Natural Science and
Philosophy Gene Marshall

Physics
Biol-
Math

Heavy
on
Physics

Please allow me to introduce this course with reference to a little personal history;
I tell this to you because I think it's a clue to the times we're in. This is the reason why this area of study is important to you and to everyman who makes up the congregation of mankind. In high school after faifling at basketball I turned to mathematics and physics. And really my first love affair with life carried me to the wild psychotic limits of reason itself and ripened me for assault of the theological recovery which began to impinge upon me in the last years of college issuing in the utterly incredible decision from all radical points of view of going to seminary. And then I was struggling with what inthe Hell does it mean to be Gene Marshall. That was the only issue that was then essential - mathematics and physics were dropped somewhere out in the universe. Or selfhood was the second serious love affair with life. And through Kierkegaard, Bultman etc. this was the struggle of struggles so to speak. Midway in my tour of duty in the army as a Chaplain, I began to be awakened to a third love: that is the problem of social justice. American foreign policy suddenly came to me as a great huge, overwhelming reality and problem. The race question suddenly came to me as a huge, overwhelming problem. So it seems to me that for about 13 years there, my first love, mathematics and physics, though never wholly answered I suppose, was shot clear in the backwash. And selfhood and society, occupied my being- they were the preoccupation of my mental energy. Now, some of the naivitay has been hammered out of my skull, a new passion for mathematics and physics has emerged with a brand new kind of relevance. Its as if my very concern for self and for social justice drive me back to a reconsideration in a whole new way of the natural sciences. Other people who are having a similar experience make me believe that this is not just a personal quirk, but rather that the total situation is pushing all of us to look in a new way at the human meaning of the natural sciences. And that will be the subject of the lecture this morning. The human meaning of the natural sciences. This is not a lecture on physics, biology, or mathematics: it is a lecture on the human meanin g of physics, biology, and mathematics. Now, of course, this lecture is on physics

biology, and mathematics, and intends to be true to these disciplines, falsifying them in no way. But this lecture will not compensate for your having a void in sciencé in college. It will not make mathematics easier; or suddenly clarify all the enigmas of the physical and biological universe. If you are an accomplished person ~~and/or~~ in one of these areas, don't leave bacause you assume that this is going to be unavoidably elementary; for I discovered that being an accomplished physicist, biologist, or mathematician does not make you clear about the human meaning of physics, biology, and mathematics. Last Sunday morning we talked about human meaning of psychology, and before that, the human meaning of sociology We have looked at the human meaning of history, and the human meaning of art, and tomorrow, we will look at the human meaning of philosophy. The last three days, in the morning, of these last three weeks, have dealt with the practice area- this week we're going to deal with the family in three sessions. Last week, we dealt with the city, that inter-mediary reality between the family and the globe. The globe was the first week struggle in the classical area. Now human understanding or gestalt of the indellectual disciplines of our time is a necessary undergirding for competant, practical model building. It's necessary, I think, to divide between the theoretical widom of our time and the practical model building issues of our time. Yet, these two are intimately related and one cannot work without the other. In terms of practical model building, you need grasp of the over all theoretical wisdom of our culture. And few of us if any, got a liberating education in college. That is an education which allowed us to use practically the vast wisdom of our time. No one can be an expert in everything. But the revolutionary, must know how to use all the experts. And we do not turn our lives over to the experts through this. Most experts don't know how to use themselves, morally. It is the job of the revolutionary churchman to know how to use all of the experts morally. All the experts and all the intellectual disciplines are related in this way. And if this is not the way it is, then you had better come up with it if you're going to be a moral revolutionary. Let me work through this diagram. If you take all human knowledge, all theorhetical knoving, all objective grappling struggles, to get hold of reality - (the sciences are dealing with the objective construct of just raw bearing) The humanities are dealing with something like the personal images of your

reality relationships. The humanities, in that sense, feed off the work of the raw objective struggle the sciences are dealing with, and give the depth relationship that goes on. It's also an objective task to talk about the way man really is relating and struggling with the relationship to reality in any particular time in history. Theology grapples with the universal symbols of the spirit deed, the universal symbols that grab hold of what it means to be a man in every time. Yet, of course, monks do their work in relationship to the times in which they live in order to say something. Now if we put out here these dynamics of God, Christ, and the Holy Spirit, we have rather well set our structure here. In science - put natural science up at the top, social science over here, and ~~psychological~~ Biological science down here. Over on this side - put philosophy at the top and art at the right. What this is saying about the natural sciences and their inter-relationship is something like this. That the raw science is in one sense social science; that the humanity of science is psychology and that the theology of the science is natural science. Or - this is the scary one, this is the mysterious one, this is the one that goes into the far reaches of mystery itself. And the relationships also go this way; natural science and philosophy relate to the fundamental question of the awe and mystery of being itself. Sociology and history relate to the communal dimension in which this final word is articulated. And the holy spirit deals with the art and psychology or the struggle out into the very loose and the deep of the human spirit and it's manifestation back through all of the others structures. To look at just the lower part of the diagram sociology and history we have put together as dealing with the communal strutures of man; psychology and art, the personal and natural science and philosophy now deal with over the all. Psychology is fun, I think, because it polls your personal life and shocks you with your most personal - ---- . And art is fun too, because it tickles your personal life and turns you on with new intimate awarness. It may not be fun if you're running away from certain things that it painfully shows you, but generally it's fun. Sociology analyzes the social structures and how they change and is far less fun. History is a little more fun. It enables you to locate your own personal existence in the universal sweep of things.

Philosophy however, is a numbing thing, like a calculus course, or like what I'm doing now. I have to work hard to make it fun, unless of course, you are an intellectual bug who ##### tingles at arid clarifications of the progresses of reason and ontological structures of human existence. Philosophy is generally kind of a whooey subject. And natural science is even more arid and eeiry than philosophy. Basic rational order withing which all of our psychological and social takes place. Oh, that basic rational structure up against which the philosophical system building tumbles and re-constructs itself. Natural science is the comprehensive. It is comprehensivly covered in these three dimensions which I'll put up here. Mathgoes at the top, physics, and biology. Now if you thing something is left out there like chemistry, geology, statistics, computer science and ## astronomy, all that is in there, it's part of the proliferation of the sciences and they all happen to think they needed a separate department on the university campuses. But chemistry is either physical chemistry or else it is biological chemistry. Geology is either physics, or else it's a tool of the social sciences. And astronomy, that's physics and so on and so on. The reason that we've had so much trouble here is that no one (has?) ##has?come up with the kind of model that gives ontological grounding to all of these. Let me read to you a little bit from Kazabtzakis. "WE come from a dark abyss (P. 43) ..... and with this vision to modulate our thinking and our aciton." Now this striving toward death, toward matter is the symbol for the physics. The cooling off of the stars in great cosmic drama where even the possibilities of building complex atoms for supporting life finally comes to an end. And then the struggle toward life, the struggle for organization we'll point to as a kin d of reality that biology is struggling with. Theclimb in the complex atom, the climb in the complex molecule, the birth of the living organism. The birth of the self-conscious living organism - the birth into global humanity. Brash consciousness will engulf the very stars and keep them burning. I'm sure it would if it could. Biology is the objectivy analogy of this fantastic force. The rational construct that holds these forces present to our understanding the fundamental/ rational construct in obedience to which all the other constructs in civilization must come to terms. The whole of knowledge is built out of and on top of the fundamental way in which man images these utter fundamental natural forces. Now what is mathematics? Let me give a quick ontological grounding

again. I'll read another very brief passage form Kasantzakis. " I am the worker of the abyss. .....(p. 48)Within these limitatious the mind is the legal and absolute monarch." Mathematics is the invention of order itself. Mathematical invention is the invention of reason itself. Mathematics is reason itself. Abstracted from all concrete reference./ Again. Mathematics is the setting of rational relations themselves: Mathematical invention is the invention of order. Mathematical invention is the invention of reason itself. Mathematics is reason itself, abstracted from all concrete content. Mathematics is a natural science related to these other two as forming a fundamental rational construct or fabric out of which all other thinking goes on. I find this picture a very helpful one. Here is the over the all dealing with life and within that sociology and personal struggle goes on. It's always presupposed: it's always out there. So let us adventure into natural sciences. Wipe all victim? images away, relax the rigorous hold that taken for granted stereotypes have on our fogged imagination and gird up your wits for a journey into the fantastic. Perhaps I had better give you an outline of the lecture. I've just finished the introduction. That was on, what is natural science? Now the first point is an overview of intellectual history. And then, we're going to deal with physics biology and math. And here, relatively briefly, just trying to whow forth a structure of what each of these disciplines are, where some of the edges are in our time - where the struggle against where the sheer mystery is in physics, biology and math., and of course for the human meaning of that, of those images that are being struggled with. I'll try to give us an overall picture of the ways these are functioning in our own lives and their crudial importance for us. And then the conclusion will be how the natural sciences relate to the spirit dimension. Now an overview of intellectual history - I want to go way way back. This is a map of time. Here is zero and here is the year of 4000 B.C. And on this end is 4000 A.D. And we're somewhere in this spectacular interval right here. About the time when this whole intellectual context just collapsed into the ground and in the midst of the time when this whole intellectual way of looking at reality is just getting out ahead of this other one. As you go clear back here, you begin to see the kind of inventions that took place there that enabled this whole thing to come into being. ONe is shocked almost at the way in which this has come into being. Itt was a group of people called the temple priests.

