical reaction—and I'm really giving a rather narrow interpretation—you could put such a chemical reaction in a tube, with mirrors at either end, and you would have a chemical laser, because the essence of a laser is that you should have more excited species than unexcited species in the tube, let's say, between your cavities—between your mirrors, I should say.

This would be guaranteed if you took a reaction such as one that was later used in the scenario for Star Wars, fluorine atoms reacting with hydrogen. You form hydrogen fluoride. A lot of the energy of that reaction is deposited in vibration in the hydrogen fluoride. And if you now put mirrors on either side, the infrared emission that I spoke of before that we were recording for basic reasons will be amplified as it goes to and fro through the gas, rather than being absorbed, which is, you know, normally one thinks of absorption. One doesn't think of the fact that, as Einstein first commented, if you have more excited species than unexcited, the passage of light will stimulate emission and add to the light beam, and as it goes to and fro, it will get stronger and stronger and will produce, in this case, very intense, indeed the most intense infrared radiation that is available.

HOLLANDER:

[inaudible]

POLANYI:

Yes. There were other applications which we foresaw, which, in fact, have been very slow in coming, and that would be that if there are chemical reactions that deposit their reaction in vibration, there should be chemical reactions running this movie film

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backwards that can be preferentially encouraged to take place if you put vibration in the reagent. It's the same reaction backwards.

Indeed, we showed by simple theory that reactions which are uphill, endothermic reactions, which have to climb a hill, will generally be of the type that if you put vibration into the reagents, they will go lickety-split. So the idea was, let's separate heavy water from light water by exciting the vibrations in the heavy water, but not the vibrations in the light water. And it sounds marvelous, and, in fact, it's very difficult to do because the molecules hit each other and they transfer their energy from the heavy water to the light water. So it has taken until recently for that application actually to become a reality. But it is now starting to become a reality.

HOLLANDER:

Turning to the Nobel Prize. How has that affected your life?

POLANYI:

Well, everybody has asked this question. Yes, that's right. I think, you know, I hope it doesn't sound arrogant to say it's affected my life less than many people's because I was a very talkative fellow before. I was very much involved in political debate. I gave a lot of talks at the interface between science and society. The difference was that now I had an audience for my talks, which, after all, is a difference.

HOLLANDER:

What are your interests there?

POLANYI:

Well, one is the health of science, because I believe science to be a beneficial and civilized undertaking. Obviously, it can be misapplied. So I'm very interested in schemes for getting the best out of science per dollars spent. There are a lot of foolish schemes around which involve trying to manage the right science into existence, and to know where a discovery can be made is not something that governments are likely to be good at. To know which discoveries are going to produce commercially viable outcomes that benefit a particular country and do so in a reasonable space of time, governments may pretend to be able to predict that, but they can't.

So if governments take this sort of utilitarian view of science and support science on the basis of stories that we scientists spin about how wonderful the benefits will be from the basic science that we are doing, they will be encouraging us to write science fiction, which, actually, most of us have got very good at.

But this sort of fabrication, I mean, putting it harshly, lying, eventually comes back to haunt you, because people say, "You said that you were going to have an application.

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Indeed, you said it was going to be this application. Where is it?" You bring discredit on science by agreeing to that sort of arrangement.

So I've been fighting against that, and I've been saying, "Fund the best scientists, fund them only a few years at a time, see that they are still doing good science, judge them on the basis of their results, and you will get value for money," because when you produce a new intellectual tool, i.e., a discovery in basic science, it is guaranteed that people can use that intellectual tool for something. Of course, then comes another question for society, and therefore for scientists, too, to see that the applications are wisely chosen.

HOLLANDER:

How do you ensure that?

POLANYI:

Well, scientists are just members of society with a particular specialized education, a sort of literacy, and their obligation is to participate as citizens, not as philosopher kings, not dictating to society, which wouldn't stand for it, thank goodness, but participating in public debate and participating to the extent they have—I put it literacy, because it goes beyond one's special knowledge, which is very narrow, and it goes to the general sort of knowledge that a scientist has. So it's a matter of encouraging scientists to set aside some of their time to study in depth and responsibly some of the issues that are facing society as a whole, and make a contribution as citizens commensurate with our special skills and special knowledge. You know, we're beginning to do that, but that's a change. A half a century ago, we were locked in our cloisters.

HOLLANDER:

How about some examples [inaudible].

POLANYI:

Well, I mean, the moment of truth came with empowerment, if you like. I mean, when the atom bomb was demonstrated in the desert of Alamogordo, it dawned on the scientists involved, as [Robert] Oppenheimer put it, that scientists have lost their innocence. He didn't mean that they'd done something immeasurably evil. What he meant was they could no longer, like a bunch of kids, play in their laboratories. They had lost their innocence in the sense that they were going to have to participate in some very difficult decisions, and they did.

