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Genesis II: Man Becomes as God

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The 1982 Winifred E. Weter Faculty Award Lecture

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Acknowledgments

I extend my thanks to those affirming colleagues who have offered inspiration, the wisdom of humorous metaphor in Russian folklore plus critical comment throughout the preparation of this manuscript.

A "biological revolution" is underway and has come along at a time when we are caught up in something of a crisis in values with the two related in several ways. We can see that on one hand the biological revolution contributes to the crisis--tinkering with the genes, psychosurgery and fetal research--but on the other hand it might help relieve the crisis.

The ultimate impact of this revolution will be perhaps more dramatic and pervasive than that of the Copernican, Industrial and Darwinism revolutions for it now is possible to systematically modify genetic and possibly behavioral characteristics. We have the prospects of fundamental changes in human values, functioning and relationships. With such prospects it is tempting to rephrase a familiar line and say: Wake me when the revolution is over--tongue in cheek perhaps--but this so called "ultimate biology" is weighty stuff.

Religion deals with human beings and their values--or in fact divine and universal values which apply to human behavior. A religious belief is related to beliefs about nature and to origins. It is related to questions of life, death, immortality and to reasons for man's existence as well as relationships with fellow human beings. The issues of concern include a sense of the sacred in nature and life and the relationship of man with the Godhead.

For some all the answers are in and there are few if any problems with these questions. For others the long search continues. The answers are not to be found exclusively in science, nor in religion, which tends to be suspicious of science, but it would be a mistake to overlook the contributions the sciences can make. The rapidly accelerating development of information--particularly in biological sciences may offer insights as well as questions in terms of human values. This deserves increasing attention from religion and from politics. The radical nature of this revolution in biology and medicine assures us that the human future will be quite different from the human present.

As we look ahead at the radical possibilities for ultimate biology with prospects that a few years ago would have been deemed impossible I am reminded of an excerpt from Alice in Wonderland: "There is no use trying," said Alice, "one can't believe impossible things." "I dare say you haven't had much practice," said the Queen. "When I was your age, I always did it for half an hour a day. Why, sometimes I've believed as many as six impossible things before breakfast."

Such an attitude is an integral part of the creative aspect of human nature. Increased comprehension and appreciation of nature accompanies each major advance of science--that the earth revolves around the sun, the laws of gravity, that man can travel in space. We are open and confident--this leads to faith in the reality of possibility. Einstein expressed this challenging statement: "The mystery of the universe is its comprehensibility", also, "the most beautiful thing we can experience is the mysterious; it is the source of all art and science." Art and science strive to make mysterious man comprehensible.

There are rival trends in our cultures--specialization and synthesis. Scientists are thought of as specialists and able to master only a fragment of human knowledge. The need is present, however, to attempt such a synthesis and a failure to do so would give credence to Albert Schweitzer's remark:

"Our age has discovered how to divorce knowledge from thought, with the result that we have, indeed, a science which is free, but hardly any science left which reflects."

Certainly it is important to be sensitive to the potential polarization between not only scientists and the humanities and religion but also to prevent polarization between scientific elitists and those who see science as the servant of more fundamental human values: the reductionist view against the holistic one. The real danger of this reductionism or the viewing of human life as a biochemical machine is the "single vision" of science as it has been called by Theodore Roszak.[1] This view, of course, is created at the expense of wholeness and does not encourage contribution by more human philosophies. Fortunately there is an increasing voice being heard that argues for convergence of man and nature. Science needs to include the realm of human values lest we lose what it is to be human. It is no longer sufficient to claim that we can confront the universe as objective observers. We now understand that science is not bult on facts but upon observations. Observations are not passive but represent an active relation between the observer and the world. Science is thus an evolving activity, not a mechanical index of facts.[2]

Man has arisen by a creative power inherent in the universe--man has been invested with a cosmic responsibility. Michelangelo's image of Adam who was created on command by God is a more attractive and intelligent symbol of man's position in the world than simply a description of man as a chance aggregate of atoms or cells.

The Weter Lecture event is an affirmation of the value of the liberal arts and an appropriate forum for my attempt at weaving together ideas, feelings, and language of science, arts, humanities and theology.

Some of these thoughts have come to me during my near daily running of Discovery Park loop trail--thoughts grand and compelling while running seem less so when set to paper--euphoria of endorphins no doubt!

A notion of convergence requires a common understanding and common use of language. Out loud, I wonder if my words here can accomplish some of this and I am alternately comforted and concerned by a statement of Samuel Beckett: "My work consists of little attempts to make shapes with words... attempts that always break down in the same way. It's curious: one knows that they are going to break down but still one persists."[3]

What is this problem of language? A simple story may illustrate some features of the problem so eloquently addressed by C.P. Snow in <u>The Two Cultures</u>.

Imagine a quiet lunch break on a college campus when a biologist member of the group announces his task for the afternoon is to return to the lab to start a culture. An anthropologist overheard the remark, mused a bit, then chuckled as the multiple meanings of the word sifted through his thoughts--on the one hand a sample of nutrient added to a batch of bacteria; on the other a picture of tribal people in a distant land.

This event typifies the varying and specialized use of language--here

the word culture. The essayist, Harold Morowitz writes...consider two physicists discussing the measurement they call a magnetic moment. A student of French literature hearing the conversation, finally said, "Magnetic moment. What a wonderful name for a perfume." That's probably not exactly what C.P. Snow had in mind but we have to start somewhere.

The lack of communication described as "two cultures" is probably charitable. Actually two is most surely an underestimate since a biochemist has difficulty talking to a physicist and they both are divided from the theologian and the poet. This separation involves the knowledge of content of respective activities but perhaps more importantly an incomprehension of the nature of the other's inquiry with some skepticism of its value. Such fragmentation of our intellectual life results in our conversation being confined to the banalities of academic politics, or perhaps worse.

I would like to share some thoughts about the human enterprise of science. For one thing, it is an activity of people--people with hunches, intuition and creativity, who do reasoning. Secondly science is not the compilation of an endless dictionary of facts--no more than literature is. Science is creative--there are similarities to that which is done by Leonardo Da Vinci, by Keats and by Einstein. Science is as integral to our culture as the arts and as necessary to our education.[4] Even with it's own customs and rules, the scientific enterprise is accessible to any of us because it is quintessentially human.

Science uses images and imagined situations in experiments--much like art. The reasoning process is like the imagining process. Both use movable images just as poetry does. It has been suggested that ideas of nature whether philosophical or scientific are also the stuff of poetry. Certainly John Milton's poetry ranges through cosmology and biblical views of nature. In Genesis we read:

> For out of it thou was taken
> For dust thou art
> And unto dust thou shalt return.

Walt Whitman, Gerard Manley Hopkins and others have elaborated the ideas of natural world in poetry.

Science has developed explanations for many of the ideas represented in the symbols of the poets--thus a form of cycling has occurred. Cycles are a fundamental part of physical and biological processes: energy cycles, nutrient cycles and the like. Perhaps we have a hint about resolving the problem of the "two cultures" by recognizing that the route of a noble idea might be from poetry to science and back to poetry?

In a comparison of art and science Bronowski likens the well known statement $E=mc^2$ (Energy = mass x speed of light) to an excerpt from the poet John Keats who wrote in something like equation form, "Beauty is truth, truth beauty--that is all Ye know on earth and all ye need to know."[5] The symbols 'energy' and 'mass' are like symbols 'beauty' and 'truth' with little or no difference in the use of such words in poem or equation.

There is the notion that ideas of science are very abstract and only expressed formally in equations. The mind always works with images to explain any working of nature. We always use metaphors to link different parts of our experiences and in turn find likenesses between the parts.

