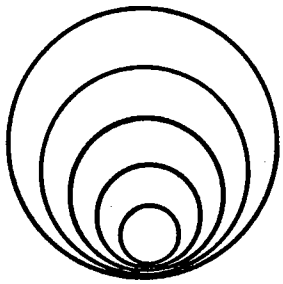

BILL MOYERS' WORLD OF IDEAS

Chen Ning Yang

Producer: Kate Roth Knull

Executive Producer: Jack Sameth

Executive Editor: Bill Moyers

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Chen Ning Yang

BILL MOYERS: *[on camera]* Good evening. I'm Bill Moyers. The Westinghouse Science awards are something like Nobel prizes for teenagers; they recognize outstanding work in science by high-school students. In 1988, one New York City public school had eleven Westinghouse semi-finalists, something of a record. Their names; Ming Choi, Victor Chow, Irene Eng, Chen Lin, Jung Ho Kim. Every one of the eleven was of oriental background. Was it a fluke, as the principal said? Or do Asians bring something to the study of science the rest of us had better learn to emulate? My guest tonight — nobel scientist, Chinese native, and American citizen — has something to say on that question. Join me for conversation with Chen Ning Yang.

[voice over] Dr. Chen Ning Yang is the Einstein professor of physics and heads the Institute for Theoretical Physics at the State University of New York at Stony Brook University, one of the leading centers for math and physics in the country. Dr. Yang says he has had the best of two worlds. He grew up in China, learned English from his father, a professor, and chose American Benjamin Franklin for his boyhood hero. In 1957, Yang and a colleague, T.D. Lee, working together became the first Chinese scientists to win the Nobel Prize. Yang is now a U.S. citizen. He has raised his family here but he returns to China frequently. We talked on the Long Island campus about how East and West see science.

[interviewing] What did the Chinese Communists think about an American being the first Chinese to win a Nobel Prize? The only one?

CHIN NING YANG: At that time.

MOYERS: At that time.

YANG: Well, I would say they were enormously proud. Because, in the late 1870's, there were Congressional hearings in this country about whether there should be Chinese immigration allowed. And there was a famous testimony by a so-called scholar who — this is recorded in the Congressional records — said that the Chinese people are undoubtedly inferior and he supplied scientific evidence. He measured the size of the brain of different racial groups and proved that the Chinese are definitely inferior. And this is deeply felt by the Chinese people. So I would say that if you want to ask what is the most important reaction to the announcement that my friend T.D. Lee and I won the Nobel Prize in 1957 in China, it was tremendous pride. And I can see this, I can sense it.

MOYERS: *[holding report]* This is something called a National Report Card that was released not long ago by the Educational Testing Service. And it says: "American students are remarkably limited in their knowledge of science and their ability to use what they know." And not too long ago there was an association that ranked teenagers around the country, around the world, in 17 different countries and what that study showed was that the United States ranked last in biology, 11th in chemistry and 9th in physics. What do all of these facts and statistics say to you?

YANG: The kids from the Orient are more disciplined. They have a tendency to listen to the advice of their parents and their teachers, and learn that you have to work hard before you can get some enjoyment. Here in America the system is quite different. I'm not attaching any value judgment to this statement. For example, my kids are born in this country. My wife is also originally from China.

MOYERS: You have how many children?

YANG: We have three; two boys and a girl. They are all grown up now. I noticed that when they were very little, when I said, perhaps you should do this. They said, "No, I don't want to do it." "Why not?" "Because it's boring." Now, this concept that something may be boring and I don't want to do it does not exist with children in the Orient. Somehow society is structured differently. They hear different things. They therefore do not have the idea that I have to find instant gratification before I would launch into something. Where here, the kids all want to see something immediately, to see the

point. And oftentimes, that's not possible.

MOYERS: If your three kids had been raised in China instead of here on Long Island, how would their education have been different? What would they have heard, as you say?

