SCIENCE, TECHNOLOGY AND HUMAN VALUES

May 1-2, 1992

"Humanity and the Cosmos"

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When Ron Thiemann asked me to give a talk on Humanity and the Cosmos I was really a little frightened, how could one possibly cover that subject? I have tried to focus it on the question of where we fit in to the universe, and thereby discussing the origin of the universe, general development of life and humans and where we are now.

The "big bang" I think everyone is familiar enough with, I don't need to expound on that very much. I would like to comment on these recent findings which of course have been very exciting and what will they change in what I have said here. What I have said is "yes we have convinced there was a someone unique period when the universe was expanding and but just how it started we don't know too much about". On the other hand we can trace a lot of the history really in a very satisfactory way and fitting in a lot of empirical data.

Now the recent findings of Colby were played out in the newspapers as being almost the answer with all that really tells us, we know just how the universe behave as it expanded. It's a very valuable experiment and a very difficult experiment, very well done, on the other hand, I would have to say it's somewhat marginal in terms of its precision. That is the errors are, statistical errors are 1/6 th of the value of what they find, in their best determination. And then uncertain laws of we've fluctuated and varied the dimensions the law is just not determined at all hardly, I would say is a 50 % error in the exponent of the law. So it's beautiful experiment, a very difficult experiment, it does tell us something. I think the most striking thing to me about it is that the fluctuation found was large scale, are constant with the fluctuations we see in the distributions of galaxies. That doesn't explain the galaxies themselves which differs in scale by about a factor of a hundred, but yet it projects on the basis of a reasonable theory which people have produced in relation to our universe and the theory of fluctuations and indicates the presence of at least some dark matter. So that's very satisfying to many people, that was a favorite theory and its certainly consistent with that theory, on the other hand one can believe, I think it can be consistent with a variety of other possible explanations and how definitive it is. I think we will have to wait and see.

Now we do know a great deal less, as I said, about the details of how things developed in particular after the galaxies were formed, which we don't understand very well, how stars could be formed and heated up and the energy that generates their energy, , we know about how that happens. The fact then that the stars then explode, why they explode, having produced the heavy nuclei which we need for life, mainly carbon, oxygen, nitrogen, iron, and so many other things, a whole spectrum of nuclei. Instead of just the simple elements, hydrogen and helium, which were produced in the big bang itself, these were cooked in the stars and then our own sun came along about five billion years later, at least, maybe ten billion years later. Some time later, was formed out of these materials which new chemicals, elements had already been manufactured, and thereby made an opportunity for life to evolve on the earth. Because we needed those chemicals. It's really impressive to see how much of this we can understand and at the same time there are some very basic things we don't understand, including why the numbers came out the way they did. Why the laws of physics are the way they are, why the constants are what they are, and so on. And those are very basic to our existence at all, very basic to the whole character of the universe. The relative strength of the electrical magnetic and gravitational forces and the many, many details of the laws of physics are just for to get anything out of what we see today.

So in a sense we can say it is very delicately tuned, fantastically so, very impressive how delicate the whole system is tuned in order to come out the way we are, anything like the way we are today, and that's given rise to what's been called the anthropic principle which says that everything was planned this way, to make man, or at least all the laws of physics are consistent with our being here. But of course that might just be disregarding the topology why we're here, so it has to be the laws of physics have to be such that we are here and scientists in general object to being unique. There was a great deal of an initial objection to the big bang because that sort of seemed to make a particular point in time there couldn't be any real beginning, and we can't specialize ourselves and say that we were so outstanding that there is nothing else like this. There are solutions to that, one is that the universe perhaps is expanding and contracting and we are just in one cycle, so it's always been here and we don't have to have a beginning and there is nothing unique about this time.
Now that has difficulties, on the other hand, that's a kind of model that some people favor. One of the several difficulties is that there is not enough mass that we can see to allow to bring the universe back together again, if the gravitational attraction was slowed down and make it come back together again. On the other hand we do see most (?) only a factor of four or five maybe, we can detect a presence of enough mass to at least stop the universe from expanding. These new observations indicate that maybe there is still a little bit more dark matter that nobody has ever seen, perhaps of quite a different character of any that we presently know. Nevertheless they are not accurate enough to say yes there really is enough mass, and that's the way we go.