At any rate, the scientists bear an increasing responsibility to consider the human implications of what they do and how they think. It is valuable for all of us to consider the human implications of what they do or how they think. It is important to consider that the scientific way of thinking is a human way of thinking. To make this work we (all of us) need to share an understanding of the language of science. After all, the methods of science and the concepts (abstract or artificial) are on a continuum of the human process of language and perhaps it is the right to view science as a highly formalized language. To quote T.S. Eliot, "Few things that can happen to a nation are more important than the invention of a new form of verse."[6]

A language is developed from symbols that have been defined with unambiguous maning--at least at the beginning. For molecules to interact there is a language--the assignment of unambiguous meaning takes the form of chemical and physical interactions. The next step is assignment of meaning to combinations of symbols and to interactions of the combinations. The genetic language is such a language. In it symbols eventually get linked together in cooperative units just as words in our language. The molecular language is complete with the punctuation of commas and periods (known as "stop signals"); start signals, verbs (the enzymes) and terminology such as translation, transcription and interpretation. All the organism's functions are precisely coordinated through the words of the molecular language as it is arranged in a text divided into sentences. Very recent findings show us that the genetic language even includes "gibberish"--we should feel right at home with our cells.

The story of the cell can be represented as: DNA → RNA → Protein → Everything Else. This sequence or theme has been called the "central dogma" of molecular biology--certainly it should get reviewed as one of the exciting short stories of all times. Douglas Hofstader is interested in strange loops and tangled hierarchies whereby something of nature or art turns into its opposite in logical ways that subvert our sense of logic. Illustrations of topics that interest him include drawings of Escher and the cannons of Bach but also lead one to muse about this molecular language. What if somehow the genetic language is switched around and the codons or message bits or words are altered so that "words" and messages are meshed in such a complementary way that although the internal information transfer is different the external character of the cell appears as before. An analagy could be drawn between this and the different use of writing forms of prose and poetry with use of metaphors and images which convey the same message or expression to the reader or observer. These essential "languages" are necessary for self-organization in a biological cell, for men to communicate and for ideas to evolve. 44-47

A division of man from man by fragmentation of knowledge is hazardous to the individual and to science itself. The enterprise we call science is based on common value judgments being made by society.[7]

A contrast exists then where we have the scientific specialization complete with awesome derivative technologies on one hand but an increased

willingness to recognize the human dimension and the mystery of the human personality.

This contrast creates a complex but exciting issue--on one hand the non-scientists, be it men of letters, theologians or what have you, and on the other hand, the scientists, all recognizing the need for understanding. Perhaps, as the scientist puzzles over wondrous results, behaving as a closet theist, there may be a theologian, occasionally acting the closet doubter.

A dramatic and focusing example of how the two points of view need a common language has been the issue of recombinant DNA and genetic engineering research--the current "biological revolution".

This new technique of gene splicing will enable the biochemist to write with the genetic language, thus intervening with Nature. The apprehensions about this are intense. The defense and advocacy for it is equally intense. Recombinant DNA research carries dangers as well as opportunity. Whom can we trust--whom should we trust? We realize that species can be changed, and in fact can be created, and man is the Creator. It is an irrevocable step--do we do it or do we not? Maybe the question is best asked by T.S. Eliot[8], "After such knowledge, what forgiveness? Think now. History has many cunning passages, contrived corridors, And issues. . ." or perhaps a reminder from Ecc. 1:18: "For in much wisdom is much vexation; And he that increaseth knowledge increaseth sorrow."

There is a convincing argument about the inherent spin-off potentials for the biomedical sciences--for correcting birth defects, for dealing with cancer, for working on aging as well as for agriculture with a potential for new energy and food sources. There are risks and worries--in fact it has been suggested that to do such genetic meddling is wicked. Have we finally accomplished what Mary Shelley wrote about with her Dr. Frankenstein? Is it time to stop or do we believe the answer to dangerous knowledge continues to be more knowledge? Scientific information is doubling at a rapid rate--about every two years in molecular genetics! Thus no apparent shortage of knowledge is foreseen. René Dubos calls for "criticism of science formulated by enlightened nonscientists"[9] but the problem is one of getting the non-scientists enlightened.

A celebrated case of people-scientists and non-scientists getting involved in this issue is the Cambridge affair where the mayor threatened to drive gene-aplicing research out of the city. The essence of this affair was that in 1977 the City Council of Cambridge, Massachusetts set about framing their own regulations on gene splicing. The Council had become aware of an intense debate within the Harvard scientific community. The Council--a housewife, a student, a security guard, a pharmacist, a college administrator, a welfare mother, a rubbish disposal contractor, a court clerk and a tax collector created the Cambridge Experimentation Review Board. This board consisted of lay citizens who represented a slice of life of the Cambridge community with no involvement in the recombinant DNA research. Contrary to some expectations, the citizens took time--some seventy-five hours of hearings--to learn the language and understand the issue. Guidelines were established which are in

accord with federal guidelines and with a few exaggerations by both sides, in a real sense it was successful because the lay public was involved and acted responsibly upon a technical scientific matter.

Still, the issues addressed here were immediate public health issues, not the longer range issues of gene splicing. It appears that we still have some thinking to do. Is there a central question to be dealt with? If so, I expect it may be whether there are certain kinds of information that lead to sorts of knowledge humans are better off not having. That is a tough one.

The recombinant DNA line of research upsets us because it makes us face the fact that the genetic language and the machinery of life can be tinkered with so easily. It is unnerving to think that anything as fixed and stable as a species can be altered.

Some have referred to the hybrid species that could be made from gene-splicing in terms of ancient mythology[10]--that the hybridization of Prometheus with Herostratus* is bound to give evil results.[11]

The eminent biochemist Edwin Chargaff and a central player in the DNA drama, makes an argument on a moral and aesthetic consideration of science. . ."science was one of the attempts of humanity to learn the truth about nature--not to improve or modify--just understand it.[12]

Will the ability to do gene splicing provide Faustian power to do repairs and "improve" the species? There may be peril in such things. Accident probability calculations for recombinant DNA accidents look attractive but the reality is that the probability figures for nuclear reactor accidents including that at Three Mile Island in 1979 were far smaller; nevertheless, they occurred. Robert Sinsheimer, biophysicist and now chancellor of the University of California at Santa Cruz, argued a few years ago as an ardent advocate for genetic engineering but has moderated considerably and reminds us that this search for truth is a privilege bestowed by society.

Since things of science now have the potential for such consequences it may no longer be enough to wave the flag of Galileo and reveal the legacy of Galileo's battle with the Church, the Galilean Imperative ". . .to explore every domain, unravel every mystery. . .consider not the cost. . .[13] in such context only when scientific discoveries have been applied somehow have questions arisen about consequences (a test of the $E=mc^2$ hypothesis over Hiroshima did not count as "inquiry") but we ask does human curosity need to learn restraint? The reality is that there is no turning back--the genie is out of the bottle.

It is difficult to predict how science will turn out--really good science is not possible to predict. That is the way of the enterprise--you accept it or you don't--there will be practical useful bits as well as disturbing and upheaving pieces of information. In one of his essays,

* Prometheus stole the gift of fire from the gods and gave it to man; Herostratus burned down the temple at Diana at Ephesus to give himself a name in history.