YANG: I have speculated on this. I think they would be very different individuals today. Namely, they would be willing to be drilled. Where here it doesn't work. Of course, you realize that my wife and I try to say to them that, "Look, this doesn't work. You've got to study hard." And I think they listen to it but having grown up in this environment they have a different set of values. So I think that in this respect the educational system in the Orient has a great advantage. And the manifestation of that, one of the manifestations of that is what you referred to in this report; that if you take high-school kids and give them science or mathematics quizes, American kids on the average don't do as well.

The other side of the coin is that kids trained in the Orient tend to be too timid, tend to say that, "My God, there have been all these sages, all these saints, who have done this and that. Who am I?" They are taught that there was Newton, there was Maxwell, there was Einstein. Who are you to challenge any of these great people of the past? This produces a quieting influence but it produces a too timid attitude.

MOYERS: What does this do to them psychologically, to always respect authority, take the teacher's word for it, follow the given path?

YANG: It has good and bad elements to it. We see this very clearly among our graduate students. The graduate students from the Orient are more quiet, more willing to work, make very good grades, but are somewhat restrained from making imaginative leaps.

MOYERS: What do you think explains the fundamental difference? I mean, knowing that every culture is the product of particular forces that have been shaped over centuries.

YANG: Well, Bill, I'm not a sociologist or historian, but I like to speculate. I think America is a new country. It is a young culture. The spirit of the opening of the West is still with the Americans. It's a very practical and individual-based kind of philosophy that had worked in America for a long time, had been very successful. And the spirit is very much there. In the last 40 years America has grown older too so the respect for learnedness has increased. You see, Bill, there is a very ancient Chinese saying which goes something like this: "If you know what you know, and know what you don't know that is true knowledge." That philosophy has had a profound effect on the Chinese system and on Chinese society. So you as a child would be scolded if you pretended you know a little bit more than you actually do.

The advantage of this is that you are more solid. You don't open your mouth when you don't really know what's going on. The disadvantage of it is that you become afraid. I told my graduate students from China and from Taiwan that you must overcome this. You go to a seminar and most of the time you don't quite understand what's going on. I told them you don't have to be afraid. I go there, I also don't understand quite what's going on, but that's not necessarily bad because you go there a second time you find that you learn more. I call this learning by osmosis. Learning by osmosis is a process which is frowned upon in China. The reason that the Chinese graduate students are less daring is because they don't want to get mixed up with something which they only half know. But in frontiers work it's always — or research work — it's always half knowing, half not knowing.

MOYERS: But, given what you say, I would expect the United States to be in a stronger position scientifically. And yet we're told over and over again that we're becoming a nation of scientific ignoramuses, that only 10 percent of American high school students ever take a course in physics. Only 7 percent of American kids learn enough science to perform well in college level classes. This daring, this experimentation, this spirit of innovation and adventure does not seem to be taking hold down in the masses of American kids, particularly in regard to science.

YANG: The point is that the American system is capable to produce enough very good people to sustain this frontiers effort for some time to come. But the general level of

