A DIALOGUE WITH HENRY EYRING

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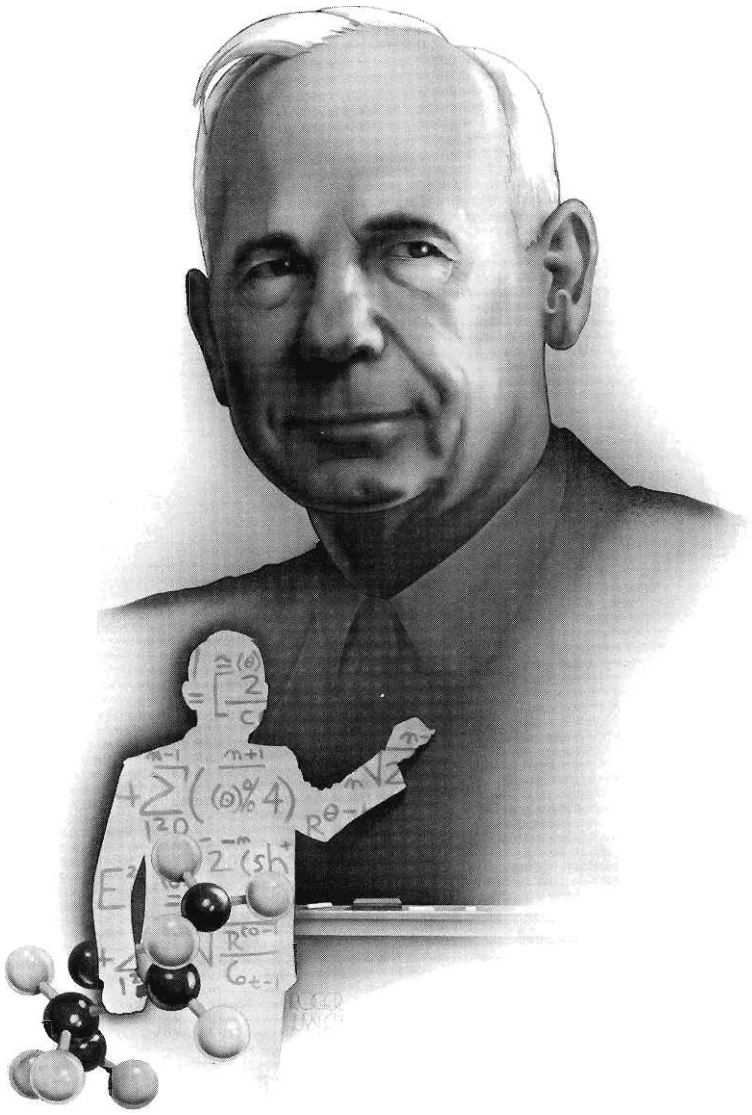

Henry Eyring, Distinguished Professor of Chemistry and Metallurgy at the University of Utah, is probably the most widely known scientist in the Church. He was born in 1901 in the Mormon community, Colonia Juarez, Chihuahua, Mexico. As a boy he helped his father wrangle cattle on their ranch. In 1912, the family fled as refugees from the Mexican Revolution and settled in Pima, Arizona.

Over the years Henry Eyring's status in the first rank of scientists has become secure. He has produced a staggering volume of research publications in the fields of his interests: application of quantum mechanics and statistical mechanics, radioactivity, theory of reaction rates, theory of liquids, rheology, molecular biology, optical rotation, and theory of flames. He is a longstanding member of the National Academy of Science. His work has led to seventeen major awards, thirteen honorary degrees, and leadership in numerous professional organizations, including terms as president of the American Association for the Advancement of Science and the American Chemical Society.

Henry Eyring is a man of warmth and wit. For the past sixteen years, he has put up prize money for the first four places in a fifty-yard dash run by his ten to twenty graduate students. He is a regular competitor, though the students seem to run faster than they once did.

He has served faithfully in various Church positions. He was district president in New Jersey while teaching at Princeton, presiding, as he says, over 3,000,000 persons, "though most of them were blissfully unaware of the fact." He served on the General Board of the Sunday School for twenty-five years and presently serves as a stake high councilman.