So lacking that, I think we'd have to say at the moment we don't know. The universe may continue to expand and just cool off and maybe there was a time it was unique. On the other hand we also have the alternative of making into many universes created and initiated in the same ways ours was and to have those characteristics, the one which happened to have the right characteristics which exist is of course the one we see. Again, the situation with respect to uniqueness is saved, and we can understand then in that case, we are simply an accident of a particular formation of a particular universe. Again, that's speculative, that's a way of saving the situation from our being quite so unique.

Now life itself, its uniqueness is another open question. I say it's open I think I'll emphasize that a little bit more than most scientists would. Life began rather early on the earth, the earth is about four and a half billion years old. The sun was perhaps five billions old and the earth in its present form is nearly almost that ole (?) our only sun. and life began perhaps as early as four billion years ago, relatively soon, and it has adapted fantastically to various characteristics of the earth, we know forms of life that live in very low temperatures and high temperatures, and high oxygen content and low oxygen content and using sulfur and using different kinds of chemicals. It seems clear that the early life did not use oxygen for its primary source of oxidation energy, but rather a reducing atmosphere for some time and we know now forms of life that can still live that way, which were perhaps very old. In fact life interacted very strongly with the nature of the earth itself, and here is something I didn't put in the text, that I think perhaps I should have, to mention at least the gaiam theory of the earth as an organism. This was proposed initially by Lovelock and Gaia is of course the goddess of the earth and he regarded it as an individual organism and everything is interacting on the earth and life itself is forming the earth as well as the physical nature of the earth forming life.
There is a great deal of truth in that excepting that I myself wouldn't regard it as an organism, I would say it was a relatively closed interacting system getting energy from the sun, and then the different parts of the earth modify each other. For example, one can note that about two billion years ago, most of the iron that we are now mining, and most of the iron deposits that we know were laid down about two billion years ago. It is believed that's because of life that the atmosphere became oxidizing at that point; the growth of life produced a lot of oxygen and that then oxidizing iron and depositing the iron. There were major changes in the earth's atmosphere, changes in the earth's temperature, and the whole thing was adjusting itself in a kind of developmental picture of the ecology and the temperature were adjusted probably by life itself to the forms of life which adjust the temperature to the types of temperature in which they could exist. So clearly it has been an interactive system and after this long time of about four billion years, a relatively slow

development although it was fantastically varied, and then larger animals came in. Somewhat large animals began about the time the atmosphere began to be heavily oxygenated, and some of the thought is well, that was the point where enough energy could be obtained by using the oxygen that large animals could get around, although many of these things are still quite speculative. Of course the age of mammals is relatively necks, coming about after dinosaurs died off, and man itself is only a couple of million years old.

One of the points that I emphasize throughout is our newness, the newness of our type of civilization and the increasingly rapid development that we are going through. A lot of this is because of human knowledge. Some of it one could attribute to the nature of biology, but a lot of it is because of knowledge which we scientists would like by science, so knowledge in general.

Now let me get back to the question of the origin of life. It is very enticing to speculate about the possibility of life on other planets, the possibility of life on other stars. Many people are thoroughly convinced that there was life on Mars and life on some of the planets around so some begin to wonder why we should be so special. Well the space program has told us enough about the other planets that we know that none of them really would support life of the type that we know and there is no (?), such as no life, at least only very primitive life on any of them now. Probably not, there might possibly be some life on Mars and maybe we'll find some remnants, but those other planets are just not suitable. It takes a fairly special kind of situation to produce and support life in spite of the fantastic adaptability which life has.
What about on earth, and what about the probability of life on some other planets, maybe on other stars ? and again that's an intriguing possibility, terribly interesting, fantastic if we can find it, we are looking for it, trying to listen for signals, so far we haven't obtained anything, but then there is a very open discussion, well what is the probability. I think the probability is small, we don't have much evidence, but I think there are three pieces of evidence. The one, which is perhaps to me, the clearest, is that life can be created, we exist, so life can be created, and hence , why not again ? The second piece of evidence which I think is also fairly a good piece of evidence is that probably life began on earth only once. We know that from the signature of its molecules, molecules we call left-handed, and you see the right hand is just as valid as the left hand, so far as we can see, the right hand should work just as well as the left hand, so right-handed molecules should work also (?) life.
You know life is related in the sense that we are all made from these left-handed molecules there are no right-handed types around that have been found. Of course possibly a right-handed type was formed, it just died out, that's possible, but after all there are many niches for life to exist even now on earth. This is a wonderfully favorable place, all the garbage we have around, warm temperatures, and so on niches where different types can exist, they feed on each other of course, but they nevertheless continue to exist. So I think there is some evidence that life should start more than a few times, otherwise there would be (?) species here.