that got this started. Theywere religious men but relgiious in a strange sense. They were mathematicians and they invented all kinds of things. They invented the king, they invented the city, they invented social classes, and so on and so on. But even before they invented all those things, the structure of the universe itself which enabled this invention and this invention and this invention to be invented. They were greatly concerned with numbers. The number 10 was a very hand to hand mechanical number. But there were other numbers much more holy, much more divine. The number 360 was an especially holy number because that's how many days there were in a year. And we use 360 degrees in a circle to this very day because of that error back there. And the number 4 was a very magic number. You think that it's an accident that we have four directions? North, East, South, and West got invented back here. And maybe to show the picture of that invention, you have to see a great pyramid which has four sides. And those four sides of that pyramid detirmined the directions of the universe. East, north, south and west. But not only did they get that set, but they also set what was up and what was down. Up was divine - up was the star - up was where the cosmic fears operated- up was where the divine numbers of seven, like seven heavenly bodies operated. Up was where the structure of things was that they then finally called the order of heaven. Down at the base here was the base. That was the nitty gritty. That was the bottom. The whole social pyramid was also constructed out of this. The king sat on the top, and the peons stood down here at the bottom. The king mediated the divine order of society and these people participated in it as their only hope of living in an overall type of structure. They had grasped in other words a whole vision that enabled them to organize society in a whole new way. We might call that new vision, in retrospect, something like eternal realism. The idea was every time is not entitled to it's private system of looking at things. No! There is an order in heaven to which everyone must bow. Now, on the other side of this radical revolution, you have to write another word. I'll call it relative realism. This is not a re-occurance of the anarchy of private tribal opinion but a depth understanding to the bottom of reason itself. Society must now march forward in terms of a gigantic social consensus. The best model of the overall is the most adequate to predict the future because of the big construct, in terms of which you worked.

science back here in the 16th century began in this context. They worked in this overall view that there was an eternal order of heaven to which all men must bow. And all the critical idealism tried to hold in one system of understanding this struggle with science abd the old, old, philosopphy which goes way way back, back, but science in the 20th century broke through the frame , and demanded the whole intellectual community to recontruct the whole frame of things. Scientific thought in our day is understood as a threat still for the rational grasp for the hard objective reality. But the hard, objective truth of our time is that objective reality is beyond our grasp. That objective reality is beyond our -- well there is none. The raw objective thereness is not rational order, it's sheer mystery. But rational order, though a human creation, is our only hope to get at working with things in a context without disintegrating into chaos. And the mystery of existence we now know is most adequately experienced by those who push out to the rational end of the struggle of society where the limits of raw mystery are known to be subjectivity. And the awe breaks through to the very center of the highest most incredible creation of the human mind. Now, this kind of an overwhelming shift in our basic intellectual way of coming at things, I think is a context to work at what we're going to talk about in physics, biology, and mathematics. One more thing, before I go on. If you had to choose two periods in history which were such radical turning points, you'd choose the one that we're in, the present which begins back with the 17th century and moves up to our time giving, of cours, special emphasis to this last phase in which you and I live. If you had to go back earlier, you'd pick out the period of 750 to 500 B.C. In this strange, wierd period things took place all over the planet; that is the Hebraic prophets lived in this period. Greek philosophy got it's edge in this period. Buddha lived in this period. Confucious lived in this period. Taoism got it's start in this period. Zoroaster lived in this period and gave a whole new thrust to the Persian culture. And in a sense the whole social structure had begun to crumble loose in deep crevices and enabled a brand new probe into the bottom of individual olfe to take place. And ever-since then, we have with the overall ~~intellectual~~ intellectual grasp with which we've been struggling, we've been struggline more with the individual. Back here the fundamental turning point of civilization was getting brand new social vehicles in being, that could get beyond the structures of the past. And now, clear on down to our time, the

bottom of the individual struggle- We haved finally shoved the individual dimension clear on down to the bottom and in our time we call that the secular revolution. And we also see that we are in the midst of a brand new birth of an entire new social vehicle unprecidented in all of history- and we call that the urban revolution, by which we mean the very vast and overwhelming thing. But equally overwhelming, in the whole force of human history is what we've called the scientific relovution. And if you want to say - Newton was the first scientific revolution, and Einstein was the second scientific revolution - there's great wisdom in doing it that way. What I want to say is that One great intellectual revolution that pushes out man into a whole new way of living down on out as far as we can see into the future. In intellectual history, the invention of Einstein's order is prior to seeing it in nature. That's crucial. Intellectual revolutions begin in mathematics and then move on to physics and then they move on to biology. Let me illustrate back here. These fantastic new mathematical ideas that enabled them to put forth the concept of the order of heaven, enable to come into being these kind of structures. And probably one of the great happenings in the history of mankind took place again in this period in which plane geometrycame into being in which triangles and circles and squares and so so forth. What this did to the whole human history is just astonishing. Domes were possible, cathedrals with all the towers were possible, Christian theology was possible. Science and physics dealt with trigonometry and this was basically these eternal forms as they called them of Euclidian geometry forged fundmental axioms out of which mentality operated clear on down at least until 900. And here from new sciences mathematical inventions took place. One of the things that was invented was the concept zero. That concept did not exist before then although that seems incredible. And also the concept infinity got itself born here. At the same time was born abstract notation which is really what these are examples of. Abstraction of notation that moved the abstract of mathematics out of the raw concrete number into abstract number. It enabled algebra to come into being. Monolithic (?) philosophy and all this kind of intellectual endeavor would never have been possible had not these kind of abstract mathematical inventions taken place. Now just before the scientific era got going another great deed of mathematical invention took place in maybe 1300 or something like that. They began to occupy themselves with quite un-Aristotlian ideas -

like periodic movement, and periodic motion. And these made it possible for to talk that way - something rotating through zero and back through zero forever. That was a fantastic new concept that came into being: It enabled Capernicus to build a new structure of the universe, Galileo to see pendulums- pendulums had never been seen before in human history. It enabled the clock to be invented. Beofre that time, all you had was sand dropping grain by grain - substance by substance through a little narrow opening. Suddenly there was a whole new way of grasping time of measuring time came into being. And a little later, all the breakthroughs of the scientific revolution - these ideas were carried on into inventions like the calculus, inventions that had to do with continuous variables. Without concepts like abstract notation, periodic motion and the pendulum there would have been no modern world. These ideas enabled the physics of the mechanical maching that went round and round and round and on and on and on operating by these kinds of ideas. It enabled the huge oedipus to come into being . Now in the 18th century around 1800, the late part of the 18th century another incredible occurance took place in mathematics. We call it now non-euclidian geometry. You have to get the shock of that to go way on back to here and call into question fundamental axioms that have to do with the eternal forms of the universe - it's a shocking notion. That you do not have to construct your algebra that way that there are a couple of other ways to construct it. Only consistant algebra: and which one fits reality best nobody knows. This was not the only mathematical invention that took place here. It called into question the whole oedipus of continuous ----- by raising the question of how many numbers there are on a continuous line. The meaning of the whole of mathematics came into chaos several times. And mathematical reconstruters are still working at the fundamental concept that number series call into question. They're trying to reconstruct what on earth mathematic is and what on earth order is. Now without this radical mathématical invention you wouldn't have had physics. Einstein could never put together theories of relativity without non-euclid
ian geometry which enabled him to do that. And the use that quatum mechanics has made of
quantum
number theroy and all is equally phenomenal. Following the work that takes place in physics you move into biology. Let me illustrate that in just two cases. Back here biology was the hyphen-nesses of things. But after the Smithsonian machine hit the imagination of man, then there had to be a Darwin to come along. To create the concept of evolution or a continuous