scientific knowledge among the general population that is where there's a great worry.
MOYERS: Why?
YANG: Because look at Japan. How did they achieve the present industrial strength? They achieved it because they have more educated people. They have more people who have real knowledge, not just diplomas.
MOYERS: Real knowledge?
YANG: Yes. And they have more people who have learned science. They are more educated, and in particular they are more scientifically educated. This is very clear. You look at all these tests that you were referring to and Japanese kids do extremely well because they really learn in schools. Here the kids don't learn in schools mostly. There are a few very bright ones who somehow learn even in this morass and they are really brilliant and they are nurtured by the American system of freedom, pushing for the individual achievements. And then they later rise to the top and either achieve something as a big organizer or as a scientist. And that's what's sustaining the United States. And it will sustain it for some time to come. But this modern society has to be built on a general population which is knowledgeable, which has the right drive. And that's where I think the American future has the greatest dangers.
MOYERS: What does it say to you that Japan with half our population produces twice as many scientists and engineers every year as we do?
YANG: They now want to forge ahead in basic sciences which they did not pay that much of attention to compared to applied areas in the last forty years.
MOYERS: Basic science is where we've been so strong. So now they're coming after us.
YANG: And that's formidable. If you have 120 million people there are bound to be a large number of very bright youngsters. And if you have money, and if you know how to organize, how to use them, how to encourage these kids to get into the fields where they can excel they will do very well. So I would say Japanese basic science, as we said earlier, is not yet on the same level as the US but I would think they are coming up very fast.
MOYERS: What does it mean to a society to lose its competitive edge in basic science?
YANG: I think in the sciences there is still the general belief that America is still tops. For America to lose that I think would be very bad not just speaking as a scientist myself. I think it would be very bad for the morale of the whole country. Take biotechnology.
MOYERS: Biotechnology.
YANG: I have many friends who are in it and they say that the United States is tops but Japan is a very close second and they are coming up very fast. So basic science also has economic connotations. Many people believe that in another twenty years the economic returns from biotechnology equal to that of computers. That's why the Japanese are also pooling their efforts in this area.
MOYERS: Those are the practical aspects of the importance of basic science. Are there spiritual aspects as well? I mean, in your field, which I think of as the realm of pure thought - are there any of life's answers in there?
YANG: Of course, because what we are doing is we are reducing the fundamentals of the structure of matter, of the universe, in to a few equations. These equations look very simple but it contains the basis of most of what we see around us. Mr. Maxwell, of the last century, came along and wrote down a few equations. They are just four lines, but that describes electric and magnetic forces in total and with great accuracy. What is meant by this accuracy? The marvelous thing about it is that if you have an extremely bright graduate student you can shut him up in a room and say now you compute the magnetic moment of the electron and if he's bright enough and if you have taught him enough he should be able to come out after a few months with a number which is eleven decimal points long and agrees exactly on the dot with what is measured. Just imagine that. He started with nothing. Just a few of Maxell's equations. That means that we have penetrated the structure of nature in an unimaginable way.
MOYERS: Why should I care about that? What difference does it make to me as a

citizen? As an individual? I'm not a scientist. I'll never understand the formula on that board that you put up there.
YANG: In the last century people like Maxwell and Faraday before him understood the structure of electricity. They understood the structure of electricity in terms of these formulae. If there were no understanding of electricity at the end of the last century the 20th century could not look the way it does today. Everything depends on it. Just think about it. If you cannot maneuver electricity everything collapses. A car would collapse too because a car has electricity in it - you have to have the ignition and so on and so forth. The world would look completely different. Therefore when you really understand something in such detail which is so fundamental, I think our experience is that you will be able to use it in a major way. Now you would ask, "okay, after Maxwell, what next? "

The chemical structures are outside of the nucleus and that's very powerful and that dictates most of what we see today but there are stronger forces, forces which are something like a million times stronger inside of the nucleus and that we are beginning to unravel and then you ask, "Are we very close to utilizing the knowledge that we gained?" I do not know how to answer that question. I only know that when we do understand it - since it's much more powerful, I think, it stands to reason that it would also be harnessed. But I cannot predict when.
MOYERS: It's something within an atom that's smaller than the atom, that has more power, perhaps, than even the atom that we've unleashed.
YANG: Right. What we are after is the true fundamental structure. We are after Maxwell's equations for the inside of the nucleus and if we have that then we will be able to control it much better than the present ability to control it.
MOYERS: Are we going to get there in your lifetime?
YANG: Well that's a very good question. I don't know. I think that maybe not because to do this you know that we need very high energy accelerators to crack open the smallest domain inside of the nucleus, and that's getting more and more expensive. You have talked to Weinberg about the SSC.
MOYERS: Dr. Steven Weinberg, yes. The superconductor collider.
YANG: I hope it will be built, but I think that nobody knows at this moment whether it will certainly be financed.
MOYERS: When I talked to Dr. Weinberg we talked about how you physicists are looking for smaller and smaller particles, and after that interview aired I received a letter from a viewer who said this: "Particle physics reminds me of a man who throws rocks at a window and then classifies each piece of the broken glass until he finds it necessary to break each fragment into smaller and smaller pieces all the time looking to discover what is a window." And he said, "Is it possible to find the pieces and miss the meaning?"
YANG: If our field is just the field of cataloging these pieces, that would be sort of like what he was talking about - it would be a useless field and would not attract the interest of us and it would not have this awesome achievement that has impressed everybody who has been in it. Instead, what we find is that there are patterns of these very complicated phenomena, and these patterns generate laws which are written in the form of equations and these equations amazingly agree with experiment. So we know that nature has an order, and this order we can aspire to comprehend because past experience has told us that when we did more research we did comprehend large new areas of physics and they are beautiful and they are powerful.
MOYERS: Beautiful?
YANG: Yes, if you can reduce many, many complicated phenomena to a few equations that's great beauty. What is poetry? Poetry is a condensation of thought. You write, in a few lines, very complicated thoughts. And when you do this well it becomes very beautiful poetry. It becomes powerful poetry. It becomes concentrated poetry and that is what we are after. And this is not a dream. It is a fact. Because we have already achieved some of these. By "we," I mean collectively, physicists, starting from Newton, Maxwell, Einstein and so and so forth. And along the way we continue to find that