It's not easy, it probably took very unusual conditions, some conditions which are not at all like they are now, but rather this reducing atmosphere and probably involved a kind of chemistry that is not so clear to us now. We of course know the chemistry of the body reasonably well, we can see how the molecules do their functions, but exactly how it started is a question, and while we see that life is enormously adaptable and hence, why shouldn't it be almost everywhere ?
What we don't know is its origin, that's the basic thing we don't know the mechanism, so we can't calculate the probability. There is no way we can estimate a probability when we don't know what processes were involved. We can guess at some of them.
We know furthermore, there are many molecules including ethyl alcohol, for example, there is an abundance out there if you want to go out. But lots of reactive things like hydrogen cyanide, formaldehyde, alcohols and ethers, there is everything out there.
I think most astronomers are now convinced, we've got about a hundred molecules in all identified. I guess two thirds of them are organic.
So here is all this material ready to form life and when it condensed and came to the earth, a very rich soup, and lots of possibilities there, but exactly what worked is what we don't know, and hence we can't calculate the probability and my guess is that life is fairly rare.

One other piece of evidence that people like to quote came from Fairmy actually, she said "Well, if there is all that life out there, then why haven't they stopped in to see us?" So, they must not be out there, and that's based on something a little more profound, that after all if you look at our rate of progress, the rate of progress of our science and our technology, we've gone to the moon recently and we really could only dream of that a hundred years ago. Now we can really do it, and given another million years why shouldn't we be traveling to the stars in spaceships and so on, and exploring the rest of the universe.

That's part of the nature of humanity that we would like to explore and expand and there seems to be no special reason we shouldn't do that, including occupying and inhabiting other planets and so on.

So any reasonable civilization that was at all like us with the kind of curiosity that we have might well have been exploring and stopped in to see us if it were common.

That doesn't mean that it is uncommon in absolute terms because even though the probability is small, there are so many stars, so many planets in this universe, there are something like a billion galaxies and each galaxy has something life a billion or ten billion stars in it, so the numbers are very high, the probability is small, how you multiply those together and say how many cases of life there are is any person's guess.

Now here we are having been nurtured by this planet and the sun for some billions of years has been nurturing the earth, has another five billion years probably in its lifetime. It will be a long time more, we can expect further development, of course there will be natural catastrophes, some catastrophes we'll make ourselves. My own claim is that, yes natural catastrophes, along with the ones we do ourselves, certainly can set us back enormously and put us in a much more primitive state that we are now but our knowledge is such and human nature is such that probably we will overcome that in some relatively short time, like a hundred years we could build back to where we are and continue, and those may not happen at all.

In any case, over the long run we have to expect that we will continue to expand, continue to learn new things and are powerless in terms of manipulating the surroundings and using our surroundings will increase.

There are a number of uncertainties, of course one of them is the uncertainty principle of quantum mechanisms. We can't predict everything. We can say probabilities and microscopic things, we can predict with a good deal of surety but not always, some quantum (?) al events can have very profound effects on microscopic phenomena.

Furthermore, we have complications in our microscopic world which produces uncertainties which generally they call chaos. Chaos I think can be best understood in terms of the weather. The weather is a very complex phenomena depending on a lot of details some of which, the smallest (?) here or the flap of a butterfly's wing, people like to say, in China, can build up through interactions to become eventually a source of a major storm in a different part of the world, and our predicting that kind of event, and exactly what's going to happen becomes almost impossible, not in principle impossible to get closer and closer to it, but predicting the weather further than a few weeks ahead is exceedingly difficult.

We have the best of computers now, and how far we can go in the long-run is quite uncertain, and certainly as one goes a longer and longer time, very major events can happen as a result of very minor things and it becomes too complex for us.