Lewis Thomas writes about the word "hubris" as an old word that is applied in a pejorative sense these days. It is hubris that brought us atomic fusion and fission for blowing each other up as well as stripmining, food additives and now the whole biological revolution with prospects for altering our genes, cloning prominent politicians with bits of their own eminent tissue and making hybrid creatures. We are facing up to the fact that we don't understand everything--in the past we pretended to understand or filled the gaps with stories. The greatest danger now would be to pretend that we do not need to satisfy our curiosity, to pretend we are some other kind of animal, and to imagine that we can rise above our ignorance by simply saying there are things not necessary to know. That could be a form of real hubris.

I will add that the intellectual toys of scientists are not the only cause for major disruptions of civilizations--the poets, prophets and philosophers are just as liable. In a longer view, ideological ends are more important than the technological means which are powerful but not our rulers.

The considerations that have put molecular genetics in the spotlight could not have come to pass without the startling discoveries that we have made about genes. The genes, of course, are made of DNA. We know the molecular configuration and the chemical code in which its genetic messages are written--the language of life--the genetic blueprint.

What is this keeper of the keys to life? How did we come to know about it?

The stuff of science can be thought of as ingredients for classic drama--strong willed characters, unexpected turns of the story line, themes dealing with eternal issues. Upon reading James Watson's The Double Helix, one sees that the human context is important--without it the reading of science can be as dull as textbooks. Even if it is an imperfect rendition of the larger story to capture a flesh and blood likeness of the process of science in action might offer some insights and might even raise a few goosebumps.

There is an undeniable drama in the discovery of DNA. We are not all main players in the drama but it's exciting at least to be a member of the chorus. There were experimental antecedents and threads of several lines of evidence. Added to this was a complex web of relationships between the scientists working in near frenzied competition. There was wit, insight and luck as much as thoroughness and hard work for the winner's formula. The chief persons in the comedy/drama possessed brilliance, eminence, ambition and vanity. As Maurice Wilkins, one of the protagonists, said, "DNA, you know, is Midas' gold, and everybody who touches it goes mad."

Scientific teams work on problems with very little of the daily work being discovery. Somewhere the answer is shaped and the insight occurs in the mind of a prepared person. The discovery then twists and grows--it is not a neat tidy publication at the beginning. Eventually a story emerges but the exact process and details are often hard to reconstruct.

The Age of DNA might be an apt title for the story wherein it seems that the science of molecular biology sprang full-blown from the brows of

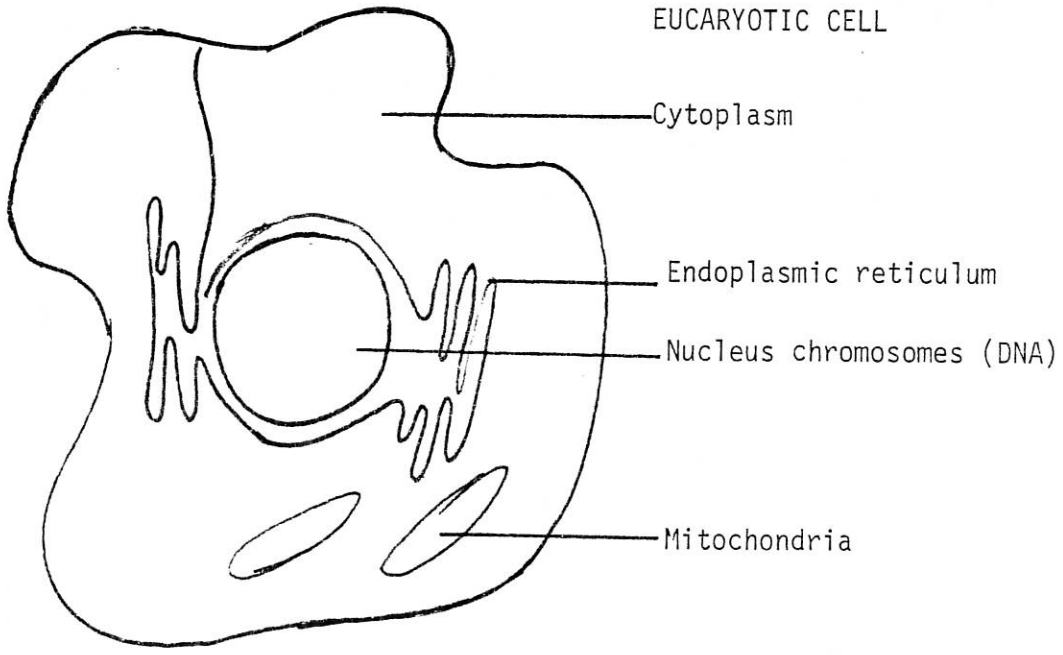
James Watson and Francis Crick. In 1953 they described with appropriate British understatement, in a single page scientific paper, a molecule with "novel features which are of considerable biological interest." This triumph, built with the work of many others--signaled the leveling of the walls between biology, chemistry and physics. With a tone of joyful seriousness, Max Delbrück, one of the several physicists who turned to a question of molecular biology and who was a central figure in the beginnings of this revolution, wrote a letter to James Watson and Francis Crick. . . I have a feeling that if your structure (of DNA) is true. . . then all hell will break loose and theoretical biology will enter a most tumultuous phase.

What is this keeper of life, this double helix, that stores the genetic messages for eyes blue, lilacs fragrant and feathers iridescent?

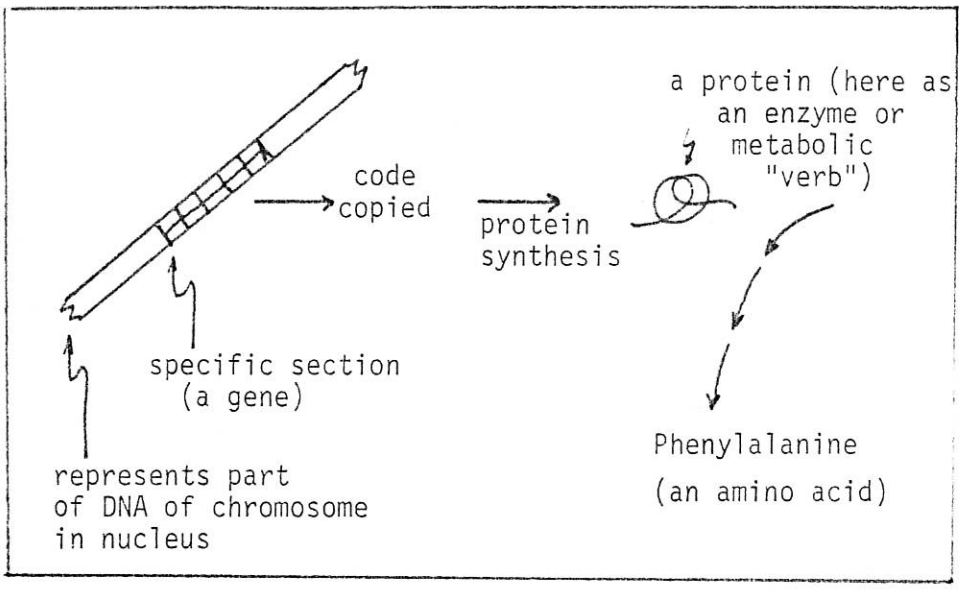
Cells are the basic units of life for all plants and animals; bacteria consists of a single cell, a human being, a hundred trillion cells. Thirty thousand red blood cells would fit in this "o". There are trillions of molecules in any given cell. There is remarkable geography sculpted into a cell and we have yet to understand everything about a single cell.

