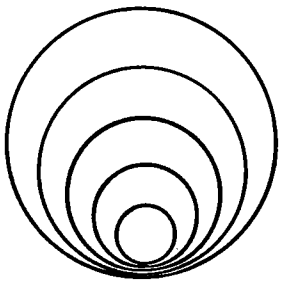

BILL MOYERS' WORLD OF IDEAS

Steven Weinberg

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Steven Weinberg

BILL MOYERS: *[on camera]* Good evening, I'm Bill Moyers. I would have flunked every course I ever took in science had it not been for a teacher's pity or the generosity of a smart sweetheart. Over the years experience, especially my experience in government, altered my appreciation if not my understanding of science and scientists. "Theirs it is to wonder," said Emerson, "and wonder is the seed of discovery." From the quark, so small nobody will ever see it, to the 53-mile long supercollider, so expensive we may never build it, the world of physical science gropes with the deepest question of all: why is there something instead of nothing? Sooner or later the ambitions and illusions of politics come face to face with those driven men and women, those scientists who accept no doctrine until the last doubt has been disposed of. In this broadcast, we'll have a conversation with Dr. Steven Weinberg.

[voice-over] Here at my alma mater, the University of Texas at Austin, Dr. Steven Weinberg is a member of both the Physics and the Astronomy departments. Weinberg is a high-energy particle physicist, whose world is as wide as the Heavens and as small as subatomic structure, but he calls himself a pre-computer scientist. He likes to work on blackboards or yellow pads, sketching theories about the basic forces that govern the universe; theories that won him the Nobel Prize in 1978. Dr. Weinberg, who heads the theory group in the Physics department, writes not only for fellow scientists, but he reached out to a popular audience in the *The First Three Minutes*, his seminal book about the big bang. We talked in his office on the campus.

[interviewing] Why do you study physics? What drives you? What do you get out of it?

Dr. STEVEN WEINBERG: It's a remarkable exercise of the mind. I still can't get over it, that you can sit at your desk and noodle around with equations and try out ideas and put together physical principles that may or may not be right, and every once in a while you can say something about the real world. You can predict the result of an experiment. A new particle. Or say something about the forces of nature or about the way the universe evolves and all out of pure thought.

MOYERS: Most people don't think of pure thought as synonymous with the real world. We think of the real world as that desk, this chair, that body, not some intangible idea up here in this mysterious organ. But it is the real world you're talking about?

WEINBERG: Yeah, it is the real world. And one of the ways you know it's the real world is because you're often wrong. That's a great experience, that natural scientists have that is very chastening and humbling; that all your great ideas can be overturned by experimental data.

MOYERS: But isn't it true that you're dealing with structures so small they can only be imagined?

WEINBERG: They can be imagined, they can be described with mathematics. Right now, for example, there's a tremendous amount of excitement about a new idea in physics. It's not really new but it's been revived in the last few years, called "string theory," and string theory is very mathematical. But there's a more physical side in which you say, the basic ingredients of the universe, the basic things the universe are made out of are little strings, little glitches in space time that go zipping around and vibrating and when you say you have an elementary particle what you really have is a string in a certain mode of vibration. You can get into terrible traps by using the physical description, but in fact we use it all the time. When we talk to each other we talk about these strings zipping around.

MOYERS: What comes to my mind is a string like I use in ordinary life; that seem to me the danger, that I'll confuse that with what you really mean in a pure way.

WEINBERG: Yes. Physicists aren't mathematicians. The mathematics express the concrete pictures. But sometimes we get very far away from those concrete pictures.

MOYERS: Let's take this layman's question for a moment. If it did begin with a big bang so what? What difference does it make that everything that exists today was once part of a single force?

WEINBERG: There's a tremendous amount of interest in these questions. It gives us a sense of finding out what kind of drama we're actors in, and I don't know how any one could not want to know that.

MOYERS: What is it you want to know about the universe?