continuum hypothesis that held meaning together in the evolutionary process. And in a way the post-Einsteinian physics , a new conceptuality in biology is also born. Lets take a look at the structure of physics and where the edges are breaking inupon us and the importance of these images to four lives. Aristotle said physics was something like this. It had to do with form and of course these were pretty well eternal forms or relatively so, substance, and mechanics. Or interaction. Interaction of stubstances of which there were four and the forms that held rationality into the substance structure and into the mechanical structure. Just this form moved into the 20th century. You might compare it this way. Here the mechanics is the construct of the macrocosm and over here the construct of the microcosm Now what I mean by macro and micro cosm is in a sense, man sort of standing in the middle of the order of things and he looks down into the deeps of things and it gets more minute and minute. And as man has struggled with what substance is in the 20th century- atoms and atoms electrons, and protons - I mean it get frightfully minute. It's been an incredible revolution in that direction. And in ~~[illegible]~~ images or in rational structures of the microcosm, it is being pushed in the same manner. In a big picture, in the way the stars functions in relationship to one another, the way automobiles function in relationship to one another, etc. etc. thereis where the revolution in Einsteinian physics primarily relates. Now of course these two are deeply inter-related and consistently move back and forth between each one. But mankind has never existed without a construct of the naturalcosmos - the big order of things- and move down to man's size and tell us how things work. How they function in relationship to one another. And what are things finally composed of, how does that work. Physics has to construct concepts in both of these areas. And what's this third area of construction that the 20th century _____ It's the construct of order in the universe. The fundamental order and here is where the great debates of physics goes on. What physical concepts are adequate? The classical physics and the concepts and the meaning of those concepts were radically called into question. To get a feel after this, let's look at it in three stages. We'll let Aristotle be our symbol of the ancient- he was a great systematizer who pulled together all of the wides of the ancient ages. Newton was a part of the new invention of experimental science and Einstein's relativity formed the end product of that process. Now, here we look at Aristotle's way of looking at these three dimensions of life these form up

here or the concepts of order, there was a static, linear, geometrical order in the universe. It was just there. And we look down into the construct of the macrocosm- everything sought it's goal, it's end was the fundamental motif things fell because things sought their rest. And here in substance, there wasn't any empty space, there was just substance - air substance and water substance and so on. Now as you move into the Newtonian physics and it's consequenc again you have a sort of a static concept of order - maintaining that's there's some static order in the universe to be found somewhere but great changes were coming into it, the infinit variables, the periodic motion and all give a whole new feel to the nature of that order. And the machine is the fundamental concept that grabs hold , everything is like a great body, everything works like law and order. And here you move down into the particle, the particle the particle. The little particles that relate to done another and so on. Maybe this image holds it for you. Everything has a rotating center and then things rotate around it You think it was just a natural discovery that they found an electron rotating around the atom. The truth is that nobody ever saw an electron rotate around an atom. This is the model they came with. They discovered it looking at the planet. And they used it. In other words, to interpret what was going on, they thought, down here in the deeps of the structure of the atom. No longer is this really very adequate or very helpful in the post-Einsteinian physics. I'll characterize this way, There's something dynamic about the whole order now and dynamic about the whole of existence. The stars are dynamic entities, the whole reality of the universe is a dynamic entity that exploded back here somewhere, came into being, and burns out, in the end of things, in an expanding dispersion out into sheer darkness and abyss. That's a whole new concept of things. And here, with the theory of relativilty, and the fundamentttal concept C or the speed of light. And here the quantum theory has determined our work and another incredible concept of h. Now we look at those very briefly in order to see the awe and the incredible being is broken loose. Newtonian physics was bukit to deal with marbles, and pool balls and automobiles and things. And electromagnetic phenomena like light and electricity, X rays and so forth gave newtonian physics headaches from the beginning. But they kept everything pretty well in the system until the 20th century and then all the structures broke loose. One of the first/////// happening that was so clear so that you couldn't avoid it any more was some experiments

with the nature of light- the speed of light. Everybody had discovered that light travels very fast. I mean it really moves out, 186,000 miles a second and that is moving. But it was not an infinite velocity, and it had limits on velicity. So they began to do some experiments that would give them great clues into the structure of the whole order of the universe. If light is travels at a finite speed, then light rays must travel through a medium, you know kind of like you drop a pebble in the water and the waves spread out and the water moving down stream causes the waves to move down stream. So they said let's see how fast the earth is moving through the universe. Because obviously there is a stable structure to the universe through which the stable earth is stably moving. And so let us see what that stable structure is by measuring the speed of light and all the rest of it. And that will tell us about what they call the ether wind. That is the ether was that physical conceptual substance that light vibrated through at a fantastic rate of speed. And so if the earth is moving through the ether like this then the speed will be different measured that way than if you measure it this way. The chagrin of the whole experiment was that the speed of light was the same no matter how it was measured. They did that over, and over, and over and finally just quit. They looked at the whole structure of physics and said that this can't be. Either the earth is the stationary thing in the universe or else something is radically awry in our whole way of looking at things. Einstein took the latter, and proceded with these two suppositions. One, all motion is relative to some system of reference. And what he meant by that is the simple thing that you know when you're on a train. You're sitting in the train, you look out the window and see the train moving, you have to ~~~~ decide whether you're in a train moving in one direction or the other train is moving the other direction. And to decide which references you're going to work into. Usually we find the ground somewhere and work in that reference system and decide that whichever train is moving in relation to the ground is moving and whichever one is not moving in relation to the ground is not moving. We discover that they're both moving when they're both moving and they're moving in respect to the ground and they're moving in repect to one another in a different speed, and soforth. All motion is relative. That is simple enough. The thing that bugs us, the whore in the whole structure of physics is the second presupposition. The velocity of light is constant

to all sytems of reference. Now you first don't see that that's a radical idea. You look at the consequences of it for the whole of physics and you begin to see some incredible things taking place, which you'd believe weren't possible to be so unless you go out and look at them and My God, they weren't so. Here's point a. Point b is moving out from point a at .99 the velocity of light. It's really moving out. It's not going the full speed of light but almost. Now point b is being moved out some by point c at the same kind of velocity .99 the speed of light. So that the speed of light relative to a is .99c and the speed of c relative to b is .99c in the opposite direction. If you're looking at it from b it's moving out in this direction and this one is moving out that way at the same kind of speed. Now what is the speed of c from the referance point of a ? Well old Newtonian physics would just add these two numbers and you see that it's 1.98c is how fast c is moving out from a. Well, in the Einsteinian universe, that's not the way it works out. c is moving out at .999c. Or to give you one more picture, Silmutanaéáty, in the Newtonian context, if two things happen simultaneously hell, they happen simultaniously. And now you've got to ask simultaneous with respect to who? Because an event that's simultaneous with respect to c is not simultaneous with respect to b at all. There's interval time between them. An event that's simultaneous with respect to b is not simultaneous with respect to a. There may be an accident now and then where events that are simulaneous to one system are also simultaneou to another system. But the universe is not put together in theis model. Now, one more quick picture, if you went out here to Argon laboratory and watched the protons go, they go round and round in that four mile track and every time around a big electrical charge here gives these protons a boost, I mean it gives them a kick. So they go faster and faster and faster and fastver and faster each trip around. And if you were working in Newtonian concepts, the more energy you gave them, the faster they would go on a very linear kind of progression. That is a unit of energy would give you a unit more of velocity and momentum. So that you could draw a graph that looked like this- putting the velocity of the proton out that way and the energy kick you gave it up this way. It would move out that way with a kind of equation: Force = ma. It was a very regular way of looking at it. But in this Einsteinis physics, that isn't the way the model works out. The model works out this way. You come out to this place where the velocity reaches the speed of light, something happens to this

straight line. That is, it was pretty well a straight line for awhile. But out here, it slows down, it went up like this. And no matter how much energy you gave that proton, you never got beyond the speed of light with it. And if you don't believe that's so just go out there and watch the protons. That's the way it works. They can't accelerate them beyond the speed of light. They seem to get heavier and heavier and heavier every trip around. And that's what he means by a change in mass, it just takes a hell of a lot more force to get it going each trip around the track there. Now, with respect to the protons if you were riding on the proton, the changes are altogether different. He gets the same kick every time around as far as he knows and has the same increase in velocity every time around as far as he can tell. But his sense of time changes. That is his clocks work much slower with respect to the clock on the ground, of course. He would probably say that his clock stayed the same and that the clocks on the ground sped up. The effect was that his kick came more frequently according to his clock. And so on. And so nothing stays the same when you change systems. Now, you may have read some science fiction which takes/~~XIV~~ a man traveling out in space - he's two years traveling in space and when he gets back 80 years have passed on the planet earth. That's the kind of wierd reconstruction of physical concepts that the theory brought into being. One would never believe it. In fact, the experimenting with the structures of the functioning of the universe did not work that out. What this means for us is: Any objective analysis presupposes an/ observer to whom it is objective. Any objective analysis presupposes an observer to whom it is objective. And so you have to say with respect to who and with respect to where you're standing in the structure of the universe. What space, time point are you occupying when you say that? Or secondly, everything is inter-related in a dynamic concept. There is not static motion and substance through static time in a static universe but all is a dynamic network of relationships. And three, that there is a kind of a power in mass and this we've been most familiar with in the atomic bomb- that the power of mass present, it changes the whole structure of things around. And when mass lends itself it has a phenomenal potential. Our very presence changes everything around. And the expanding of ourselves releases fantastic power into the process of human evolution. What this means then in the deed, is that we have to grasp ourselves making a committment- having to be someplace, having