> Any one cell, embodying as it does the record of a billion years of evolution, represents more an historical than a physical event. You cannot expect to explain such a wise old bird in a few simple words.
>
> --Max Delbrück

The nucleus is a special place and includes chromosomes. There are forty-six chromosomes in a human nucleus. Each chromosome is a package of DNA divided into hundreds of different genes. Each gene corresponds to a section of the DNA and sends messages to other parts of the cells on how to make enzymes and other proteins. The enzymes control the metabolic pathways which include production of eye color, hair color, central nervous system development and "intelligence", height and other physical characteristics. The forty-six chromosomes threads, if linked together, would reach more than six feet but they fit into a nucleus less than four-thousandths of an inch in diameter.



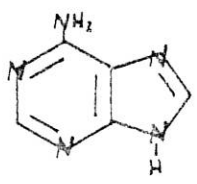
Another view of events of genetic information transfer is shown here.



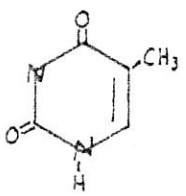
The phenylalanine (a language symbol as discussed earlier) gets produced by a cell by control of an enzyme (a protein) which corresonds to a specific section (a gene) of DNA. A disruption of the gene by mutations for example would lead to a genetic disorder e.g. phenylketouria (PKU) with accompanying brain damage.

The genetic material, DNA is a long threadlike polymer made up of a large number of building blocks called nucleotides. The individual nucleotides have an attached group called a base. There are four bases that occur in DNA--adenine, cytosine, guanine, and thymine. The order or sequence of bases specifies the genetic message for the cell, part of the language if you will. Interestingly, no matter what the source of DNA, man, mouse or bacteria, the bases are the same and the bases constitute a four letter alphabet known as the genetic code which is universal to all forms of life on earth.

An example of the bases, e.g. Adenine and Thymine:

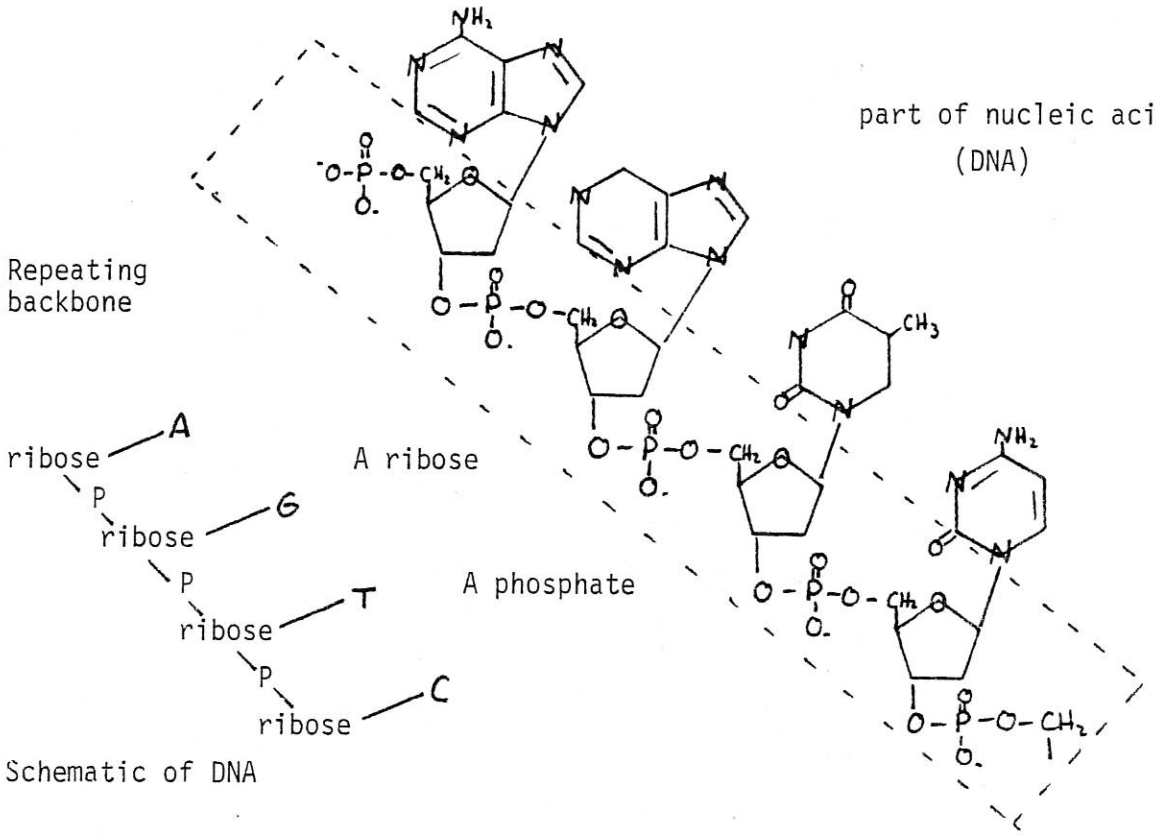


Adenine (A)



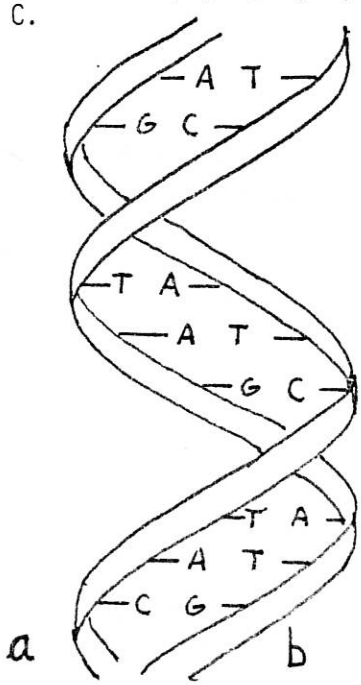
Thymine (T)

A nucleotide is composed of a base, a sugar (deoxyribose) and a phosphate. A sequence of nucleotides is linked by alternating sugar (deoxyribose) and phosphate (H_3PO_4) links to form a chain.



Schematic of DNA

These chains or strands are usually paired together as a double helix structure--something like a long rope ladder twisted around a corkscrew shape. If you straighten the ladder out then the sides of the ladder are long chains of sugar and phosphates. The magic of the latter is in the rungs. The size of the bases (A, T, G, C) allow pairing or rung making for A to T and G to C.