So chaos, or complexity is one of the problems we face, as well as the basic uncertainty principle. Now I think complexity is one of the issues for science and for our thinking here which is going to be in the long run quite important. It has to do in part with the nature of biology and that's already been brought up.

It's even more important perhaps when we come to the human mind and our consciousness. As I note here, in the brain itself, we have about 10^{14} synapses, ten to the 14^{th} power synapses, and that's about a bigger memory than anything we have at the moment, but furthermore those synapses are all interacting together. The complexities are such that we can't handle them at the moment.
We can of course look at individual processes and we can understand some kinds of more complex processes and maybe get into something we can call artificial intelligence, but I think we are still uncertain how far we can go in a relatively complete understanding of the workings of the human mind. In fact I would raise the question whether it is conceptually possible or whether it is in fact possible for any system to understand itself.
I am not sure that there are any simple systems which can understand themselves, maybe there are, but it seems to me that's a problem that's not easily answered. How thoroughly can a system understand itself, especially a very complex one, or do we need still more data points and still a bigger brain to understand our own brain?

Of course another basic problem which humans face, and connected with that is the question of freedom of will.
I note, I think almost every scientist, perhaps unconsciously, feels that he is acting freely, he can make choices in the fields in which he has freedom of will.
We sort of all assume that and this is the way we work. On the other hand we can't justify it, as Steve has said, well I think we understand the laws of physics and chemistry enough to say well these are the principles involved and simply no room for a freedom of the will, unless we construct it in such a way that it's really just the same thing.
Say well we are an organism formed of molecules, and that creates our world, and our world acts like molecules act, but of course it doesn't give us freedom of will in the kind of sense which we generally assume.
This freedom of will I think is one of those problems connected with complexity.
On the other hand I believe we will make a lot of progress in complexity particularly because of the computer sciences and all the capacities that they give, the kind of emphasis that they are giving our science and the kind of work in which people are doing now will lead us probably pretty far along that route and it will be fascinating to see just how far we get.

Now perhaps the most striking element of all in this whole story is the increasing speed of change, particularly brought about by human knowledge. We frequently think of science in terms of that rapid increase and science is increasing somewhat exponentially, roughly exponentially, and science grows on itself. I tend to see a kind of exponential law and if we look back over our lifetime, we can understand the enormous changes that have about. A hundred years ago things were still very, very different and most of modern science is not older than a couple hundred years, although one can trace some of its beginnings back a long time. Nevertheless the rate of growth from the last hundred years, the rate of growth the last fifty years has been enormous. It is sometimes said that more scientists are alive today than ever lived in all time before. To what extent that continued increasing rate will stay with us is hard to predict, on the other hand I think the increase in our understanding, I don't doubt that at all. Whether it will continue to growth exponentially is really as important as it is increasingly very rapidly and our powers over the universe around us are increasing. Our powers over ourselves are increasing very rapidly.

In a sense we of course always depend upon our universe and are nurtured by the planet earth, by the sun, we are bounded by physical laws. We can't get outside of the laws of nature and disobey them. Nevertheless we can mold nature to our own use and to our own ideas to a remarkable extent, and that is what is producing these faster and faster changes on earth. I'll try to emphasize in a moment, it also faces us with the picture of changing ourselves, not only are we going to change the things around us, the human races going to be changing itself. In a sense we have already been changing ourselves. Medical practice, for example, has saved the lives of people with various kinds of diseases. Other defects allow them to reproduce, increase the genetic content of that particular strain, and we've changed the inheritance of the human race over what it would otherwise be if we