to occupys position, as the beginning point for all of knowledge. Centering in me is a no. of the whole universe. In quantum mechanics, the concept that broke loose here was the dimesion of radiation was a dis- continuous process. That is there are indivisible _____ of energy. And that violated the continuity concept, where you had a little more and a little more- you could only have ahlf Energy didn't come in indivisible parts: it came in packs and this constant h was figured into measuring those packs. What does this mean for our time? Many many things. One of the things that we've been very clear about in trying to think through this whole new relationship in the deeps of existance in the microcosm- is the recognitions that observation changes the object observed. Being there looking at something with a ray of light interacts with that thing withn packet of energy. And so when you get through looking at something it isn't ~~[illegible]~~ what you looked at. The light with which you looked at it has changed it. And forever after I'll have to be clear that there's no final objectivity. The only way you learn something about reality is to enter into inter-action with it. And when you get through learning, it's different than when you atrated learning. And another thing that has to be looked at that makes trouble with trying to look into the deeps of existence- we have to decide ahead of time what kind of a model to look at it with. You could look at the phenomenon of the atom with a picture of wave mechanics that is con- tinuous theory and you say what you saw. You could also look at it with a packet - particle theory idea and you saw it from another angle. And it wasn't that one of these was the real way of order, it was, my lord, they were complimentary theories with which you could look at the same reality and therefore more thoroughly expound the reality. And which way things were really ordered is no longer even an issue. Then what you've got is two ways of ordering what's going on -and what's going on down there is in one sense incomprhensible. You can use contradictory theories if you like to look and you see with them different kinds of things. This does something to our whole ideas of physics and to our ideas of objectivity. And we recognize that we have to sense a new kind of lucidity about the whole rational process and the way it operates. How the models of physics -- the Einstein model gives us a way of ordering the whole structure of things, still when you look down into the microcosm you still encounter sheer mystery. And the particle physics of our time is an illustration of how the awe of reality breaks through- even these fantastic models of Einstein. And you've been reading perhaps about quasors moving out into the vast expanse

of the way things operate-we run into another enigma. I though you'd enjoy this little poem written by an astronomer. Horrid quasar, near or far. this proves to you I must confess, my heart for you is full of hate, oh super star in floating gas , explodes crash. You're glowing speck upon a place, of Einstein's world you've made a mess."

Now let's look at biology- if you look at the structure of biology, you see in the microcosm of biology of the cell and in the macrocosm of bilogy the whole series of evolution if you like. And if you look into this dimension, maybe what you see here is self-hood and consciousness or the strange capacity of life to order itself. Now where is the mystery leaping into biology today? Where is biological fundamental conceptrunning into wild reality that reality now always seems to be. You remember that we had a large continuous line of evolution constructed by Darwin, and now we're beginning to grasp there are curious leaps Ther's a leap from un-life to life. And I mean that was a leap. At this point this is still' utterly unexplicable and then, there was another leap from life to self-conscious life. That also is utterly inexplicable. All along this whole Newtonian coninuous content there is the demand that we be able to explain the more complex things in light of the more simple things. And thus show a rational progression of how you can really make life out of unlife. You can really make self-conscious life out of life. But many attempts to render a continuum from one of these steps to another step have failed. We synthetically formed higher biological ////// molecules and we've been able to analze the biological processes of life, take them apart and put some of them back together again. But we have not been able to synthetically initiate the life process from a process that was unlife. We have not been able to do that. It may be that we shall never be able to do that. One thing we know is that the natural history of this planet in a very short interval- life came into being. Out of the complex of this planet. And it is a phenomenon that has not happened since. as far as we know and one that we have not been able reduplicate. It may well be that the jump from life to unlife may never again be reduplicated in this planets history. And those who are disappointed by that are having a favorite imperitive called into question there. Complex things dirived from simple things by ////////////..... The leap from life to conscious life is equally mysterious and probably unduplicatable also. And if these leaps could be synthetically instigated we have no idea what monsterous processes we might

BE STARTING. I mean by monstrous that they would be anti-thetical to the whole life process bacause of some different kind of a start. Our same conceptuality convinces u s that life is probably developing somewhere else in the universe because these are naturally processes therefore life is devoloping somewhere else and it probably exists many other places. I don't know if this is true or not but I would say that where you and I would be most offended is if we discovered that we were it. If we discovered that we were the only happening in the whole universe of the birth of life out of unlife. That would most offend our peradim. Of course, you know we have no support for either one. The process of evolution itself is not seen as a statistically probable theory of accident but the process of evolution of life itself is understood differently. Its as if the adult organism's experience with the environment enables the organism to decide how the new organisms are going to go. It's not that mutations come forth by pure accident, mutations come forth by decision in the adult organism. Now it's a very comples kind of decision, but it's the kind of process dispenses any kind of random possibility series. It makes the whole field of evolution something different- the life process is something like a giant organism making experiments out in this direction and if that doesn't work, backtrack, and make an experiment out in another direction and if that doesn't work make an experiment out in another direction and so that the tree of life becomes a great series of rather unconscious intentional experiments if you like in all kinds of direction. Some animals like the dinasaur have gone too far in one direction and therefore were a dead end. And other animals like the shell fish adapted to the universe so well that there was no motive for evolution so they were at a dead end also. And it seems clear now that the really live end of the whole evolutionary process is man himself. And a third awesome edge that's present in this is that man has a self-consciousness about the very processes of evolution itself and is therefore able to exert incredible forces and enter into those processes and take charge pf the whole life experiment on this planet. That is we are now in charge of it. Everything from the snails clear on through. Man who exists with such potentiality is deeply afraid of himself and his potentiality and of course may destroy himself rather than go on with the experiment. But this gives us a new insight into life itself. Life is the capacity to trancend time. Life is the capacity to remember and to anticipate and to intentionally relate to the future in a creative manner. That's what it

means now to be alive. Now where is the awe seeping through in the struggle of mathematics? One of the places is that that I mentioned earlier - seeing the phenomenal role that mathematic is having in human history. The second might be hinted at by pointing to what I would call the computer illusion. Mathematics is struggling with foundational concepts. How mathematical order emerges and what are the tests of consistency and so forth. The popular concept, we might get at it through the idea you often hear said, that the computer is becoming such a wonderful thinker that it one day will be able to do anything that man can do better and quicker. Have you ever heard that? Computers will eliminate the need for man. They could repair themselves, make their own program adjustments and so on. Now indeed, the computer can do many things. And do them better and quicker and so forth than the human brain can operate. But the computer will never replace man and those who say that the computer will replace man obviously have a very high understanding of the computer but have a very low understanding of man. That's the problem. Anyone who says that has a reductionistic understanding of man and the way man is able to create order. And at the deeps of the mathematical order that's really where the debate is. Let me put it one more way - the computer is an incredibly potential invention but it's finally nothing more than an extension of the mechanical processes of the human brain. The computer maker man cannot be replaced or reduced down to the mechanism that he is able to reduplicate in his computer. Man is more than that. Even in the deeps of his thinking process man is more than he has been able to reduplicate in his computer. Man can make inventions of order.... A computer can do so on the basis of a program of random selection- it can do trial and error, and because a computer moves so fast is can do a lot of trial and error in a hurry and therefore beat man in that kind of process. But man can beat trial and error. Man has intuition out of which he creates order. He beats any mechanical process he's ever been able to invent. The whole mathematical history is inexplicable in terms of just chance, trial and error. And maybe the structure of mathematics here will quickly show how that debate is going on. One whole area of mathematics foundational theorists are called intuitional. And they are really pushing mathematics is able to work in itself out of it's own deep intuitions of before. Another group is called the formal and they work out of the understanding that math is really disguised empirical relations or abstracted empirical relations. For mathematical order comes into being and the fundamental criterion for it's existing would be the relationships in natural