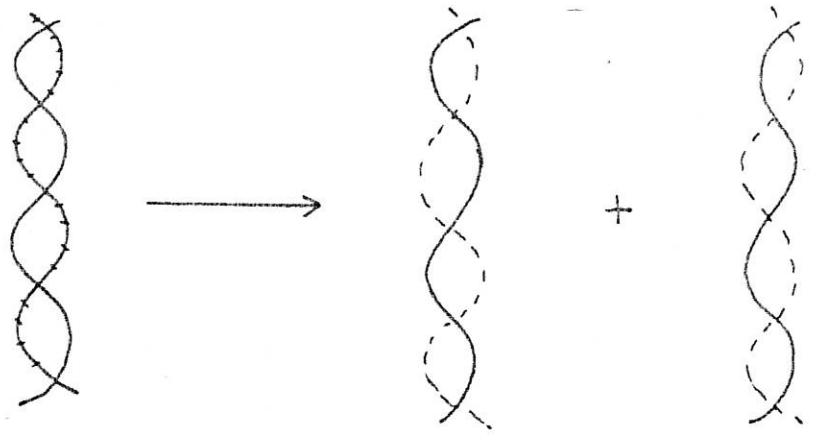


DNA Double Helix

a strand

b strand

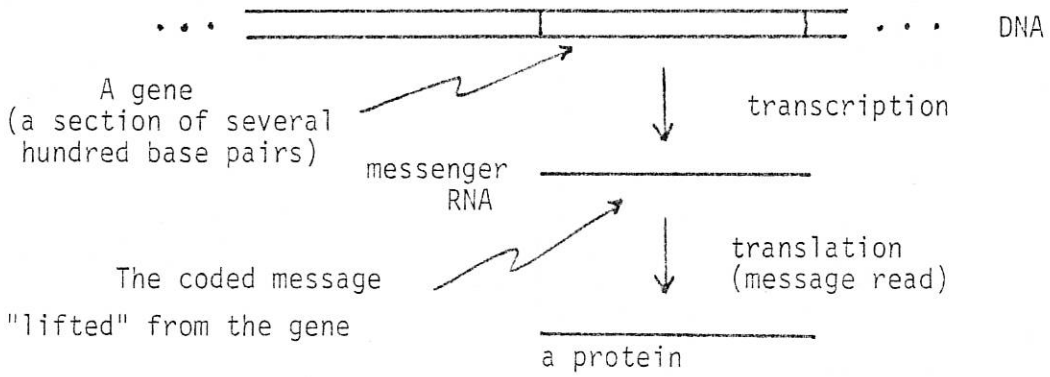
When cells divide the double strand unwinds and each strand is copied (replicated) to form two new offspring--thus cells multiply.



Parent First generation

An alternative is that one of the strands can be copied (transcribed) to form a messenger (messenger RNA) which moves from the nucleus to a region outside the nucleus and the message is decoded (translated) to form a protein. The central dogma of molecular biology is this flow of genetic information--from DNA to RNA and then to protein, and proteins make everything else.

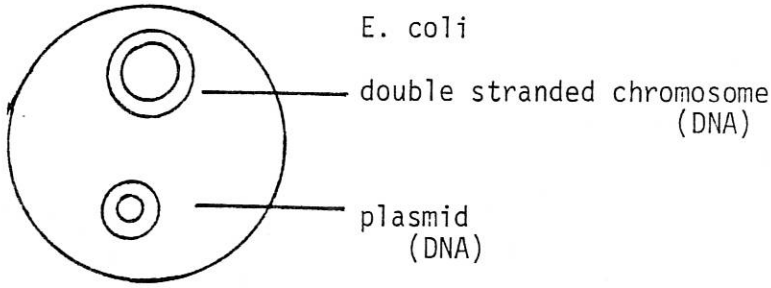
A summary of these events:



If the message or genetic literature can be altered, the protein product can be altered. Certain events cause changes, or mutations--such events include the action of chemicals causing serious genetic damage such as the tragedy that occurred at Love Canal in New York when toxic chemicals were buried by chemical companies, or ultra-violet radiation (excess sunlight) which causes skin cancer. Hundreds of genetic diseases or errors of metabolism are known . . . albinos lack a specific enzyme (a protein) to make pigment chemicals, sickle-cell anemia (Hemoglobin-S) individuals have an altered protein (hemoglobin) which is used to transport oxygen.

The persistence of genetic uniqueness is remarkable, especially among bacteria, since even when they o-cupy the same habitat they do not ordinarily endanger genetic information. The exceptions exist with bits of DNA called plasmids which are circular forms of genetic material which are in effect accessory chromosomes. They can pick up a short segment of information from the chromosome of its own cell and transfer it to the cell of a related bacterial species where it sometimes can become integrated into the chromosome of the recipient cell. Thus the plasmids act as vehicles to carry the spliced genetic information.

In 1973 scientists Stanley Cohen at Stanford and Herbert Boyer at the University of California at San Francisco reported the splicing of genes from two different sources--genes from a toad into genes of bacteria (Escherichia coli). The result: DNA chimeras* named after the mythological hybrid creature.

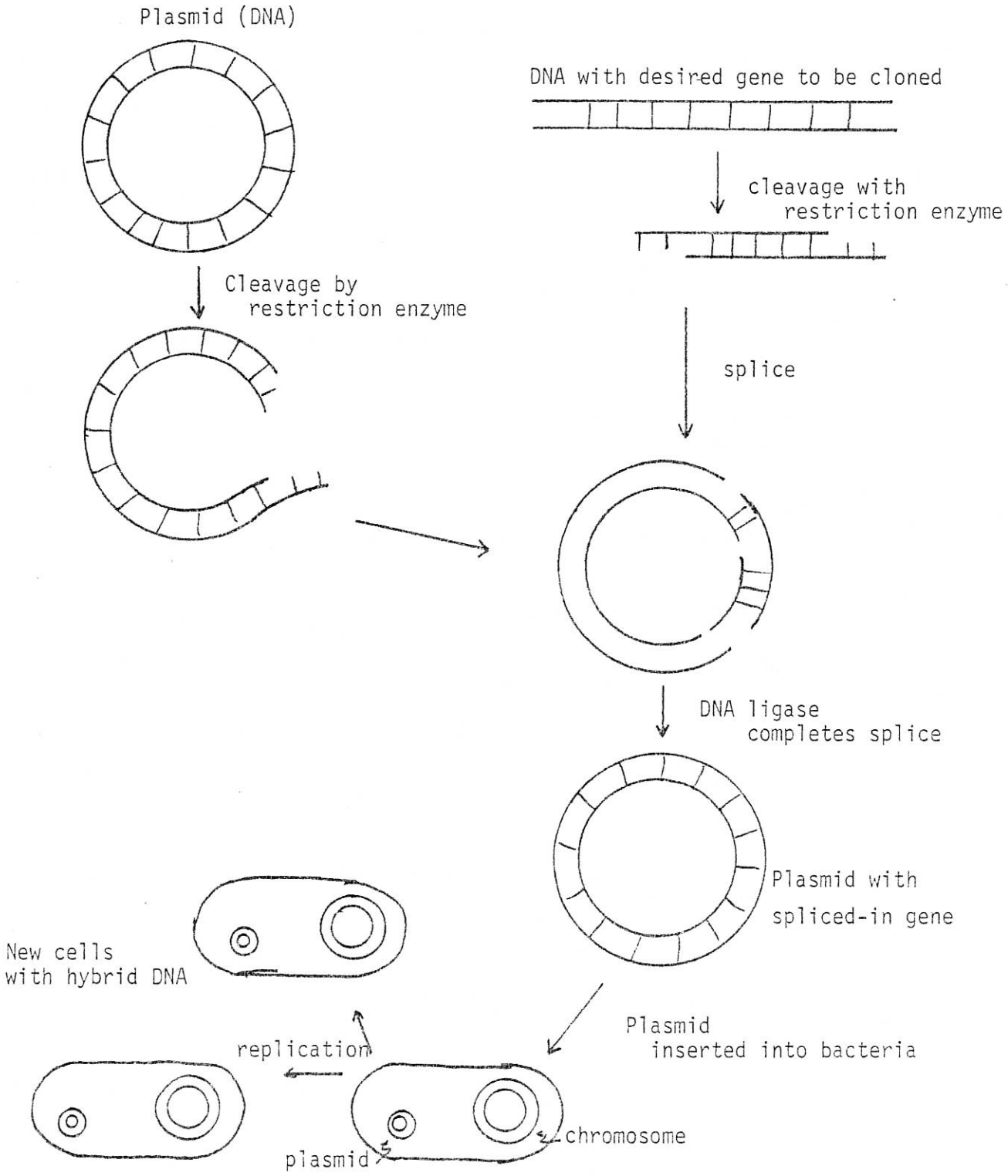


Since the methods of analysis for simpler systems were less successful for advanced systems (eucaryotic cells) this technique of gene splicing was like replacing a hammer and chisel with a scalpel. A major finding by Paul Berg of Stanford was an enzyme that functions like a biochemical knife called DNA ligase--an enzyme that normally repairs breaks in DNA and can join two loose ends together.