didn't have those medical practices.
We've also changed the population of certain groups of people enormously, particularly in the tropics here tropical medicine has been an enormous help in saving lives, and so populations have changed a great deal. We've already affected ourselves a great deal. On the other hand, it's pale by comparison to what can be done with genetic manipulation, and here I think the human genome project has kind of alerted everybody, not because it is anything unexpected or new, but it is has just forced us to look at the problem and think about the future a little more cogently. The human genome study is really just a part of the whole process of our understanding of genetics, and genetic engineering, the possibility of changing genetic characteristics, and the possibilities of changing human themselves. Now one has to be careful that we can't say well let's just make a perfect human, now we know how to do this because it is very difficult and complex.
On the other hand, I think we have to expect that we will know how to make very major changes, that we can make those changes, that we will probably be tempted to make some changes, and some of them can be enormously good in getting rid of certain inheritable diseases, possibly also making us more immune to some of our environmental hazards. One can imagine, of course, even developing specialized humans like, let's say somebody with enough money and interest in sports might see that his children are athletic and have all the right genes and characteristics, and this could go on to developing a special class of people, especially athletic, or a special class of people who are especially good at computers, and so on. And we could develop (?) principles. One could wonder who makes the choices about these genetic changes. And what are the ethical issues involved, should society have control, to what extent would the control simply by the people who have money to afford these things and they can see that their own children have the genetic inheritance which they wish, so those are some of the problems which are approaching us.

I think the primary note that I would make is that we now not only can influence the things around us in a very major way, we can influence ourselves, we can change ourselves. So whether we like it or not, we are embarrassingly in control, we are increasingly in control, and we are going to be more and more in control and the question is well how ready are we? and like it or not, that's where we are and that's going to increase, and we are going to have to make choices, we will be making choices.

I think in the end an individual might feel more or less powerless. Probably many individuals feel powerless, as an individual what can they do to civilization or the world and so on?
On the other hand the human race as a whole is certainly not, it is affecting our planet in a major way, already, of course, it is going to affect itself in a very major way and we already have (?) medical practices, but I think the new (?) are going to be still more tolerable.

So it is that rate of change, that increasing power that liked it or not responsibilities which we have, it seems to me that science has particularly forced on us and it is the nature of science to continue to grow, it builds on itself, as opposed, unfortunately as so many of our other fields that change plus or minus maybe. Science always is increasing. I think one can find limitations, one can find dangers in the human race, can find things that may happen to us.
Nevertheless, I think that process is inevitable and that's what we have to face, that we can modify our universe, we can modify ourselves and which way are we going to go. Well of course that depends really on our goals.
I think the basic biological drive of simply reproducing ourselves, increasing population, we are past the stage where that is a needed biological goal, in fact it is an embarrassment now, overpopulation.
What really are our goals, then?
I have already assumed that some of our goals are going to be like those we've known in the past, mainly curiosity. Curiosity, and learning, and interest, and finding out things. One might argue that people may lose interest. My thesis is that the development of science, while it is a cooperative venture to a large extent can be done by relatively few people.
The breakthroughs in science are often made by one or two individuals, other people pick them up

of course, but a relatively small fraction of the total human population is making these changes.
So that I doubt that progress of science will change regardless of what the average goal of the human population is, but how we direct those as a group is the big question.
In addition, whatever our goals are, their success is going to depend a lot of collaboration, and in a way we've been very successful in finding goals on which we can all agree and collaborating on them.
What kind of instincts are going to be dominate and what sense of values we have I guess we can all guess at, and we've been guessing at some of them already, the things that make you feel good, the things that enrich you in society, and all those kind of things, but then we also have a certain pension for seeking power.
We want to do something important, or it may be just power of the people. We also have a certain pension for physical satisfaction like eating and sex and drugs and maybe ultimately just getting the right electric stimuli to the right places in our brain so we can just sit around and be happy.

But I suppose perhaps the biggest, maybe the biggest question or certainly one of the questions, is to what extent can we unify and produce goals which are meaningful and good and work together, or will the sort of medley of values which we have in the human race, a medley of values, a medley of attitudes, a medley of goals, or just produce clashes and a variety of purposes and a variety of outcomes which are maybe not very definitive, but perhaps will produce some extremes of behavior and extremes of development and results.
In any case we have learned a great deal. The universe is steadily yielding its secrets; it is really inspiring to see how much we know.
It is also inspiring to see what we don't know, but there are many very basic things we don't understand, but many of them should yield in time to science.

How far science can go is another question one can ask? Will there be an end to our knowledge? Will we really finally find out everything?
I hope there will never be an end because it is so much fun, inspiring and interesting. But my guess that will likely to be the case, that there will never be an end, that we'll continue to be more and more adept at controlling those things around us and controlling energy, controlling materials and doing those things which we decide we want to do.
But what is not so clear about our future is our values and what we really want and our ability to act together in a coherent way. Though I tried to be more informally and summarize some of the points here.