order. Another group is logic, and they understand that mathematics derives from language or linguistics processes and man the highly abstract thing and finally finds it's test in human comprehensive ability. If you pushed back against this, you'd finally have to say that these all are true, That mathematics does develop in dialogue with physical struggle in the natural environment. And here of course with relationship to the scientist in all these rational structures mathematics is interpretive and so on. But the truth that these people are blasting for over against these is that math in the deep eerie sense of the human being itself - he is able to create order out of nothing. And it's these creations of order that finally determine the logical structures of human society and of course finally give possibility to order in nature out here. Man is the order maker who makes order out of nothing, and order out of nothing in a way the computer can never do. Like Aquinas's model: he says form comes from nature, in another of his sources, forms comes from the mind of man, and another source of form is the mind of God. Which is another good way of putting that. It comes from nowhere, it comes out of the sheer being of nothing. YOu see how fantastic the arguments can be, with these kind of depth issues going on at the foundations of mathematics. Now let me quit. Just this statement in conclusion. The human meaning of the natural sciences is that man only knows order through constructing order and if you go on out to the edge of the order of society, that's where you get to the sheer mystery of things. The research scientist in one sense knows more about the sheer mystery than anybody. I think all of us hope in our order loving way, that the scientist was out there explaining evertything. And now we must learn to use the scientist as a vehicle to get out from the unexplicable. To get out from that which has no explanation. There's no more hiding back in the safety of what was rational yesterday. We must learn to accompany the scientists out into the very premises of reason itself. We must learn to take rational courage and venture out into the deeps of irrationality where reason itself dies, and is reborn. And the second thing I would say about the spirit dimension of the natural sciences is that we learn by negation. It is when our order of things runs into crises or runs into chaos, runs into the inexplicable that the possibility of reordering brings forth a new to take place. And thirdly, that in the very structure of the natural sciences is built

the principle of perpetual revolution. And maybe a quick picture or two. When you look at theoretical wisdom, you're looking at what you might call relative universals. That is they're universal in the sense that they're more universal than my family plan. Or other rational constructs are less universal than the universàls of our whole social order in our times and dialogues between this are written into the very structure of even these very final models that hold together reality itself is the principle of perpetual revolution. These final rational structures are but the fortress of the society in which we're attempting to anticipate the tomorrows of mankind. While these are stable in the sense that you don't just change them every afternoon, there is in the deeps of them this principle of perpetual revolution. And so also, that means that all rational thinking has this kind of dimension to it. This means that when you build rational forms, you build a stance about the whole of reality. When you build a model for your family you do so in relationship that anticipates the whole content of the social environment. And you decisions to give order to the world are not just private endeavor. When you give order to the world you give order to the world. And it's your responsibilty to fight for your stance. To give all of manking, your intellectual vision. Intellectual life is incredibly social. It has to do withthe whole social process. Relativity does not mean that my opinion is ok because everyones opinion is relative. That's definsive privatism or tribalism. The responsible man argues over against the whole field of thought. He shows how this one is true, but this one is true but this one is tryue but and this is what holds reality together and this is true period. And that's what you mean by relativity. But tomorrow you put it together again.

If being the church means being the mission to history, then no one can be the church without a liberating education. Now these courses that we've participating in have nothing to do with enabling someone to be a pshchologist, a socialogist, a physicist, a biologist, or a mathematic they are intended to assist one in understanding why in the world one might be a psychologist, a socielogist, a physicist, a biologist, or a mathematician or a theologian. In other words, the problem of this cirriculm is what is the human meaning of the disciplines? What is the human meaning of the disciplines of natural sciences? What is every human being who lives in the 20th century and lives in such a way that he can participate in the creation of the tomorrows of mankind have to know in order to participate in this time? So these lectures have been lectures on physics, biology, and mathematics, but on the human meaning of physics, biology, and mathematics as these disciplines are wrestling with the frontier rationalities and irrationalities of this moment in human history. Now of course, these lectures are on physics, biology, and mathematics. And therefore intend to be true to these disciplines, falsifying them in no way. If waht we are saying about philosophy, biology, or mathematics, or physics, is not so, then we ought ot be corrected. But theses lectures are not out to do a job that any physicist, biologist, or mathematician, could do better. No, In fact those physicists, biologists, mathematicians have not the foggiest notion about the human meaning of physics, biology and mathematics. Shall I say that again? Those physicisits, biologists, and mathematicians, have not the foggiest notion about the human meaning of physics, biology, and mathematics. Now there are a few physicist, biologists, and mathematicians who self-consciously or latently are the church, and therefore have got to put forth the effort to get to the bottom of the human meaning or the spirit dimension of their discipline. And such a mathematician, who had thought himself through could give this lecture that I intend to do. One who had not could not give this lecture- he's never even looked at the problem with which this lecture intends to deal. Not such statements as these illuminate afresh what it means to be the church in our time- To be the church means to know that you have the secret of history in general. The answer to every human problem. The experts do not have the answers. They only have expertise, out of which answers can be formed. The people who form answers to the humanization of man are those who in Jesus Christ know what it means to be man. Let me say

that sentence again. Those people who form answers to the humanization of man are those who in the only reality, Jesus Christ, know what it means to be man. The church does not cover therefore before the physicisit or the mathematician, but interprets to the mathematician his own life, including his discipline of mathematics. Those who cannot see this vision or evade this responsibility, are the little mice who do not know yet. The eternal significance of being the church of Jesus Christ. How liberating education as a whole is one of the frontier issues of the civilizing enterprise. And the church must, and indeed finally only the church can, lead civilization in solution of this problem of liberating man to live. And searching to the bottom in every intellectual area of going-on ness of our time of the reflective life of the 20th century, the human, I say human, dimension of what's there. Now when we begin to look at the human meaning of the discipline of physics, we said that physics was about- and I'm putting it a little bit differently, the question - what is isness? And then we dealt with the biology or what might more accurately be called in a broader sense, the life sciences, but biology has been our symbol. And here the question is what do life and how does man participate in it? And in the mathematical sciences the question might be put- what is rational patterns? And how does man participate in it? Or another way, another word that can be put here- is that the physical sciences are about the mystery of the matter content of humanness. And therefore you could use the word, the unconscious. And this is about the mystery of the living content for humanness, or about consciousness. And the meaning of consciousness that every living form is conscious in responding as a total organism to the encounter of life. And here the abstract relations content of humanness that everyone participates in which is related to self-consciousness. Now in terms of the evolution of the reality which these three disciplines point to, you're clear that physicis comes first. Isness precedes life in the movement of time. And also, life precedes conscious life, or mathematics. Mathematics on the scale of evolution is a very late arrival on the scene arriving with the self-conscious man. But if you're talking about the disciplines and the way they relate in the history of man, then the curious thing is that the reasoning about reasoning, or mathematics comes first. The reasoning about reasoning precedes the reasoning about isness. And the reasoning about isness precedes about biology. Or to put it another way, mathematics in the realm of fundamental thought and images in the cultural revolutions of man is first. It's the pioneer- It is believe it or not the revolutionary of

the three. The first one on the beaches of a new intellectual era is always mathematics. And after the new fantastic overwhelming abstract possibilities of imagination have been discovered invented, worked up - depending on your ~~fffff~~ theory of mathematics; then break-looses are able to take place in physics. And when these break-looses have been crystylized in history then break-looses are able to take place in biology. This is the pattern every time through out the history of western civilization. Now, a few comments on what is mathematics? Mathematics is contentless rebàtionship - if you could think of a relationship that's diagramed in such a manner as this. You talk about a relationship between two human beings then you've got a concretion on each end of that relationship with one human being on one and and another human being and you talk about the relationship. But mathematics focuses on the relationship between utterly contentless entities. Utterly abstracted entities, entities abstracted from all possible content. So the study of mathematics is the study of abstract relationships themselve Or to use Plato, he called them the eternal forms of the universe. We tend to cancel out the word eternal and the word form in the 20th century imagination has been transformed into the word relationship. Everything is relationship, relationship, relationship. It's been true in mathematics for a long long time- the fundamental concept is relationship. Abstract is somewhat of a dirty word if you were running an art form conversation, but in mathematics the highest abstraction is the highest power. And it's power both for avoiding in life misplaced concretions; if you can be very abstract, then you can avoid calling something that is abstrac - calling it concrete. And it also is very powerful for perfection concrete understanding. Or to put it in another sentence, the power and the ability to be abstract is the power and the ability to be concrete. The two powers are one and the same thing. The uneducated man is one who is always confusing the abstract with the concrete. He does not know the difference between the abstract and the concrete. And of course this is all of us, because in certain levels of our lives, we are assuming to be concrete certain unconsidered assumptions that are misplaced concretions. And it's when the full depth of the abstractness of our ideas dawns on us that we can rediscover wherein we are believing abstractions to be concrete where there is no even having thought about that before. The capacity to be abstract is at one and the same time the capacity to be concrete. Mathematics is not about number although number plays an extremely huge role in the application of mathematics in other areas. The concept of number