WEINBERG: I just want to know one thing, which is why things are the way they are. I think that we've come a long way, you know, if you ask any ordinary question about every-day things: why is the sky blue? Why is water wet? We actually know the answer. We, meaning the whole body of physicists and chemists and biologists, we know the answer to these things. Then you ask, why are those the way they are? And we've come a long way. We now have a picture that underlies atomic physics in terms of the properties of elementary particles, it's sometimes called the standard model. Which is a way of saying, we all believe it and use it without being absolutely sure of anything. And then you ask why is that true? Well, that's what I want to do. I want to trace these chains of "why" down to their roots.

MOYERS: Almost like a five-year-old child that goes around asking his or her parents, "Why? Why is the bird singing?"

WEINBERG: Yes. That's it. We want to be thoroughly unpleasant and keep asking, why is that true? When you get an answer you say, well, why is that true? And the amazing thing is that we can go pretty far, but in doing it we discover some remarkable things about the universe. One of the things we discover is that these chains of explanation seem to converge to a common source, because it doesn't matter whether you ask, why is the sky blue? Or why is water wet? You always get down to this level of elementary particles.

MOYERS: What's it finally made of?

WEINBERG: Yeah. It's true, when you talk about biology or astronomy, you have to bring in other elements like the fact that the universe is billions of years old, and it's had a long time to cook. But you always get down to that, that very simple level, and also we find that things get simpler, as you get toward the roots of the chains of explanation.

MOYERS: What do you mean, things get simpler?

WEINBERG: You have to say less and less as you get deeper and deeper. There are fewer and fewer principles. We're beginning to get a feeling that we're really getting rather close to the roots.

MOYERS: Is it really possible to take, to carry these whys so far back that you can say what's likely to have happened in the first hundred-thousandths of a second? The first three minutes? The first three minutes as you say in your book.

WEINBERG: We understand the history of the universe pretty well from the first 100th of a second on. When you go back earlier than that you get into problems of physics that are difficult and we have to be a little bit more modest. Now, that's really just tracing the history back. It doesn't really answer the question why the universe started at all. Why is there something instead of nothing? We don't know whether those kinds of questions are forever going to be separate. It may be that in the end physics and history will come together and we will not need special assumptions about the beginning.

MOYERS: You said a minute ago that it helps to understand the kind of drama we're in, and if your theories are right, that this universe is an expanding universe, then we are caught up in a drama that is evolving, that it is changing constantly, regularly, normally, inevitably. It is. It is changing. There has to be some significance to that, it seems to me, in terms of our every day lives. It seems to make some difference to how I think about myself.

WEINBERG: I think it does. I think that science has changed the way that we think about ourselves, about our role in the universe. I think there's lots of historical evidence for the tremendous change in Western society that is caused by the scientific revolution of the 16th and 17th century. You know, we stopped burning witches. I think the changes are incalculable. I wish they would go a little further.

MOYERS: What do you mean?

WEINBERG: Well, it bothers me terribly, for example, that anyone still takes astrology seriously. Now, it's not because astrology is wrong, I mean, there are lots of wrong ideas, and I've had wrong ideas. There's wrong and wrong; there are wrong ideas that are simply wrong because there's evidence that they're wrong, and there are other wrong ideas that are wrong because if they were right you'd have to throw away everything you knew. How could it possibly matter to life on Earth that a particular ball of hydrogen and carbon and whatever, or if Jupiter is in one position in the sky rather than in another. If you believe that, I think you really have to rethink everything else. And you have no right, if you believe that, getting into elevators or taking

aspirins or using any of the other advantages of technology because you're spitting in the face of all of the science that produced the technology.

MOYERS: People don't want to believe what the scientists explain to them.

WEINBERG: No, they believe it and they don't believe it. They believe it for some purposes and not for others.

MOYERS: They benefit from it, the technology that comes from your discoveries is a beneficiary but it's also, in a sense, ultimately threatening, isn't it? You even said the more comprehensable the universe becomes, the more pointless it becomes.

WEINBERG: In studying the universe scientifically, you don't find a point. Now, what kind of point would you have wanted to find?