Edward L. Kimball, Professor of Law at Brigham Young University, conducted the interview for Dialogue. *His mother is Henry Eyring's eldest sister.*

Kimball: To what do you trace your strong commitment to education?

Eyring: My grandfather Eyring spoke seven languages and had a good education and was very much in favor of education. My father went to Brigham Young Academy when it was still a high school. Although my mother only went through fifth grade, she was well-educated and later taught school. She was a quick person who read a great deal and learned readily. I grew up in a family that spoke good English. I think I had all the advantages I would have had if my parents had had college degrees. My uncle, Carl Eyring, went to BYU and started his Ph.D. with Milliken at Chicago and finished at Cal Tech. My oldest sister motivated me very much. She came back from school in Utah and told me I ought to get a Ph.D.

I never had any other idea but that I would go to college. My parents were poor, but not so poor that they could not let me go, providing I could work my way through school. I was quite able to do that. As a matter of fact, the first year I had a $500 scholarship and that meant I had money to send home.

Kimball: How did your career in science begin?

Eyring: I took my bachelor's degree in mining at the University of Arizona and then was an engineer in the Inspiration Copper Company in Miami, Arizona, and in Sacramento Hill in Bisbee, Arizona. Rather early in my mining career I was working as a timberman repairing a squareset when a rock about as big as my head came down and hit my foot so that my boot filled with blood. I was glad to get out of that place. It was a death trap. I left, not so much because I was frightened as because it seemed stupid to stay where one was gambling without enough to win to justify it. I neither wanted to work in the mine myself nor to send other men into it.

I went back to get my master's degree in metallurgy and then worked at the United Verde Smelter in Clarkdale, Arizona. I remember very well the day when I was in the blast furnace aisle where there were about twenty blast furnaces belching out sulphur dioxide. I had my handkerchief dipped in bicarbonate and was putting it over my face. The superintendent of the smelter came up behind me and said, "Eyring, I like the way you are working out here at the smelter. If you stay here another three weeks, I am going to put you in charge of these blast furnaces." That is when he lost a metallurgist. I took up chemistry. I got a Ph.D. from Berkeley, taught briefly at the University of Wisconsin, spent time as a National Research Fellow in Berlin, and taught for fifteen years at Princeton before coming to the University of Utah in 1946 as dean of the Graduate School.

Kimball: You were on the General Board of the Sunday School for many years, weren't you?

Eyring: Yes, in fact, they asked me before I came. Milton Bennion, my wife's uncle, had inside information that I was coming to the University of Utah. He was dean of the School of Education and wrote me a letter before I even left Princeton, and I accepted. I was on the Board for twenty-five years.

Kimball: Were there assignments you particularly enjoyed as a member of the Board?

Eyring: I particularly enjoyed my assignment as chairman for the Gospel Doctrine committee. We had to prepare a new set of lessons every year, though of course we had help. Associating with faithful Sunday School workers throughout the Church was tremendously rewarding.

Kimball: I understand you were part of a high-level meeting to plan the new Church magazines.

Eyring: That is an amusing story. I got a letter from Richard L. Evans to come down to a two o'clock meeting for the new magazines, along with a great many other people. I was visiting your parents and I said, "I am going to a meeting for the magazines." Your father said, "I am going, too, at nine o'clock." I had forgotten in the meantime that mine was for two o'clock and assumed it was the same meeting. My secretary was not there that morning and I was a little bit late, so I hurried down to the Church Office Building. When I got there, I went in and said to the receptionist that I was supposed to go to a meeting. He said, "Well, isn't it this afternoon?" I said, "No, it is this morning." And so he took me in and there were four apostles—your father, Marion Romney, Brother Evans and Brother Hunter—and the magazine editors. I was quite surprised that there was no one else from the Sunday School but I thought, well, they must regard me very highly, and so I just sat down. Your father shook my hand, so did Marion, and everyone—I knew them, you know—so I sat down. The discussion went around and I was willing to offer my views quite freely. However, Brother Evans said, "Your turn will come in a few minutes."