has been a provocative overwhelming concept in realtionship to mathematics. And most mathematics is applicable or derivable from concerns with number. But this has to be said nevertheless; mathematics is not finally concerned with number but is concerned with abstractions of which number would be one concrete application. Even the very concept of number as mathematics uses it is an abstraction. Let me show you what I mean. If you count one, two, three, four, five, apples and you go over here and note that there's one, two, three, four, five fingers on your hand and then you experience one, two, three, four, five trips up the hill- do you not see that it was a radical breakthough in human consciousness when some creative mathematicain discovered that all three of these thing contained the same abstract entity, namely five. That five, what a dawning, that five was an abstract entity that had myriads of applications. And you have so presuppose that time in history when man did not notice that five objects over here, and five fingers on his hand, and five trips up the hill had anything at all in common. And then when number dawned, it dawned as an abstraction. And the more you work with number the more one realizes the abstractness beyond the abstractness beyond the abstractness that is present in the very concept of number itself. We'll come back and look at that a little later. Also geometric figures like the triangle and square and circle- these are abstract entities. You never found one in reality. Do you understand that? Only a very close approximation is the best you can do. I've tried very hard many time to draw a square and measure the four corners and have them come out to be 90Z. Its extremely difficult. Or a circle is described as that entity which is equidistant from some point. Unless you have an extremely careful hand to really draw a circle is exceedingly difficult, and finally there is no such thing a as real circle. There is just a closer and closer and closer approximation to the ideal image of circl Or of triangle or of square. Or to make it more ridiculous line and point. A line is a dimensionaless entity. And anything you put on the board here has enough dimention for you to see at the back of the room. And a point is also a fantastic abstraction which has to do with a contentlessness. Anything I put on the board here has space enough for you to see. The whole of geometry is about abstractions in that sense applicable to concrete reality. Now also you must see that there are many other applications to mathematics than geometrics. Or apllication to physics is what I meant to say. Pure mathematics can be applied most anywhere. Pure mathematics being the study of abstract forms. Applied being the use of these abstract

forms as interpretive tools in you different areals of reality. One often does not notice too carefully that the middle ages used mathematics to interpret the dynamics of the trinity. That is God, Holy Spirit and church. This was an application of Euclidian mathematics to the dynam that were experienced in the ////////// interior grappling with theological reality. This is true through out the world that mathematics has been used to talk about the interior dimension. WE sometimes look at most of these illustrations as fantasies, you know, utter number superstitions and so forth. But examples of it are myriad of it through out /// every culture on the whole of the globe. The Indians, the Mya's and the Inca's in latin america have used mathematics not for physics at all but for the design of socity. And every society was designe with utter mathematical precision. Or if you want to look at mathematics in Soren Kierkegaard in the sense of the abstractness beyond the abstractness beyond the abstractness in terms of application. He says the self is the relation which relates itself to it's own self and in so doing is grounded transparently in the power that constituted it. Now I mean that's abstractness. YOU've got to work on that awhile in order to even get any reality reference out of that at all. And it's mathematical in the sense that the reäätion which relates itself to itself is talking about reäationship of relationships. Or if you want to talk about the polarities and the tripolarites that we're using ih the organization of the disciplines. That there is a polarity between mathematics, biology and physics. Or psychology, natural science, sociology. This is a mathematical model used in the organization here. Or if you want to talk about that people that are located in this space between this noman's land here etc. etc. Many application of mathematics we do not recognize are mathematical because they become so common in our life. Now a little bit about the history of mathematics and just why it is an important discipline in history and move down to what it's doing right now and what this means for humanness in this particualr point in human hisstory. The first stage of mathematics might be called the origin of number and number systems and so forth. There are many many varieties of number systems. Western civilization is characterized by the development of mathematics that did not happen in other sections of the world. And the first key figure in it is this man Pythagoras. YOu may have heard of the Pythagorean theroem. Pythagoras was the first individual of whom we have any memory who made mathematics a completey abstract thing. Who made generalization completely general so to speak. And the influence of Pythagoras on Socrates and Plato and Aristotle is

immeasurable. Without this abstract vision that broke through the mathematics of ancient Greece, there could have been no Socrates, and been no Plato, and been no Aristotle. When Socrates, Plato, and Aristotle got through, Aristotle shoved into history his logic and a certain man named Euclid who was greatly concerned with geometry from Pythagoras and with logic constructed our first plane geometry or Euclidian geometry as you may recall. What he was doing in constructing geometry was reducing the logigal postulates to fundamental dynamics of the whole of geometrical fugures as it has been played with. It is very interesting to note that the Greek mind was primarily concerned with geometry in contrast to the Hindu mind that had been concerned with numbers and almost not concerned with geometry at all. But the Greek number system was so unwielding and so impossible of use that it seems incredible to us the work that they did in geometrical mathematics. And through out this whole era clear on down until modern mathematics in Western civilization, geometry predominated. I'm going to call it the geometry of eternal form, As the key title for this era of mathematics. And there was tremendous development in the Middle Ages in mathematics. The development of trigonometry and conic sections. You can tell by those very words, trigonometry being the study of the triangle and conic section, a geometrical projections and so forth that geometry, geometry, geometry was the fundamental thing. The use of this geometrical figure in theology, the building of cathedrals of cones and triangle and so forth. This was the mathematical mind set of the middle ages. Now in the late middle ages there is seeping in here- well maybe earlier than late in terms of this first example, the arabic number system That's the system we use now. One, two three, four, five, six, seven, eight, nine, ten. This is a fantastic simplification of numerology. And also you find breaking in here Hindu Algebra. And these two mathematical invasions were that which enabled to take place in about 1637, the fantstic mathematical explosion. Two figures are key to mention here. Descartes and his construciton of analytic geometry. And Newton in the invention of the calculus. But many many other figure are crucial here. Almost every important philosopher of this age was also a mathematician. Locke was the only one that wasn't a mathematician and he had a lot of mathematical friends. That was the situation of life in this day that mathematics was just the ground base swelling explosion that enabled to take place what took place. I want to call this era of mathematics, the fundtions of continuous- that's an important word-

continuous variables. Functions being, you know, mathematically described relationship of variables and the fundamental emphasis was on continuousness. Illustration of this. Descarte was concerned with applying the algebra or number theory to geometry and making a correlation between numbers and geometry which is as you all learn in your algebra to do. If one coördinate is called x and one is called y then you can draw a line called x=y which is the locus of points in which the values x and the values of y are equal. And this is a correlation of numbers to geometry. This was and important breakthrough at this time. To talk of geometric figures in terms of algebraic equations. Algebraic equations of continuous variables. And then old Newton and his calculus, he's dealing with continuous variables as well. The proble is how to get qualities of a curve understood as well. And he did so by dividing it up in little boxes. And then talking about the infinite division of those boxes on down to continuity. Andthen if you can set up the mathematics whereby you can give an appoximate understanding of what this means and then integrate it down to the exact continuous relationship, you can see what he's doing. I want to point those out to give content to this concept of continuity. A straight line that has no space in it whatsoever. Another important concept that's very closely related is the concept of periodicity. This concept is also related to continuity and the impact of this mathematical concept which had to do with sign waves. which would be the best illustration - a sign curve as they call it as a description of waves which in certain periods repeats itself periodically. Or it's another way of talking about vibrations in physics. But let's listen to these few words of Whitehead to kind of underline the power of this concept and not the details of what he says but just to the impact in terms of human history that he sees this concept to have.had. "The point I want to now make is that this dominance of the idea of functionality in the abstract sphere of mathematics found itself reflected in the order of nature under the guise of mathematically expressed laws of nature. Apart from this progress of mathematics the 17th century development of science would have been impossible. Mathematics supplied the background of imaginative thought with which the new science approached the observation of nature. Galileo produced formula. Descattes produced formula. Newton produced formula.As a particulat example of the effect of the abstract development of mathematics on the science of those times consider the notion of periodacy. In the 16th and 17th century the theory of periodacy took a fundamental place in science. Kepler devised a law connectin the major axis of