this is an achievable dream so that's why we are after this.

MOYERS: As you talk about the relationship between poetry and physics, you make me think that maybe the poets anticipated you physicists. It was Blake, after all, who talked about seeing the universe in a grain of sand.

YANG: Yes, yes. That was a beautiful poem. We do have the feeling when we are confronted with something which we know is concentrated structure. And when we reflect that this is sort of the secret of nature there is oftentimes a deep feeling of awe. It's as if we are seeing something that we shouldn't see.

MOYERS: Shouldn't see? Forbidden territory?

YANG: Yes, because it has a certain aura of sacredness. It has a certain aura of power. And when you are confronted with that, undoubtedly you have a feeling that this shouldn't have been seen by a mortal man. And I oftentimes describe that as what I would call the deepest religious feeling. And it is, I believe.

MOYERS: As you go deeper and deeper, is there any evidence to suggest to you that there is out there somewhere in the universe a complex intelligence that is the shaper of this beauty, the artist, the composer of this poetry?

YANG: I wish I knew how to answer that question, because you can say it cannot be an accident that things are structured in this way; you have simultaneously beautiful things, concentrated things and yet it describes the infinite complexity of all the manifestations that grow out of it. This is just absolutely marvelous. How come? I don't know how to answer that question.

MOYERS: Because what people grope to understand — and I think this was partly behind my correspondent who wrote me the letter that I just read to you — is whether or not human beings are only a bundle of protons and neurons, a swirling collection of quarks.

YANG: If you ask me the question, "Why is there mankind? Why do we have brains which enable us to make these penetrating studies?" I don't know how to answer that. And these are questions which are deeply religious in flavor. But it is a fact. Now this oftentimes leads to another discussion. Does this mean that we will eventually understand everything? We have something like 10 billion neurons, maybe 100 billion.

MOYERS: Each one of us?

YANG: Yes. And each neuron has something like 10,000 to 100,000 synapses. These are connections. So this is a very complicated thing. But nevertheless, it's finite. And so I believe there are limitations of our ability to understand things because we have a finite number of neurons. So therefore, there will be, in my opinion, a final limit to the human ability to comprehend the most subtle, the most beautiful, the most complex equations. However I would say we should not worry about it because that limit is still very far in the future. We don't have to worry about it for many centuries perhaps.

MOYERS: Everybody is turning to science, even if they don't understand it, for answers; whether it's curing AIDS or putting a man on the moon. Has science become the new religion?

YANG: Science has become something that everybody knows he has to pay attention to, but not everybody is a believer. So I don't think we should equate science with religion. But, that science is progressively playing a more and more important part in the life of every individual, is obvious. And I think this is likely to increase even further in the future.

MOYERS: *[voice-over]* From the State University of New York at Stonybrook, this has been a conversation with Frank Yang. I'm Bill Moyers.