When they got around to me, I told them that the Church magazines never

would amount to a damn if they did not get some people with independence in there who had real ideas and would come out and express themselves. If they were going to rehash old stuff, they would not hold the young people. I told them I thought that *Dialogue* had caught the attention of more people and had more influence than our own Church magazines did. It has some of the kind of independence that I think is a good thing. I think it is walking a very dangerous road and could easily go sour, but so far it has been good. And I told them that if they left out people like Brother Wheelwright, who had been working with the *Instructor,* they would be making a big mistake, and so on. I gave them quite a bit of very fine advice and I damned a little when I wanted to and when I got through, Brother Evans said, "I do not know anyone who characterizes the idea of independence any more than you do; are you applying for the job?" I said, "No, I am not applying for the job, but I think I have given good advice." Everyone was very nice to me.

I did not have any feeling, even after I had been there, that there was anything wrong, and thought that they must have a high opinion of my wisdom. When I got back to my office, my secretary asked, "Where have you been?" I said I had been down to that Church magazine meeting. She said, "That is this afternoon at two o'clock."

What is so funny is not that I made a mistake, but that I was so insensitive as to not realize it. I did not go to the two o'clock meeting. I felt I had done my work. Brother Evans got up in that meeting and, I am told, said that they had had a meeting in the morning and that very useful advice had been supplied by Brother Eyring. He did not say I had not been invited.

I am amazed at the graciousness of the brethren in making me feel I belonged, when any one of them might well have been annoyed. They are a most urbane group. On my part, there was no holding back; I just tried to help them all I could.

Kimball: The scientist sometimes finds himself in the middle on things like the age of the earth controversy. What has been your experience?

Eyring: When President Joseph Fielding Smith's book, *Man, His Origin and Destiny,* was published, someone urged it as an Institute course. One of the Institute teachers came to me and said, "If we have to follow it exactly, we will lose some of the young people." I said, "I don't think you need to worry." I thought it was a good idea to get the thing out in public, so the next time I went to Sunday School General Board meeting, I got up and bore my testimony that the world was four or five billion years old, that the evidence was strongly in that direction. That week, Brother Joseph Fielding called and asked me to come in and see him. We talked for about an hour. He explained his views to me. I said, "Brother Smith, I have read your books and know your point of view, and I understand that is how it looks to you. It just looks a little different to me." He said as we ended, "Well, Brother Eyring, I would like to have you come in and let me talk with you sometime when you are not quite so excited." As far as I could see, we parted on the best of terms.

I would say that I sustained Brother Smith as my Church leader one hundred percent. I think he was a great man. He had a different background and training on this issue. Maybe he was right. I think he was right on most things and if you

followed him, he would get you into the Celestial Kingdom—maybe the hard way, but he would get you there.

The Church, according to a letter from President McKay, has no position on organic evolution. Whatever the answer is to the question, the Lord has already finished that part of His work. The whole matter poses no problem to me. The Lord organized the world and I am sure He did it in the best way.

Kimball: Members of the Church often express pride that an eminent scientist is a faithful Latter-Day Saint.

Eyring: I think that is the wrong point of view. I have told this story often: I serve on the Board of the Welch foundation. A man named Robert A. Welch struck oil and left what is now an endowment of about 120 million dollars dedicated to the development of chemistry in Texas. Each year we have had the ablest people in the world come to discuss some subject. At the first discussion, which was on the nucleus of the atom, there were about a dozen of us sitting around the lunch table. One of them turned to me and asked, "How many of these people believe in a Supreme Being?" I said, "I don't know; let's ask them." There was no objection. I said, "Now, let's put the question as clearly as we can. How many of you think that 'There is a Supreme Being' best represents your point of view, and how many think that 'There is no Supreme Being' best represents your point of view? Let's not have a long discussion about what we mean, but just choose between these two propositions." All twelve said they believed.

I do not think there is anything unusual in physical scientists believing in a guiding, all-wise Being who runs the universe. They might differ in their kinds of theology, in men's interpretation of this big idea, but the best exact scientists in my experience are overwhelmingly believers.