Two major requirements for gene splicing are restriction enzymes and a cloning vehicle. The restriction enzymes are the scalpel for the technique. They cut DNA at specific places and are a natural part of bacterial systems--a fortunate finding since design of such a tool would be impossible at present.

The second major step is a clone vehicle. A piece of DNA, or gene, is snipped from a selected DNA and inserted into a plasmid DNA sequence. The ends of the cut plasmid possess "sticky ends" that provide a site for insertion of the new piece. The recombined DNA of the plasmid is inserted into a bacterium and the bacteria are allowed to multiply providing a population of clones--all containing the inserted DNA fragment which is a gene expressing its genetic language. There you have it--designer genes! Calvin Klein of the cell.

* From chimera, a mythological creature with the head of a lion, the body of a goat, and the tail of a serpent.



The Gene Splicing Procedure

The twin breakthroughs--Boyer's surgical enzyme and Cohen's plasmics--opened the door to a powerful and extraordinary capability. Is it a bane or blessing?

The prospects are now to take a few simple chemicals, some simple equipment and a cell culture or two and in a few days create new or modified forms of life. Bacteria to make silk, rabbits that taste like prime beef or people immune to crippling disease or, if one theory of aging is true, change the DNA region corresponding to a genetic clock--ultimate biology indeed.

Just this last year, scientists at California Institute of Technology announced an automated gene machine for under thirty thousand dollars--not expensive as automated research equipment goes--that will allow intensification of genetic engineering research--a device that promises to make synthetic DNA, man-made genes, as comman and as available as test tubes. The question of what if somebody wanted to make something dangerous has not been addressed. An unenthusiastic view is that of Jacques Ellul, French philosopher and social critic who predicts that we will eventually become overwhelmed and consumed by the biological technology we create: "When technique enters into every area of life, including the human, it ceases to be external to man and becomes his very substance. It is no longer face to face with man, but is integrated with him, and it progressively absorbs him."[14]

Since the intense debate of a few years ago, the restraints on research have been relaxed. And when Wall Street discovered the double helix, questions about implications of research and environmental impacts and public management fell by the way.

The monoclonal antibodies, new plasmids and cell regulators are viewed as potential bonanzas for the marketplace. Herbert Boyer, who was one of the pioneers, is a millionaire many times over after he and others formed a new company to do genetic engineering. The genetic engineering is part of the revolution in biology that promises to transform the way we think about our world and the way we live. Historians will probably compare this time with the 1920's when quantum mechanics established rules for modern physics. A new industry is being born and devices like gene machines, conceived as research tools, are being commercialized at birth.

Some of the products of this technology, so far, include human growth hormones, insulin, interferon (to treat cancer), endorphin (natural painkiller in the brain), as well as nitrogen fixation enzymes for agricultural use, with a promise to relieve the world's food problem. Beyond these concerns, the sociobiologists' emphasis on genetic basis for human behavior raises questions about past, present and future human condition--questions philosophical, ethical, moral and ultimately religious.

We can now clone cells, genes can be rearranged and replaced, and modification of genes for cure of disease is possible.

The question is, will we give free reign to our skills, and perhaps give free reign to our free will and free choice, and attain a new sense of full humanhood, or will we try to hold to our "natural" innocence? I suggest it won't be long until we can use the technique of microinjection, for example, to introduce new genetic information into an egg fertilized in the lab and

then implanted in the womb, to develop normally to birth with new genetic information in place.

The prospect raises perhaps the most Faustian question we as a civilzation have yet faced: What exactly, shall we create? Do we face the "biological witches' brew"as Alvin Toffler suggests? A political compromise involving all of us seems a requirement lest we dare disturb the universe in an unhappy way. The words of H.G. Wells[15] in The Island of Doctor Moreau and of J.B.S. Haldane in Daedalus[16] lead us to conclude that man cannot play God and still stay sane. It is not necessary to forbid experimentation and exploration, however. The real thrust is that of intent. If we as humans are on the verge of becoming the dominant mechanism of evolution, what ends do we choose for the course of evolution? Are we wise enough to be masters of our own evolution? Clearly we have some thinking so. Some have examined human ideas rigorously and concluded that science is indifferent to ethics.[17] Noted geneticist Joshua Lederberg said in his paper at the Nobel symposium in Stockholm, "The suppression of knowledge appears to me unthinkable, not only on ideological but on merely logical grounds. How can the ignorant know what they should not know?"[18]

Joseph Fletcher, noted medical ethicist and theologian proposes that for the first time in the evolution of life, a living creature (man) has both the understanding and the ability to design itself and its future.[18]

If man has such a detailed molecular view of the mechanisms of biology, do we view man as just an elegant machine? Jacques Monod in his book Chance and Necessity[19] suggests man is a sophisticated machine with exquisite capacities for abstraction and mental stimulation, but no more; thus, is an existential void and the underpinnings of religious-ethical systems are removed. The voice of this twentieth century scientist, a Nobel Laureate in molecular biology, also offers these words: "Any mingling of knowledge with values is unlawful, forbidden."

The mechanistic doctrine suggests that humans have canceled the "ancient covenant" and stand alone. By penetrating to the core of DNA, biochemistry has removed the cloak of the unknown which bred the forms of god-making. Man is a product of physics and chemistry and Francis Crick suggests simply a "biochemical theology" for the future. These narrow views of scientific knowledge are perhaps understandable as the successes of biochemistry have come by reducing a large body of knowledge to a compact system. At present there is no complete theory of molecular biology, but hope persists, and the really important question is, will we find a deeper law underlying all this, just as the quantum mechanical principles have done in chemistry and physics? A key feature of this work in physics has been the realization that the observer cannot be excluded from the observation and this stands in stark contrast to the assertion of Monod. There may be more to the story.

Like Polanyi[20] we can appreciate a hierarchy of aspects of knowledge. Even if we know all about the physics and chemistry of the universe--the beginning and whatever end--we would know nothing about the possibilities of life--the potential of life; we would not predict consciousness, sentience. The discovery of those aspects of the universe however is not difficult--we who discover are who we are. The possibilities of life and mind by far extend and transcend the limits of physics and chemistry.[21]

Consider the concept of complementarity principles. Certain features of an atom--for example its stability--are not reducible to mechanics. Similarly we may find features of living cells which are not reducible to physics but whose features stand in a complementary relation to those of atomic physics. This is an idea suggested by Max Delbrück, a physicist turned biologist. It does not appear that revolutionary physical principles are required to describe the gene--just a lot of interesting chemistry. Unique qualities of biological systems are more likely to be found in the more complex mental qualities of human beings. The chemical interactions of genetic materials are somewhat taken for granted, but can the composition of consciousness be viewed in the same manner? Can we discover some transcendental element of consciousness to which the molecular revelations of molecular biology would rest in complementary relation? Consciousness and genetics are extremes of biological behavior. A consciousness factor that might be central to understanding the mind would have a physical aspect congruent with chemistry. The capacity for self-awareness is expressed only in the most complex array of matter, the human mind. How might such a concept be revealed? One difficulty here is the problem of raising the vitalistic dogma if there is a rudimentary form of consciousness that is present in simpler organisms, but certain forms emerge without necessarily implying the features of the higher forms existed in a rudimentary manner in simpler forms.

Thomas Kuhn argues that science is guided by paradigms which are defined as universally recognized scientific achievements that for a time provide model problems and solutions and any new theories or observations inconsistent with the paradigm are resisted. Perhaps we are in a transition approaching a new paradigm of sorts, with a unified outlook of the convergence of theological views of man, and the consciousness of man in his unique position is the high point of evolution. Man not only possesses consciousness but is also self-conscious; he knows that he knows.