the planetary orbits with the periods in which the planets respectively described their orbits. Galileo observed the periodic vibrations of the Pendulum. Newton explained sound as being due to the disturbance of air by the passage through it of periodic waves of condensation and rarification. Heiggens explained life as being due to the traverse waves of vibration of subtle ether etc. etc. etc. The application of the theory of periodicy to a variety of concrete instances but this would have been impossible unless mathematicians had already worked out in the abstract the various abstract ideas which cluster around this notion of periodicy. Now what's very exciting about the mathematical breakthrough at this hour of history is that revolutions have come in the very heart and structure of this whole preoccupation. The first of these is not a radical one, but it was somewhat radical. And this was non-Euclidian geometr as it was called. Geometries were constructed that took this fifth postulate of Eudlid that never quite made a logical proposition and replaced it with another postulate that wasn't quite a logical proposition either and found a whole new geometry emerging. It was equally as consistent as Euclidian geometry- which were geometrys of plane surfaces or plane three dimensional undrstanding. And so there broke loose a whole new preoccupation with geometry in which you could have any number of dimensions of geometry, any dimensions of curvature that you wanted to have in your geometry and so forth. We are somewhat familiar that these inventions in mathematics were what enabled Einstein to do the theory of relativity. Without these geometris that enabled him to talk about time being a fourth dimention or a fourth continuous variable with the three dimensions in space all of which four variables curves, not in a Euclidian manner but in whatever manner was necessitated by the presence of mass in the midst of the space in which they described. Without this imagination that the non Euclidian geometries gave them, Einstien would not have been. But even more radical to mathematics, is the second revolution. And these revolutions began in the 18th and the 19th centuries. Way back in the 1800 non Euclidian geometries began to be dealt with. So you can see immeadiately how this imagination breek-loose pre-dates quite awhile the application to any physical concepts. And near 1850 this pre-occupation began to be present in mathematics. They began to notice as never before, the relationship between mathematics and logic. And ask new kinds of questions on what you might call- what are the logical foundations of mathematics, is one way of asking the question. And another is, what does mathematics tell you about the meaning of logic?

IN other ourds this rebationship became the preoccupation of mathematicians. And in the current struggle in mathematics is out of this that all the problems, arguments, confusions, wars,battles are being waged. So what you have to grasp as the whole era of this mathematical development in this period is the foundations of mathametical consistency. Now to give just a few illustrations of what in the world these people are concerned about and why they're concerned is utterly crucial for your life and my life. And this would be the kind of illustration of the important role of mathematics that I think is needed. Let's go back and consider the concept of number because there you are dealing with the foundations of everything. They began to ask whether it was logical to do what was done in mathematics. That is, consider continuous n###### variables as if they were numbers. Or how many numbers are there on a straight line? Well it's very clear that when you number down a straight line one, two, three, four, that you've left out a whole lot of numbers in betweeen there. How many numbers are there inbetween there? Well there are an infinite number of these if you extend the line out infinitly, but there are also quite a few here between zero and one. That is an infinite number. And there are different kinds of infinity. Now to understand what they mean by diff= erent kinds of infinity you have to understand the concept in logic and mathematics of a set theory. A set is a group of entities like a group of numbers or a group of lines, or points, or whatever. And there's a definition called a subset- now a subset is part of a set, every member os the subset canbe made to correspond with some member of the whole set. That is if you have 50 human beings, if you've got 10 human beings here- 10 human beings is a subset of 50 humanbeings if you can find a human human being in the fifty that corresponds with one in the ten and so forth. But one of the mysteries that began to come into the discussion of the sets of infinites was this kind of a thing. You can take the number one, two, three, four, an apply to it numbers- double them you know- three, two, four, six, eight. Now you can see that these numbers if you extend them on out to infinity, are a subset of these numbers here. That is you can apply the two to two, four to four, six to six and eight to eight and so forth. But the mystery is that also for every member of the set, there is a member of the subset. So you have the curious thing that a subset is equal to the set. Do you see that? That there is the same number of in this set as there is in this set because you can correspond the even numbers- which is half the numbers- to all the numbers and never have any number missing. So that's the definition of an infinite set- a set in which one of the subsets of the set is

equal to the set. That's the definition of an infinite set. Now that's called a denummerable set because you can number them. That is you can order them and number them and count them and reproduce them on out to the end. Now that's fine because they begin to struggle with what they call rational numbers. Now a rational number is a number that can be finnally it's denummerable And rational numbers are all the numbers that can be formed by any addition, division, subtracti or multiplication of these entitures. And you can see how you'd get alot of them when you do that- there's an infinite number of them between zero and one, of rational numbers. But then they discovered the rational numbers were denumberable, that is there were alot more rational numbers than there were intitures and intitures were a subset of the rational numbers; neverthel rational numbers were still denumberable or of the same power of infinity as these numbers. Ther they discovered that there were some numbers that they left out called irrational numbers. And irrational numbers were numbers like the square root of two. Now the square root of two is a number for which you cannot peoduce in any such manner or combination whatsoever. Now, that can be proved but I won't worry about proving it-even Pythagoras realized that long ago. I't a strange kind of number. But what the modern mathematician sees is that not only is this just a unique situation, there are more of these kind of numbers than there are of these. As a matter of fact, these kind of numbers are not only infinite, they are non-denummerably infinite. TMat is they are innumerable, litterly innumerable even in correspondence to an infinite series. This raises a profound overwhelming problem about continuous variables. How can you prove foundationalyy in mathematics that all laws of functioning in mathematics, divisions and so forth apply to irrational numbers in a way that it can be proved that they apply to rational ones? Well the problem of proving that is just like incredible. A man named Cantor(?) hef worked out all the proofs for it, and in the next five years the mathematicians blew holes in every argument. ANd this issued in a fantastic debate. Why this debate is so important is that is if there is some kind of logical inconsistency in the very concept of continuity, my lord, the whole structure of mathematics in which continuous variables is a foundational concept, is in joepardy. Or the whole idea that you can reduce geometry to number is in joepardy. The whole foundations of mathematics has to be reconstitûted. Now, I don't know if that's utterly clear or not. It does'n t matter, just so you see the radicallness of this kind of inspiration and what it means. Now three schools of mathematics have come into being that are dealing with this kind of problem and this three is not my invention this time!

But he says there are three schools of mathematicians. There are are those who attempt to solve these problems in terms of the concept of logic. That mathematics can be finally understood to be nothing but logic. Or that mathematics is just deguised logic statements- highly abstract mathematical statements are logic. Some very important people take that point of view. Bertrand Russell would be one of them. Whitehead has worked in that. The whole MATHEMATICA PRINCIPIA was worked out on the basis of this concept. Liebnitz held this position and so forth; that finally you could reduce mathematics to logic. And that was why the Canter problems here with infinity was so important was that Canter was proving that was so. He was proving that was so, that you could reduce mathematics to logic. And those who are saying no to the Canter hypothesis are finally saying no to the possibility of reducing mathematics to logic. One of the people who says no is called a formalist. The formalist explains that you can get rid of these contradicions and save mathematics from ruin by this kind of an understanding, that all mathematics are disguised empirical statements. And while certain aspects of infinity are not empirically experiences, other aspects of infinity are empirically experienced. And therefore we can save the whole of continuous variables by understanding that these are intuitively accurate concepts because they are related to empical experiences of man. So that they understand the whole of mathematics as disguised empical statements. And of course what they're pointing to is a very ancient truth. You can see how 1+1=2 could be understood as disguised empirical statement or abstracted empirical statement. However all of mathematics is not so capable so they've got a hard job on their hands to show us that mathematics is finally reducable to relationships that human beings experience in reality. The third school denies this, and therefore this also. They're called the intuitous and mind you all three of these schools are working on the primary problems of the foundatis of mathematics. The intuitous understand mathematics as a wholly economous and self sufficies activity. It's methods and it's insight are regarded as being neither capable of nor in need of guarantees from the formalists or the logicalists point of view. All relationships are self validating in and of themselves. Or the whole structure of mathematics can be reconstitute by mathematical means. There are more revolutionary groups as this statement indicates. Logicism and formalism have treated the antinomies of classical mathematics as a malady capable of cure, but should leave classical mathematics substantially intact. The intuitous consider