Kimball: Does it have anything to do with their being scientists?

Eyring: I think they do not see how there could be all of the order in the universe unless there was something back of it. It is hard to believe that we just happened. It is not, of course, a matter of proof. Actually you do not ever prove anything that makes any difference in science or religion. You set up some postulates from your experience or your experiments and then from that you start making deductions, but everything that matters is based upon things you accept as true.

When a man says he will believe religion if you can prove it, it is like asking you to prove there are electrons. Proof depends upon your premises. In Euclidian geometry, you learn that three angles of a triangle total 180 degrees and that two parallel lines never meet; the whole argument proceeds very logically. But there are other kinds of geometry. In elliptical geometry, parallel lines do meet and in hyperbolic geometry, they diverge. If you go up to the north pole and draw two parallels of longitude, they will hit the equatorial plane at right angles. That makes 180 degrees, plus the angle at the pole. And the lines are perfectly parallel at the equator, and the fellow that does not know they are curving will find that two parallel lines meet. It is a perfectly good geometry. It is two dimensional on the surface but it is curving in a third dimension. Analogously we do not know whether or not this three dimensional space we live in is curving in a fourth di-

mension. You can build your logic perfectly, but whether your postulates apply to the world you live in is something you have to get out of either experiment or experience.

Every proof in science depends on the postulates one accepts. The same is true of religion. The certitude one has about the existence of God ultimately comes from personal experience, the experience of others or logical deductions from the postulates one accepts. People sometimes get the idea that religion and science are different, but they are not different at all. There is nothing in science that does not hinge on some primitive constructs you take for granted. What is an electron? I can tell you some things about the electron we have learned from experiment, and if you accept these things, you will be able to make predictions. But ultimately you always get back to postulates.

I am certain in my own mind of the truthfulness of the gospel, but I can only communicate that assurance to you if you accept my postulates.

Kimball: May I ask you some questions about your professional life? What would you consider your most important scientific contribution?

Eyring: In 1935 I wrote a paper called "The Activated Complex" and practically everybody in the world who treats rates of chemical reactions uses it. It has stood now since 1935. It is a very simple equation. It says that how fast two molecules change partners depends on how hard they bump into each other. If they hit hard enough, the electrons that are holding the two pairs together reorganize and allow a change of partners. The rate of a reaction depends on how hard you have to push to come to the point of no return. It is the same equation that has to do with the fact that there are not many molecules of gas on top of high mountains because it takes work against gravity to get up there. There won't be many molecules that have energy enough to go over the gravity barrier. In fact you use exactly the same equation to calculate the barometric pressure as you do to calculate the rate of chemical reaction.

Kimball: You don't mind if I do not understand that, do you?

Eyring: But you do understand it. Let me tell you a typical chemical reaction. If you could look at a molecule closely, you would see that gravity acts like a spring that pulls it to the center of the earth. The chemical bond is not unlike the force of gravity. If in India you have a molecule and you want to have it go over a pass in the Himalayas into China, you have to stretch that spring. Since not many molecules stretch the bond that much, only a few drift over the pass into China. If you go high enough you won't find any molecules. That is analogous to a chemical reaction. You can write that as an equation: the rate of reaction is the chance of being at the top of the energy barrier times the rate of crossing it multiplied by the chance of not coming back across the barrier.

Kimball: Would you mind telling about some of the projects you have worked on recently?

Eyring: One relates to cancer. What we have found out is a theory of mutation that explains the way chromosomes are changed inside the cell. There are forty-six chromosomes inside the human cell, twenty-three from each parent. Inside these chromosomes are genes. A gene is simply a pattern for making particular molecules. Some of these molecules promote bodily reactions. If you have those reactions going fast enough, the tissue grows. There are other molecules which inhibit growth. If you lose the ability to make these inhibitors because a certain part of the gene is damaged, you may have cancer. The forty-six chromosomes have about a million genes and a small number of them have to do with the crucial function of controlling rate of growth. They can be damaged by radiation or chemicals so that the genes are not coded to make the right molecules. The wrong molecules often are lethal, but the body's defense mechanism, the immune reaction, acts to destroy them. However, some of them leave the cell enough like it was that the body does not recognize it as an intruder. It is a Greek bearing gifts. This cell without the inhibitors grows out of control. That is what cancer is. The cells are much like they were before, but out of control.