The most significant thing about all of this, it seems to me, is not that great changes will occur in a generation or two. Rather, that as we consider a long time from now as we view a grand sweep to the future, we possess self-awareness, we have a new sense about the past, the present and the future.

> So walk I on uplands unbounded, and know that
> there is hope, for that which Thou dids't mold
> out of dust to have consort with things eternal.
>
> Dead Sea Scroll

In a lecture entitled, "The Discovery of the Future" H.G. Wells said. . . "All the past is but the beginning of a beginning, and that all that is and has been is but the twilight of the dawn. It is possible to believe that all that the human mind has ever accomplished is that the dream before the awakening. . . Out of our . . . lineage, minds will spring, that will reach back to us in our littleness to know us better than we know ourselves."[22]

Where are we? Who are we? Are we on the edge of a new theology--a fabric woven to include scientific views? Perhaps we can become a society of explorers and affiliate our creative endeavors to the organic evolution from which we have arisen. Truth and our ideals give us a purpose that bears on eternity. Michael Polanyi wrote, "Perhaps the problem cannot be resolved on secular grounds alone. . . " But its religious solution should become more feasible once religious faith is released from pressure by an absurd vision of the universe, so there will open up instead a meaningful world which could resound to religion."[23] The great cosmic drama has constituted a valid myth which by means of natural images has vividly brought home to the simplest understandings the claim that the historical Christ stands at the center of the Universe and is of crucial importance to men. It is absurd to criticize the myths for not being science or history and to proceed to draw scientific or historical conclusions from them. Neither science or religion alone can supply the answer. Theodosius Dobzhansky wrote, "A coherent credo can neither be derived from science nor arrived at without science."[24] Isaac Newton saw himself not only as a scientist but as a historical scholar whose duty was to decipher the Scriptures as a true historical record. The Creator, he believed, has given the scholar two books to read, the book of nature and the book of scriptures.[25] Alfred North Whitehead suggests that God is not to be viewed as an extraneous force who creates miracles and presides over the metaphysical verities. He is present continuously and ubiquitously.

Genetics of course is intertwined with evolutionary theory. The idea of God creating through evolutionary means is accepted by Christians but the implications are not realized.[26]

A most interesting view on God's method of Creation was written by John Wesley, founder of the Methodist Church in his five volume work: A Survey of the Wisdom of God in Creation; or A Compendium of Natural Philosophy.

> "There are no sudden changes in nature; all is gradual and elegantly varied. There is no being which has not either above or beneath it some that resemble it in certain characters, and differ from it in others...From a plant to man...the transition from one species to another is almost insensible. The polypus links the vegetable to the animal. The flying squirrel unites the bird to the quadruped. The ape bears affinity to the quadruped and the man ...By what degree does nature raise herself up to man? How will she rectify this head that is always inclined to the earth? How change these paws into flexible arms? What method will she make use of to transform these crooked feet into supple and skillfull hands? The ape is this rough draft of man; an imperfect representation which nevertheless bears a resemblance to him, and is the last creature that serves to display the admirable progression of the works of God! There is a prodigious number of continued links between the most perfect man and the ape."

Dobzhansky argues that Christianity is a religion that is implicitly evolutionistic in that it believes history to be meaningful: its current flows from the Creation, through progressive revelation of God to Man, to Christ and from Christ to the Kingdom of God. In the writings of St. Augustine this evolutionistic philosophy is quite clearly expressed.[27] An additional perspective given by St. Iraneus presents a moral maturity argument that views us in a half-finished world of mingled good and evil where we are co-creators with God in this divinely appointed environment.[28]

It is clear to me that we need to reconsider a pre-nineteenth and post-nineteenth century view of religion and theology that incorporates and integrates post-scientific world view. Perhaps we need to reconsider the work of Darwin and Copernicus in this new context. It is likely that the new evolution based ethic will annoy many people just as did Copernicus' work which daringly proposed that the Sun, not the Earth was at the center of things and the church placed his work on the forbidden list "until corrected" by local ecclesiastical censors. In a way Darwin has healed the wound inflicted by Copernicus and Galileo. Man is not physically the center of the universe, but he may be the spiritual center.

Contemporary scientists such as Jonas Salk have opted for an evolution-based ethic. He describes what he considers to be a current, inexorable modifiable movement into Epoch B which will require fitness and wisdom. His outline appears to be a fairly complete theology even though he never uses the word God.[29]

Will such a grand, visionary sweep of evolution constitute merely a deterministic view with man helplessly swept along? A better view is Pere Tielhard de Chardin, theologian and scientist, who suggests that history of the universe moving toward an ever higher and more complex organization will converge toward a future focus, the risen Jesus, who is the divine influence that pulls the world forward into the future and he contains the ultimate future in himself.[30] The fundamental model of his Christology is biological evolution.

Christ had to be an element of the world in order to become the central element of the world--thus the reason for the Incarnation. The small Jesus in a cradle was not simply a lesson in humility but also a view of birth followed by Christ being engrained in this world.

Do I suggest that we try to build a set of values solely out of biology? The answer is quite simply and clearly, no. People much more qualified than I have failed in such attempts. The understanding we now have of biological systems is impressive and the potential to alter life systems is quite remarkable, but there is an incredible amount we still need to learn.

There is no question that this expansion of modern science has profoundly influenced religious belief. There are the arguments that the legacy of scientific advance has been a retreat or organized religion in the brightness of enlightenment's brightening dawn.[31] In his book, The Survival of the Wisest, Jonas Salk[32] suggests that many of the concepts and symptoms developed by religion have been poetic formulations which have helped provide a conceptual

framework by which to live but have continued to be regarded too literally or not metaphorically enough. Is religion to become a cultural "fifth wheel"--a leftover from a previous age? I argue that science and religion can resound together.

The influence of scientific knowledge has been at a maximum within the Judeo-Christian tradition where the doctrine of creation provided a cradle for empirical natural science. In this tradition God is the infinite, self-existent Creator of all things other than himself.

I refer once again to the example of Isaac Newton and others who believed the Creator has given the scholar two books to read, the book of nature and the book of scriptures and thanks in part to the relentless advance of science pioneered by Newton, God's immenence has been pushed to somewhere below sub-atomic particles or beyond the farthest visible galaxy. Religious and scientific pursuits are intrinsically compatible.

This scientific perspective on both the world and life as evolving has affirmed the theme of *creatio continua*. The scientific perspective has re-introduced this important feature into the idea of creation. It represents the realization that the cosmos, sustained by God, is and always has been producing new emergent forms of matter. Creation at the beginning establishes the conditions for the possibilities emergent in the history of creation.[33] The world is still being made and man has emerged from biological life and his history is still developing.

The classical Christian doctrine of creation did not assert that the world had a beginning at a point in time but that the cosmos continues to exist at all times by the creative and sustaining will of God. Augustine argued that time itself is not an element in the created universe, therefore no "act of creation" can be assigned to some point within created time.

The dramatic passages in the first chapter of Genesis are properly regarded not as literal records but an explanation of how human life came about as a result of a once and for all irreversible event. Science, by eliminating a naive literalism, has restored credibility of these Genesis stories as accounts of the way things are.

Much has been written about the origin of the universe and scientific cosmology does not contraduct the idea of creation.