So one has the spectacle of Albert Einstein, the lifelong pacifist, as the person who set in motion the development that led to the atom bomb. I mean, here was a scientist participating in a way that must have torn him apart. But those compromises between one's principles and the ideal, and the actual necessity to try to wind one's way through the human tragedy, which means try to find the least possible evil solution, involved one

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in those nasty decisions. It would be lovely just to sit back and say, you know, how appalling that people do such things as develop weapons.

But if those weapons are going to be used by a responsible authority and an authority which is authorized to do so by as many people in the world as possible—and I think, of course, of the United Nations—then the use of force to try to prevent some appalling evil is the least horrible thing, and one should support it. I think scientists' responsibilities as citizens, actually, go very wide. I'm impressed by the fact that scientists get involved through their academies of science now in defending human rights. That's very instructive, because human rights have nothing to do with physics and chemistry that I can think of, nothing directly. It's not scientists using their special education and understanding; it's scientists using the civilized attributes that go with the doing of science.

I mean, in doing science we listen to minority views. In doing science, we don't say, "This is true because my country said it," or my ethnicity said it or my religion said it. We come to a consensus agreement internationally in science. So, that is a civilized situation which, when we do science right, exists in science and which we are trying to promulgate when we go to another country and say, "You know, if you want us to look kindly on your country, if you want to be part of the international scientific debates and community, then don't persecute people for saying things that this particular government doesn't think is right or doesn't like having said."

HOLLANDER:

How have you personally been involved [unclear]?

POLANYI:

Well, you know, that becomes part of the history of Canada, because, actually, countries, though maybe a quaint anachronism, tend to be the stage on which we perform. So I got involved for the first time as a young assistant professor when Canada was being urged—it seems surprising now, being urged by the United States to acquire nuclear weapons, because we were supposed to help in the defense of North America, and for that we needed nuclear weapons to intercept incoming bombers. It was a long time ago.

I found that there were scientists who were saying this was a bad idea, and it's actually very instructive, because we couched our arguments sometimes in terms of technicalities. We said, "Well, if we explode nuclear weapons over Canada, Canada will be subject to radioactive fallout." It sounds elementary now, but it wasn't generally realized at this time, which was the late 1950s.

But though we couched it in technical terms, we were, in fact, stating a view about how we regarded civilization. We didn't think that the wave of the future lay in building fortifications in which the walls consisted of a barrage of nuclear weapons. That thinking

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carried through to other campaigns I was involved in, of which a recent one was my opposition to the Star Wars proposal and currently my opposition to the U.S. national missile defense proposal, both of which I think are flawed. Technically they're flawed because hitting a bullet with a bullet under ideal circumstances may be possible, but wars are not fought under ideal circumstances.

But apart from being technically flawed, they represent a retrograde sort of view of the world. They say, "Let's build a fortress." I mean, first of all, the idea was very recently, "Let's build protection for the entire United States." Canada is now being asked would it like to be included. The question is, does the future lie in the direction of fortifications?

You happen to be questioning me in a place where there are all sorts of medieval remains around, and it's clear that they are tourist attractions, but they aren't protecting anybody. And that is true of the future. I think that the defense can be overwhelmed by the offense just as I can go into my students' laboratory and wreck their experiment more easily than they can make it work, and I've proved it.

So that being the case, where does the future lie? It has to lie in some alternative means of defending oneself, and the only means I know of is international law, which is supported by international sanctions and international authority.

HOLLANDER:

Do you think most physicists agree with you?

POLANYI:

Well, yes, I think they do, but only to varying degrees are they speaking on the subject, because they feel that, first of all, it's very distracting. It lays you open to a barrage of questions, accusations that you are an idealist. Well, that would be terrible if you weren't. Accusations that you are a dreamer. Well, professionally, scientists are supposed to be dreamers. They are supposed to not only conceive of different systems of thoughts from the existing ones, but to gamble their lives on it, their professional careers.

We should be willing to conceive of the possibility that the different world can be constructed from the one that's existed for centuries. And what's more, we should be sensitive to the signs that this is happening. More than half of the countries of the world have moved towards democracy. Massive violations of human rights, even though they are occurring within sovereign countries, are now eliciting the response, "This is intolerable," says the international community. Unfortunately, it tends to stop after saying this is intolerable and not actually do something. That's a disastrous policy. That's why the League of Nations went down the flue because it made pious protestations, but the group of nations which formed it were unwilling to act on those.

I think the scientists should have enough imagination and enough civic sense, in the

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global use of that term, that they get involved in the debate which will have to underpin the United Nations and give it, or failing it, other large groupings of nations which have some moral authority. But it should be soon, the United Nations, give it the authority to go to the aid of people who are being appallingly victimized, wherever they may be.