I have collaborated with Miss Betsy Stover who has been working the last twenty years on cancer mechanisms by injecting dogs with radioactive materials. Together we have written a number of papers interpreting the results of her experimentation. I have read these papers at about twenty universities. The theory that I write down is an equation which fits the data and gives insights into possible causes of cancer that one did not have before. I did not participate in the laboratory research, but I have a facility for seeing how one can explain the experimental results in terms of mechanisms and write equations for them.

Kimball: Is that immediately useful?

Eyring: Yes, because you can make deductions from it. You can start systematizing and interpreting experimental facts. Some facts are very simple. We are overengineered against damaging mutations. Chromosomes are getting damaged all the time, but they are also being repaired. While we are young, the repair process goes so fast that cell divisions which result in a seriously modified cell only rarely take place. In their youth, maybe five people per hundred thousand per year will get cancer. But by the time they get up to seventy, it will be 18,000 per hundred thousand because their reserves are used up. If you think of scissors cutting things and needles repairing them, they are running out of needles and thread, so they stay damaged and you get uninhibited growth. What is it that uses up the needles and thread? Bad living. Anything that makes you grow old will increase the likelihood of cancer.

Kimball: I remember some research you did in wool fibers and in luciferase.

Eyring: Yes, that is related to rates of chemical reactions. And we are still working on these questions. Rates of cooking, or growth of muscles, or tightening of muscles, or using the brain—everything involves the speed of some reactions. It really means getting acquainted with the molecules as if they were your friends and knowing what their nature is and what they will do, how hard you have to throw them at one another so they will change partners. It is like a detective story;

it is the same kind of systematizing. Every time you get a nice new tool there are some puzzles you can solve.

Kimball: Is there any way of identifying the quality in yourself that makes you so successful in this kind of enterprise?

Eyring: I would think that I have a facility for seeing analogies. And I am not easily deterred by criticism. I do chemistry to suit myself. I am glad if other people like what I do, but fundamentally I do it for my own understanding.

I think I get along well with people so others like to work with me. I have had the privilege of training and directing 110 Ph.D's. By and large, I think of chemical research as my collaborators and I pitted against the complexities of nature. I never make my students do something alone if I know how to help them do it more easily. I do not put them on little jobs to find out how smart they are. I think they sense this attitude and give maximum cooperation.

Kimball: Can you tell whether someone is going to be a good chemist when you meet him?

Eyring: There are some factors I look for. One is whether he reacts quickly. You can talk with him and tell whether he sees things and grasps ideas. But he has to be more than bright if he is going to be a good scientist. He also has to be interested. That takes longer to discover, but you can work with him for a little while and find out. Unless he just gets lost in his work and feels that knowing molecules is like knowing people, he probably won't get far. If he is a time server, if he just likes to work eight hours and then go do something else, he won't change the world.

There are unsuccessful bright people who are so overcritical that they cannot even stand their own creativeness. Being critical slows down creativity because when you first get an idea, it generally does not come full-blown like Athena from the mind of Jove. If you are horrified because it is not perfect to begin with, you may abandon it. To be a successful scientist, it is often useful to be a happy muddler.

Kimball: Do you ever publish papers that you are later embarrassed about?

Eyring: Not that I *am* embarrassed about, but that perhaps I *should* be embarrassed about.

I have published over five hundred scientific papers, frequently with collaborators. I have written nine books, also with collaborators. And I have been editor of about twenty annual reviews of physical chemistry, and co-editor of eleven volumes of physical chemistry. No, there is no paper I am ashamed of, because at the time it was written, it was the best we knew. I have no apologies. Each paper was the best I could do at the time. That I was not born smarter is really not my fault. Maybe as important as anything in whatever success I have had is the ability to go ahead continually without worrying whether other people like what I do. If an idea is wrong, it will fail; if it is right, nothing can stop it.