I would love to believe that human beings are part of a drama which is built around us. That we are the central actors —

MOYERS: We were there in the beginning and built into it at the beginning.

WEINBERG: That's right, that we are the central actors in the cosmic drama, that the whole expansion of the universe and the birth of the sun and the evolution of life on earth was directed toward us and we are the key players, and that when we do something the whole universe is watching. It may be true. But, if you believe it, you're not going to find evidence to support it in the discoveries of science. You don't find hints of that in scientific knolwedge.

MOYERS: Science does not tell me that I have a special relationship as a human being to this universe?

WEINBERG: Well, you know, human beings are different from cactuses and roses but...

MOYERS: I can think about the universe.

WEINBERG: Yeah, that's right, you are different. But when you begin to ask questions about why you can think, and why cactuses are the way they are, and spiders are the way they are, you get down eventually to a level of molecular biology and then organic chemistry and ultimately down to elementary particle physics and at that level you don't find human beings playing an especially important role. I don't mean that they don't. In fact, I'd say rather the opposite.

MOYERS: This conversation suggests that they do.

WEINBERG: Well, I think in fact they do, but it's one that they make up for themselves they create as they go along. I think that that's really — in a way it's one of the more noble roles. Here we are in this great expanding universe, which doesn't pay much attention to us and we're creating a little island of life in which there's beauty and scientific research and loving each other, and we do it all ourselves. We make it up as we go along. In a way I find that more beautiful and more noble than if we were just playing a part that had been laid out for us in advance.

MOYERS: But so many people need to believe that we have this particular relationship to the universe, that we were scripted from the beginning.

WEINBERG: Well, you know, we are important. I find the people around me in my life are terribly important. It may be that there's no objective importance that registers in the cosmic equations, but importance is what we give to things. I think that's not entirely unsatisfactory.

MOYERS: You were once very pessimistic about our ability to avoid a serious nuclear war. You even said you feared we were moving toward the kind of world in which such a world would be more inevitable. Since President Reagan and Gorbachov have been to the summit four times have you changed your opinion?

WEINBERG: I think there's a chance of moving away, but I don't think we've really started to move away. I think, we have now a military system which puts a premium on striking first. It's a horror. I sometimes think I'm paranoid, that I seem to be the last person who's worried about thermonuclear war. Other people find all sorts of other things to worry about in our society. But I still feel that that's the greatest worry.

MOYERS: Why?

WEINBERG: We're — you know, we've fallen off the roof of the Empire State Building and we've fallen 70 stories and so far nothing has gone wrong and we're beginning to feel complacent, but it won't be long before we find out that we're really in danger. I don't have confidence in either side, the Soviet Union or the United States, having the ability to get out of a crisis without having to face the terrible choice between what they will see as national humiliation and taking the world another notch closer to war.

MOYERS: President Reagan says he's trying to persuade the country, the Soviets and the Al-

lies, to move toward the ultimate elimination of nuclear warheads.

WEINBERG: I think that's wonderful and if, in fact, the Star Wars defense helps us do that, I will withdraw every nasty word I've said about it. No one would be happier than I would.

MOYERS: But as a scientist—

WEINBERG: But right now it seems like it's having the opposite effect. That Star Wars will inevitably produce an all out arms race in offensive weapons as it becomes more and more real.

MOYERS: We will try to find ways to overcome it.

WEINBERG: Yes, and it's not just a theory. You know it's happened before. In fact, we developed technology, multiple warhead technology, which is very, very dangerous, because for the first time it gave the side that struck first an advantage, which is the worst possible situation to be in, because in a time of crisis, the one thing you don't want is to have any incentive to strike first. Having multiple warheads means that one missile on one side can destroy many missiles on the other side, but provided it's used first. And that was a terrible, terrible thing, which occured without much debate and was triggered, in part, because of the worry about the Soviet ABM system. We can't imagine what kind of destabilizing horrors are going to be produced by the Soviet reaction to even a largely ineffective American defense system.