The inference made about the origin of things is fashionably called The Big Bang or sometimes the Hot Big Bang but it has been suggested that characteristically we have assigned the wrong words for this beginning in order to avoid another term that might be embarrassing.[34] There would not have been any sort of bang with no atmosphere to conduct sound waves and no ears. It was something else in an unimaginable silence. It was the Great Light. "There was the true light which, coming into the world, enlightens every man" or "In Him was life; and the life was the light of men."

In any case the point of the doctrine of creation concerns the relationship of all the created order, including time, to the Creator. There are processes in the development of the cosmos that are continuous and there are regularities and relationships and things fundamentally shared.

New forms have occurred in this cosmic development and appeared in continuity with old forms, yet new emergent levels of organization have appeared that require non-reducible concepts and language to describe their distinctiveness.

Consider that familiar example of DNA. The chemical structures with specific types of bonds are describable with laws of physics and chemistry, but the actual sequence that occurs for a given cell in some organism cannot be explained purely by those laws. The DNA is assembled in a certain way to provide the genetic blueprint when it functions in the context of the whole organism. The actual sequence of base pairs are no more described by laws of physics or chemistry than the operation of a machine can be described by the physics of a piece of steel;[35] or it has been said you can describe all of the individual parts of a machine but still have not described what it can do. This explains the idea of emergent qualities that are irreducible.[36] Mental qualities of man are genuinely emergent--those capacities for abstract thought, avid curiosity and self-consciousness.

What the scientific enterprise provides is the view that matter has been in continuous development so that new forms of matter have emerged up to man himself--who now explores the world around him and the very path by which he has emerged on the scene. Man in evolution has now become history, and from a strictly biological point of view, a unique feature of humans is the ability of man to choose and shape his environment through the knowledge about that environment that he obtains through his senses and technology.[37]

Man is self-consciousness, he knows that he knows and uses the word 'I' thus proving to be a new entity with a mind that is able to transcend its own environment. There are certain human activities that accompany 'persons'--the ability to act rationally, to make moral choices; to explore; to be creative and worship and pray.[38]

What is this 'material' of the universe that in time is organized to form the brain of man, a Bach or Shakespeare, the person of Buddha or of Jesus of Nazareth?

The content and perspective of science at least can help us clarify to what sort of universe we refer when we ask about its meaning. One of the important aspects of this emergent form of life, man with his self-consciousness, is that such a creation involves a cost. Creation is an example of God, taking a risk, a self-offered love as he deliberately allows his creation to bring into existence a new and hazardous possibility--the self-determining person. Christians have affirmed that God is love in his self-imposed limits by allowing a cosmos where man can repudiate; or again, God's love offered in the self-limitation of his incarnation in Jesus Christ-this Jesus who came as a newborn baby.

I have been developing the posture that the two views of man--from the Christian experience and from the scientific enterprise--complement each other and now in this search we need to consider the possibility of God revealing himself as man and what significance this holds in the light of the scientific view of an evolving cosmos in which man has emerged--an emergence which reminds us that this and each stage represents a defining and focusing of future possibilities as yet unrealized.

We ask, what can we know of God's meaning for man? The figure of Jesus of Nazareth stands as a unique figure in history when you consider the influences on culture and challenges in his person and teaching. The impact is not like ripples from a stone in the pond but like a great deluge altering the landscape as depicted by Leonardo da Vinci.[39]

The man Jesus existed as we do--made of carbon, nitrogen, hydrogen--his body bore the marks of its evolutionary history and his DNA was based on the same genetic code used by us and all other living creatures--genetic language expressed in time and growth to adulthood. He came as a newborn baby, representing a new beginning. God certainly has shown in Jesus a new view of what his purposes are in the cosmos and the meaning written into it in the form of man. In some Eastern writers the emphasis on man being raised to God is very strong: The Word. . .became man so that you might learn from man how man may become God.[40] That may be too extreme for some but consider the ideas of Paul[41] in the parallel between Christ and Adam. Christ is the last Adam (man in Hebrew) and the second man. Jesus Christ achieves God's purpose in his perfected human nature in contrast to the mythological view of Adam, the first man who never attained what God intended. "If any man is in Christ, there is a new creation."[42]

The incarnation of God in Jesus illustrates all that men might be and this meaning is illuminated by the scientific account of the origins of man. In one of his books A.R. Peacocke states: "For God-becoming-man, the Incarnation, as an event in human history, can now be seen as the consummation of that evolutionary process in which the rise of man succeeded the general biological sequence. The sequence observed and inferred scientifically implies for Christians that both the processes of cosmic evolution and the Incarnation are alike expressions of the creative, self-limiting love of God."[43]

The scientific perspective has brought us to a view of matter which sees it manifesting mental, personal and spiritual activities--man reflects, creates, loves, plays and much more. There is convergence between the scientific view of the capabilities of matter and the sacramental view where matter has the symbolic function of expressing God. With the Eucharist we see that two sacraments--the symbol of revealed truth through a created world and the Incarnation--converge by virtue of both being represented by the very stuff of the cosmos and not an incidental emphasis on the use of bread not corn, wine not grapes--products of man in cooperation with nature.

This convergence supports a unity of views between the scientific enterprise and the enterprises of theology and the humanities. Man has been brought to a point where he is invited by his Creator to participate consciously and willingly.

It is not easy to conjecture as to how man is to become co-creator with God but the fact that a question of how it could be possible at all raises profound questions for the whole of Christian resources.

We see that by starting with the activities of natural science with its expanding influences for man's view of the world we have been led to consider the central tenets of our theological knowledge.

I would like you to join me and ask: "Is this an ending or is it a beginning?" In a peculiar way it may be both--perhaps the end of a beginning yet at a new place that makes us think of a new beginning for things as we look far ahead to the future. By future I refer to the really long run where perhaps the most certain thing is a promise of radically new things.

A symbol and a belief that is very important in the Christian context is that of new beginnings in birth and rebirth--the birth of the baby Jesus both real and symbolic and the rebirth of man as he realizes his potentialities.

This theme of beginnings and rebirth has been powerfully illustrated in such diverse ways as creative cinema and unique dreams.

Recall with me the compelling final minutes of Stanley Kubrick's 2001: A Space Odyssey. David Boman, space traveler from earth to another planet, had encountered an alien civilization evidenced by the great monolith which represented a synthesis of life, computer and intelligence--surely he must have wondered about the future and what it would reveal. Exhausted he slept and dreamed. He dreamed of floating free, viewing the universe as some gigantic mind of which he was a tiny part and then of racing back through corridors of time to a simpler world. At last the regression of time slowed and then at a timeless instant a baby opened its eyes and began to cry. The baby stared into a monolith which appeared--seeing but not understanding--future mysteries beyond. It realized that beyond would be another birth-stranger yet.

In the chapter Dreams of Earth and Sky, in his book Disturbing the Universe, Freeman Dyson tells his dream and he suggests when reason sleeps, strange spirits roam. The dream is of his travel on a small spaceship out to galaxy after galaxy--cruising the universe for a long time but seeing only infinite blackness. . . the galaxies passed before him but the Lord was not in the galaxies. Two weeks later a second dream... he was playing with his children and an important matter required attention of God. He asked the children to come along; they went to a large building--something like a church but no ceiling and the building seemed to disapper into the distance like an elevator shaft. They arrived at the top of the shaft, entered an enormous throne room. A large wicker throne appeared empty--they walked toward it, took a closer look and saw it was not empty after all. There was a little baby lying there. After a few minutes of holding him, with no one speaking, they gently placed him back on the throne and left--they had found their answer.

We start from where we are and we find as T.S. Eliot spoke in Little Gidding:

> We shall not cease from exploration
> And the end of all our exploring
> Will be to arrive where we started
> And know the place for the first time.

- - -

The Beginning.

Notes

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