HOLLANDER:

Can you think of any instance where science has won out over politics, where the [inaudible]?

POLANYI:

Yes, I should be able to think of any number, because there are any number. You know, the defeatist notion that reason has no sway and that it doesn't matter if you argue and argue well, there's nobody listening, I mean, that's a very damaging notion and deservedly will bring disaster on us.

But can I think of examples? Well, I think of the response to the use of nonbiodegradable detergents. It became evident that the sea would be an ocean of bottles if we didn't do something, and that we would destroy our drinking water. So, biodegradable detergents were legislated. There are many examples. The reason we don't all sit on supersonic transports in our travels is because reason said that this is environmentally hazardous. It proved to be more true than we had dreamt. Reason also says, of course, that it is costly and pointless.

I can give you more examples, but you don't want them.

HOLLANDER:

[inaudible]

POLANYI:

Yes, right.

HOLLANDER:

How do you see that developing [inaudible]?

POLANYI:

Well, you know, I don't see that so clearly as I should, but the fact is that not only is democracy spreading and, of course, drawing the scientific community, which is potentially a powerful international community, a very much needed community, a community if it were to be offended and withdraw its services would be missed. So this

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is a powerful community. It is plugged into some democracies.

The United States has vast numbers of committees of scientists advising on everything you can possibly imagine under the sun and probably the other side of the sun. So, democracy has involved scientists in a new way, and democracy is slowly taking—not only just spreading to new countries, but it's taken on a new complexion, because people can interact with governments from their living rooms, potentially, at least, and soon, through the Internet, in a rapid and sophisticated way, and make demands of their governments that they give explanations which are plausible and understandable.

So I think democracy is going to come into a marvelous period where this dream that existed in classical Greece, in the context of small nation states horribly dependent on large numbers of slaves, the slaves will be replaced, one hopes, by machines, and the nation states will be able to embrace the world.

HOLLANDER:

Are you basically optimistic about the future?

POLANYI:

I think everybody's basically optimistic, but I think I see grounds for being basically optimistic. I think if one wasn't basically optimistic, one would be clinically depressed.

HOLLANDER:

[inaudible]

POLANYI:

Well, I think that's a two-stage process. First, they look to scientists for somebody to blame. Then the scientists, if they are sensible, realize that the best way of countering that, and the proper way, is to be involved in the decision-making and involved in an educated and responsible fashion. And then—and we're still at that stage of demonstrating that—I think then people will look to the scientists more and with a greater degree of hope. But that they say to the scientists, "Where were you when this decision was made?" that's certainly true, and we've got to see to it that we are part of the decision-making.

HOLLANDER:

[inaudible]

POLANYI:

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Well, I mean, it existed around me in my family circle, and, you know, uncles, aunts, parents were all people who were politically conscious, people who read, who talked, got into trouble, survived it, thank God, and that lesson wasn't lost on me. But I think the reason that I accepted the lesson was because I discovered that it added immeasurably to the joy of being alive, that I wasn't locked into some small room but could roam more widely, could meet people who were shaping history in a way that I was not. And so, for example, I was asked by my government in Canada to co-chair a study which was supposed to produce the structure for a rapid deployment force for the United Nations. This was then tabled at the General Assembly. Of course, the proposal exists. It is there waiting for somebody to do something about it.

But the reason I raise it is because it brought me into contact with a whole lot of people who were politicians, who were generals, who were political scientists, people who expanded my horizons and brought me a new joy in being alive.

HOLLANDER:

[inaudible]

POLANYI:

How sensible of you to ask, because there was. It was a guy who I met when I was at Princeton, called Leo Selad [phonetic], who was one of the world's great eccentrics. I mean, just to give you a sort of measure of his eccentricity, I don't know if he ever actually owned a house. He checked into hotels because he, rightly, thought life is rather brief, and so checking into a hotel is about the right arrangement. He was somebody who could easily have won—I mean, if one could ever say that of anybody—the Nobel Prize. The scale of his thinking and the brilliance of mind was all there. He thought, “Well, that's a very passing thing,” and he's absolutely right.

I mean, you look at the pictures of all the Nobel Prize winners, and I have to tell the young people who are watching this that you can't remember the names of more than a few percent of them. So what this chap Leo Selad said to me was, you know, “In the brief period that you're on Earth, live life to the full,” and, unfortunately, it included, in his case, liking Chinese food and always ordering the meal for five. There were just the two of us, and I sort of gagged when this came in. But that's a joke. It included for him that—I went to a meeting in Moscow with him in 1960. I was young. It was a meeting about how to halt the arms race at the level when we had rather few weapons on either side, 1960. Selad said to me, “Well, you know, we aren't getting anywhere. We'd better go and see Khrushchev.” This was his idea of how life should be lived. I mean, do something. Don't be afraid. So, yes, he had a lot of influence on me.