MOYERS: Of course, the other side of the equation from the people who support Star Wars is that we have to have Star Wars so that the Steven Weinbergs of this world can continue to do their research into basic reality.

WEINBERG: Star Wars is a military system. It has nothing to do with basic science. My own feeling is that it harms rather than helps our security to pursue this program in the way we're doing it. I don't think there's anything wrong with a discreet research program. We've been doing it for many years. I've worked on it myself. I think we ought to continue working on research at the level before you get to testing systems in the atmosphere.

MOYERS: Is this an exciting time to be a scientist, a physicist?

WEINBERG: It's not as exciting as it was 15 or so years ago. Every day the theorists were predicting something new that the experimentalists might test, or the experimentalists were discovering something new that sent the theorists back to their desks. The kind of very fundamental elementary particle physics that I like to do has gotten a little too mathematical, a little too theoretical, and it's because we desperately need new experimental facilities.

MOYERS: You and other physicists are calling for the government to build something called a superconducting supercollider at a cost of three to four to five billion dollars. What is that?

WEINBERG: It's a 53 mile long oval tunnel underneath the ground. In the tunnel - the tunnel's about ten feet wide - there are two beams of particles and they're being accelerated, that's why we call it an accelerator. They're getting faster and faster, more and more energy, and when they get up to an energy of 20 trillion volts, then at certain points in the tunnel, the beams are made to cross each other, the particles collide and you get new forms of matter.

MOYERS: And that will show you essentially what?

WEINBERG: It's going to increase the energy of the particles that we can study by a factor of 10. Now, every time you do that, you discover new worlds of physical phenomena. So I could just wave my hands and say, "Well, there's going to be something new that'll come along." In fact, in this case, you can say more than that. There are specific questions that we're sure are going to be answered by this facility. But the general experience is that the questions that you know are going to be answered never turn out to be the most important ones. The most important ones are things that you haven't thought of.

MOYERS: What do you say to the scientist who argues that there are cheaper ways than these big giant projects to arrive at basic discoveries?

WEINBERG: There is one kind of question that can't be answered in any other way. We've tried. You know, I'm perfectly willing to do it all myself. Just give me a couple of number 1 pencils and a yellow lined pad and I will go to work for you, and I don't cost much. But I can't do it. I've tried, and I and my colleagues are not able, by pure thought, to take the next step.

It's not a question of improving the efficiency of our work, it's a question of allowing the work to be done at all. Do you want to know the underlying laws of physics? Well, this is the way you have to go about it.

MOYERS: I think that the John Q. Citizen out there listening to you will say, "I can understand that theories are cheap and experiments are expensive and you have to take these theories off the

blackboard and try to test them in whatever the way the scientist decides is conclusive, either right or wrong." But what bothers John Q. Citizen is how do you sort out all of the demands on scarce dollars. Twenty-six billion dollars for a space station potentially, Four to six billion dollars for the super collider, three to nine to twelve billion for Star Wars, SDI, three to six billion for this research that the government wants to do in human genetic sequences. How do we sort all of that out?

WEINBERG: The super collider is Four billion dollars, but it's spaced out over some years. It's a few hundred million dollars a year and that's not comparable to the kind of spending that's going on in Star Wars or that would be going on with the space station. It's a harder question when you compare things like the super collider with, say, mapping the human genome, the great biological project. I think they're both very valuable, they both should be done. They're not expensive on the scale that the space station is expensive or Star Wars is expensive.

MOYERS: Why don't the countries that want one, like the Soviet Union and Japan and the U.S., get together and make a truly international, non-political effort to build a superconducting supercollider that will serve all science?

WEINBERG: If we don't build an accelerator like this on our own soil, then the next generation of graduate students in physics, when they get their PhD's are all going to have to get into planes and go off to Geneva, or the Soviet Union, or Japan to do their work because that's where the front-line instruments are going to be. Our country will lose a generation of elementary particle physicists. You might say that you could face that with equanimity, but in fact these elementary particle physicists provide a very important cadre of scientific talent.