I would say the same thing about the Church. The gospel, I am convinced, is

true and I do not care about little things. I do not think anybody understands everything completely about the gospel. I think the best man in the world is human. The Lord does not just open and shut his mouth. I follow the Prophet Joseph for his moments of insight when the Lord showed him things. I have no objection to his making any number of mistakes. Of course he did, and I like it. I like to see some of the brethren make mistakes because then I think that the Lord can use me, too. I mean, it gives me comfort; it does not worry me. I know they are mortal, so I never worry about small things in the gospel. The brethren are wonderful, but they make mistakes. Of course, there are things they do not understand, just as there are many things I do not understand.

Kimball: In your opinion, who is the greatest scientist in history?

Eyring: Some professional mathematicians would pick Archimedes, Newton and Gauss as the three greatest. I would think that as a mathematician, Gauss was the greatest of them all. He started so many things! And he made almost no mistakes. He was a phenomenon, a tremendous person. He was also quite religious.

Kimball: What about chemists?

Eyring: I would say one of the greatest physical chemists was Peter Debye. He died recently. I knew him well; he was about fifteen years older than I. He was a very great man. Emil Fischer, a German, in organic chemistry was tremendous. Again, to pick out any one can give the wrong impression. There are many others of comparable attainments.

Kimball: Einstein was at the Institute for Advanced Study at Princeton when you were there. He is the scientist laymen know best. What is your view of him?

Eyring: He was first rate, there is no question about it. It was no accident that he was good in many fields, but the picture some people have of him as a lone intellectual giant is a wrong one. I prefer to think of him as a man with few peers. There are other people who are comparable. Neils Bohr was another physicist of comparable scientific influence.

Kimball: The only thing most people know about Einstein is his theory of relativity.

Eyring: Yet he did not get the Nobel prize for that, but for the photoelectric effect. The photoelectric effect has to do with the emission of electrons when a ray of light strikes certain chemicals. And the color of the light determines the speed at which the electron will come out. As he explained it, light is made of particles. Just as the electron is a particle, so light is a particle. The light particle has energy in it which is transferred to the electron. The more violet the light, the more energy it has.

Kimball: Does the fact that he received the Nobel prize for this discovery mean that it was a more valuable contribution than the theory of relativity?

Eyring: No, it means that the discovery of photoelectric effect was clean cut. It was true; it was a discovery you could write something simple about, and it was his. All of those things go into a Nobel prize. They tend to give the prize to people who have done other important things, but they ordinarily identify it with some specific contribution.

Kimball: The head of one of the departments at the University of Wisconsin mentioned that he thought you ought to have had the Nobel prize long ago.

Eyring: I am available.

Kimball: Have you made some kind of specific contribution that might attract their attention?

Eyring: Possibly the reaction rate theory. Although I made it almost forty years ago, it might fall in that category.

Kimball: Wouldn't it be embarrassing for them to go back that far? It would be something of an admission that they waited a generation too long.

Eyring: They sometimes make the award for overall contributions. A case could be made for the idea that reaction rate theory has been the most influential concept in chemistry since its formulation. And my work on theories of liquids might also be considered.

Kimball: Is there anyone, outside science, you particularly admire?

Eyring: I admire your father. He is a remarkable man. He seems to me a selfless person who has found something to serve that is bigger than himself. I think that is always a great thing.

Kimball: He works at the Church much as you work at chemistry.

Eyring: The same way. He forgets himself in it. He is a great man. I know others. I know many people in the Church for whom I have that kind of feeling, but none that I know who are more devoted than your father and my mother. My mother had that same quality of selflessness.

Kimball: What is most important to you?

Eyring: I think the gospel and my family and friends. And I enjoy science. I am interested in it like some people get interested in a game, or in making money. It is fun to try and understand how things fit together. Life is to me an exciting game, and the concept of eternal progression which the gospel teaches gives meaning to it all.