HOLLANDER:

Did you see Khrushchev?

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POLANYI:

Actually, he did. Khrushchev had the flu, and I got terribly depressed. It was late December of 1960 in Moscow, and I felt I was sitting there on the far side of the moon, and I couldn't stand it waiting for him. I went back to my family and to Canada.

HOLLANDER:

[inaudible]

POLANYI:

Oh, he did, yes. It was a perfectly sensible suggestion, yes.

HOLLANDER:

Did anything come of it?

POLANYI:

Not then. Actually, Selad's eccentricity included the fact that at this meeting, which was full of heavyweight scientists, of whom I was not one, and principal science advisors here, there, and everywhere, and he got up and he said, "Well, what I suggest is that we take wires and we hardwire some explosives under Moscow and under Washington, and we put the button to actuate this in the opposing capital. This will save us a lot of money and a lot of discussion and a lot of paranoia, because we will know that the deterrents are existent and that it works." He said this with a totally straight face in front of all these highly respectable people, many of whom had never seemed to have heard a joke for twenty years.

But it wasn't just a joke. It was supposed to, you know, in the way that Dean Swift in England in the seventeenth century, I think, suggested that famine would be cured by eating babies. It was supposed to make a point. And I think the point has been made now with the passage of time. I was sufficiently innocent and foolish, that I went up to him and I said, "Leo, do you really mean that?" And all I got was an enigmatic leonine smile on his face.

But what he said was right. I mean, that is where we will end up. The notion of nuclear weapons for warfare, it's preposterous, it's disgusting, it should be illegal, and it will atrophy. But we will still be left with the knowledge of how to make those appalling things, and that knowledge will constitute a deterrent against Moscow attacking Washington and vice versa.

How it will play itself out, I can only pretend to know. But I would say that it will play

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itself out by war becoming as anachronistic as the fighting of duels, which has happened recently. My father was old enough to have fought a duel as a young man, so it's not prehistoric.

HOLLANDER:

What is your favorite science joke?

POLANYI:

Oh, it changes every day.

HOLLANDER:

How about today's joke?

POLANYI:

Oh, today's joke was told by Manfred Eigen, and he described how a young man was hurrying down 42nd Street and said to some older guy, who he saw there, "How do I get to Carnegie Hall?" which for some of your listeners I have to explain is a concert hall in New York. And the older man looked at him and said, "Practice, young man. Practice, practice."

If this needs a footnote, it is that the older man thought that he wanted to play at Carnegie Hall. It actually has the typical structure of a joke. You set the train going this direction, then you switch the tracks.

Why is it a science joke? I need notice of that question. I'm sure it is a science joke. Everything is.

HOLLANDER:

Your favorite science joke?

POLANYI:

I don't know. You know, I was on a panel and I read a lot. They turned to me at the beginning as the front man on the panel and said, "What were the last three books you read?"

Of course, I hadn't the faintest idea what any of them were. Similarly, with jokes. I mean, jokes are something that should approach from the corner of your vision and take you by surprise. So I know lots, but when you ask, I know none.

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HOLLANDER:

[inaudible]

POLANYI:

No, I've been reading them recently. One of them, how funny, I mean, I can't think that's of any value to you, but I've just been reading a new book by Martin Amis, who is fifty years old and has written his biography. He's a very witty and iconoclastic individual. There, as a subtext, is his relationship with his father, who was an eminent writer. And since I had a father who is an eminent scientist, that was fun. So that's *Experience* by Martin Amis.

At the same time, I was reading a book by Alain de Botton, who is an Englishman and also a Frenchman, and who writes with a whimsical sort of simplicity. He's written a book called *The Consolations Of Philosophy*. I've just got far as far as Seneca. Seneca says, "It's important to expect the worst and then you'll have a happy life." In fact, for Seneca, it played itself out when the emperor sent a messenger telling him to commit suicide, which he then did with great good cheer, but actually, with great difficulty, because he was a very sturdy fellow, Seneca. But that's another story.

So there are the last two books, and I think that's more than you want.

HOLLANDER:

[inaudible]

POLANYI:

Who's what?

HOLLANDER:

The sexiest woman in the world?

POLANYI:

Oh, I suppose the nearest and the next nearest one. [Laughs] Here and around the corner.

HOLLANDER:

[inaudible]

POLANYI:

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No, no. What's a cure for sunstroke is the question I should ask soon.

HOLLANDER: [inaudible]

POLANYI:

No, no, no. No, I mean, you have such a plethora of stuff there, that I think I would do you a favor by stopping it.

[End of interview]