MOYERS: How does a scientist advise his government? The next President walks in the office in January, he has to face this question of billions of dollars for a super collider, billions of dollars for space station, billions of dollars for Star Wars, billions of dollars for genetic studies. And he's looking at a deficit that's been growing, government spending that's out of control. How does he do it?

WEINBERG: Well, first of all, the science adviser has to find the President. As matters now stand the science adviser does not—in the present administration the science adviser does not have direct access to the President. He reports through the White House bureaucracy. That wasn't the case in previous administrations. I remember during World War II, President Eisenhower insisted that the meteorologist who was giving him weather reports on weather in the English Channel before the invasion of Normandy report to him directly. He wanted to know that meteorologist well enough so that when the meteorologist said something he could tell, "Can I take it for sure that there's not going to be a storm, or do I have to take this with a certain amount of caution?"

MOYERS: So if either Mr. Bush or Mr. Dukakis called you between the election and the inauguration and said, "Dr. Weinberg, what's the most important thing for me to know?" What would you advise him?

WEINBERG: Get advice from people who are not directly involved in developing the systems that they're trying to sell you. Get advice from someone who stands a little apart.

MOYERS: What do you say then to my cousin, that lives in the panhandle of Texas who's about to retire after 35 years in one job and is worrying about whether or not his $900 a month pension will be there, and whether or not taxes won't take too much of it to say, "Why do we want to spend billions of dollars to find out what happened in the first hundredth of a second of the universe, or whether the universe is enlarging, expanding, why?"

WEINBERG: You know, there are a lot of things in our society that are not needed to get through the next day or not needed to feed and clothe and house us, but somehow make life worth living. I think finding out about the universe is one of them. I can't point to practical applications of the superconducting supercollider. There are spinoffs from the building of the thing. You know, we learned how to have super-conducting magnets. We learned how to do online computing. It's going to be the largest vacuum chamber in the world. It's going to be the largest liquid helium facility in the world. So we'll get a lot of technological expertise out of building the thing. But I'd hate to rely on that. I think that doesn't do justice to the value, I would say spiritual value.

MOYERS: Spiritual value?

WEINBERG: Well, what else is it? We're finding out what kind of a world this is. We're finding out what the rules are. I think it's a great value to our society. It's one of the things we're proud of in this country. We're proud of doing this sort of thing.

MOYERS: You said it helps spiritually, and yet, there's so many people who feel that science — I'm not one of them — but they feel that science does not give them a feeling for how to live their lives. That, in fact, it removes the ground of their faith.

WEINBERG: Whatever faith you have you ought to be willing to confront it with the discoveries of science. There's something ignoble about not being willing to look at what we've found about the way the world is and trying to reconcile it with whatever you've decided to believe in for yourself. But how you do that, and what you're going to wind up believing in is not for me to say. It's this world we're trying to explain. We create very artificial conditions in the laboratory, but it's not because we enjoy slamming particles together, it's not because we're trying to win any world records for the heaviest and most exotic, weird, new particle, it's because we're trying to answer that last why in the chain of why's.

MOYERS: And the last why is?

WEINBERG: Well, we haven't got to the last one yet. I shouldn't have said the last why, I should have said the latest why.

MOYERS: But that's just it. It's a little bit like journalism, although we operate at such a more vulgar level. Our reports are always interim reports.

WEINBERG: Yes, our reports are always interim reports too. Maybe that won't always be true. Some people think it's in principle impossible. Other people think that it's in principle possible but we'll run out of money long before we get there, and we'll never know the answer because we can't afford it. Other people think we're not smart enough, that the species is not smart enough—just like dogs are not smart enough to understand Newtonian mechanics, at least I don't think they are — we're not smart enough to make progress beyond a certain point. And they're all possibilities. Another possibility is the one that I've let serve as the organizing principle of my own life. And that is that we're really going to get there. That we're going to get to the end of the chain of why's and we're going to see the few simple principles that govern everything.

MOYERS: From the physics department at the University of Texas, this has been a conversation with Dr. Steven Weinberg. I'm Bill Moyers.