the anomolies as merely a symptom that mathematics has in many of it's branches have not been true to itself. Logicism and formalism tried so to speak to reconstruct the building to secure the foundation of mathematics so that mathematical work could go on in the upper stories without much disturbance. The Intuitous attempted to build a new mathematics at all levels by what they regard as truly mathematical methods. What that statement means is that these people are really radical. They are going to eliminate from mathematics the concept of infinity and reunderstand it in terms of concepts that can be finitized. This kind of a radical re-locating mathematics to the bottom is the kind of processes that they're going on. Now all three of these have certain kind of emphasis therefore, in terms of the very structure forms itself. These people emphasis in the productions and human life of mathematic forms, the pressure of empirical experience. That this is the place form which mathematical forms originate and therefore the place they must be finally tested. The logical man is emphasizing that mathematical forms are originating from the language. Or of the cultural knowledge of man, the cultural reasoning which is built into the language itself. That finally you can reduce mathematics to logic in this sense so they attempt to validate all mathematical statements here. If it's logical it's true. The intuitous look for mathematics to be linguisticless entities. They are not finally reduced to logic. They claim they are not finally reduced to empirical statements. They are something creativly constructed by the human mind itself. That they come out of the interior struggle with rationality within humaness itself. That they do not need to be empirical or logical to be mathematical. As a matter of fact to be mathematical finally informs what's empirical and what's logical. Do you see the emphasis they're putting? It's a creative emphasis, the world of creativity in the depths of man is where the secret of the origination of mathematical form is to be found and not in experience and not in language. And this is a very radical departure as you might imagine. Now all three of these are saying two things abouht mathematics. And maybe the way in which we can begin to struggle with their recovery is Thomas Aquinas's struggle with a similar problem in which the question was asked, "Did forms originate from nature or from the mind of man or from the mind of God?" Now just look at this parrellellism. This is rational forms originating from nature, this is rational forms originating from the mind of God I mean the mind of man, and this is rational forms originating from the mind of God. So to translate his terminology do abstract relationships i

human existence originate from empirical experience or from the logical structure of the human mind, or from tge fathomless well of creativity in humaness itself; which is it? And Thomas Aquinas said about his question, all three, all three. And perhaps finally that's what we have to say also; all three are wrestling with a true dimension of mathematics. Now it is important to see thw overwhelming enthusiasm and excitement and creativity that's going into this reconstruction of mathematical foundation gives a clue to the future and I want to spend my last 10 minutes pushing in this direction. The reorganization of mathematics may seem at first as remote as how many angels stand on the head of a pin. But in the reorganization of mathematics the very nature of methadology s of organization are being dealt with.. In the organization of mathematics the very nature of the methodologies of organization are being dealt with and thought through. What does it mean to be consistent? What does it mean to have something organized? What is the relationship between finite and infinite concepts? All these kind of fundamental questions are being clarified. Let me hint toward the significane of this by returning to some of the things we looked at in physics and in biology. One of the cutting edges of physics that I did not have time to mention the other day is the exploration into the interior organization of the atom. Do you get that? The interior organization of the atom. How is the atom constructed on the inside? And this is a fundamental problem in physics right now that answers have not been forth-coming on. They have located all kinds of strange forces inside of the atom and are arranging them and so forth. So that you have in nature these forces identified, gravity, electromagnetism.....(lost some when tape was being changed during lecture) [illegible] protons and neutons the forces that they have and within the atom itself there is a weak binding force and a strong binding force, which are two utterly seperate fewces from the forces of gravity and the forces of electromagnetics. Now what they've discovered in all three of these which are applicable to the interior of the atom is that they work with a full number relationships, that is there's a discontinuity in the structural organization of the atom. Another important concept is this one that binding expends energy and decreases mass. This is true - when two hydrogen atoms bind together to make a helium atom tremendous energy is released. And the mass that is left, that is the one helium atom, doesn't wiegh as much as the two hydorgen atoms weighed. And this is found to be a principle through out all these binding forces, that when the forces bind something together energy

is expanded and an energy structure is created that it takes an application of fantastic energy to break loose. So that when they're exploring the interior/#f//f#/ struction of the atom they have to get protons going at fantastic speeds to break loose the binding in order to release the binding forces that hold it together. Now this principle I want to apply to several things. It really has tremendous applications. Everytime something comes together energy is expended. And to get something that is together apart takes energy appling to it. Now if you work in biology again the theory of organization is a fundamental idea in biology. Theelard De Jordin works this to the teeth and shows that how there is within nature a drive force for the increase of complexity of organized reality. How the helium atom is formed out of two simpler atoms and all the other atoms are built up on the complex structures and this tendency toward complexity is the kind of thing you see in the evolutionary process. He calls this building up of the atoms and the boiling stars, geogenicism - the creation of the elements of matter and then he turns to life and shows how the complex relationships of molecules get finally so complex so well organized that the cell breaks loose in human history. And how the biological organization centers itself and becomes finally so complex that brain -human brains break loose as the most complexly organized item in the biological evolution. This drive toward complexity. And then he applies this drive toward complexity to what he calls now noogenicis - that is here all the various expressions of consciousness in this planet earth and they are in a bind. We are in a bind, we have not to organize. We have no choice because of being one sphere of biological brain matter thinking around this globe tp organize our entire consciousness. And he calls this power noogenicis. Now you can imagine the kind or reality is present if you assume that binding releases energy. What we can have going on in the world is a fantastic release of energy. That's what you have going on. Mankind is in a bind. Getting off the planet on a spaceship is a dream because on the planet wild energies are being released throughout the structures of humaness. Whether they be reactionary images which refuse to move forward in the binding together of mankine or whether they be energies that demand a new order, those energies are present there. Then the question is how is a centering structure going to come into being. How is an organization going to be created that enables all these energies bound and expend themselves in creating a new atom so that a whole new centralized entity called mankind. Or will these energies simply blow humaness to smithereens? Those are two very realistic options. And so the theory of organization

I suggest to you will be a crucial area of concern for awhile. Everything has to be organized. What organizaiton means and what the theory of organization means down to the bottom or organization is going to be the preoccupation of man. And mathematics is struggling to the bottome that issue and the fury fact of its struggle is already influencing our imaginatic more than we have ever known probably. And the solutions that mathematics brings into this problem of organization will have impact upon us. Now we've been doing some organization of disciplines in all these courses. And me in concluding here let me review quickly this task. For actually what's been going on is an application of mathematics. All the abstractne that mathematics implies to the organization of the disciplines. Man is a relationship, a bundle of relationships. Now in the sciences we have abstracted those relationships into part In reality man is a unity but when you come to analsye man you break him up into parts. And so in psychology we've talked about the psychological relations in terms of the biological relati the sociological relations the rational relations of man's interior being. And we turned to sociology and talked about the economic relations the polical relations and the cultural relations. When we moved to the universal sciences- the sciences we've been dealing with this week we have the physical relations- the isness, the biological relations- the relations to life and the mathematical relations or man's relations to relations in the highest abstraction And these relationships make up our existence. This is a rational breakdown and a relating of the relations that make up humanness is what's really going on in this kind of a model. And then we've also said that man is not only a bundle of relationships that can be broken down an analyzed in this fashion, but man is an attitude toward these bundles of relationships. And we've talked about art as the discipline which is grasping for the whole personal attitudinal relationship to his relationship. Or what is a key factor here is the whole attitude. Art grappling for the whole in the personal dimension. And history grappling for the whole in the social dimension, trying to reconstruct the whole memory back to the beginning of time and the whole anticipation out into the future out of your stance in this present existential moment. This drive for the whole picture of man. And in philosophy tomorrow we'll be dealing with the whole. The whole rational metaphors [illegible] that enable the recreation of an orderly culture and so forth. Now both of these dimensions that the humanities and the sciences deal with you might call the finite and they are related to the infinite. If you want to use

Or the ultimate eternal mystery of life in which selfhood is grounded transparently. Or that man is not only this bundle of relationships and this attitude toward this bundle of relation ships but that he is a relationship to the final, ultimate, transcendent mystery of existnece ANd he's all three of these at one and the same time. WHich we have broken down in this model before as you have seen. You put theology up here, the sciences up here and the humanities over here. This you might say is a mathematical analysis of the dimensions of rational exploration that are in human existence. That is the spirit dimension, the relation of the totality of man to the utter trancendent and this dimension of the rational structure of relationships that make up man is always present in the grappling of the whole that art, history and philosophy are dealing.with. They are always present but for the sake of analysis we break them down and study them as theology science and the humanities. In other words this is a mathematical model that enables us to analyze the parts that make up the human being. Or you might put it in terms of an equation. Man= science+ humanities+ theology in terms of his reflective dimensions. Or man as analyzable part, symbolic whole, and contentless spirit. As finally the deeps of man - this raw intention drive for a comprhensive stance on the edge of tomorrow. And that dimension of man, that spirit dimension of man is where we in the church are experts. And what this whole course on the sciences is doing in the depths is understanding how this dimension and talking about this deep human dimension is related to these fundamental disciplines of humaness. And how in the very presence of biology, physics and mathematics man is there, man is there as the great august facinating spirit being, wrestling with the being man. And our job is to illuminate that spirit man that is present even- in the struggle of what seems at first sight to us so remote a thing a mathematics.