INSTITUTE FOR THEOLOGICAL ENCOUNTER WITH SCIENCE AND TECHNOLOGY

BULLETIN

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Welcome to the year 2005, the 37th year of our existence. With our enhanced sense of purpose arising from our dedication to an as yet unfunded project in education there is a new spirit stirring in ITEST. It is hope, built on faith in God — and in some as yet unidentified Foundation(s). But hope automatically leads us to One who loves us beyond all telling. It is in part a spirit of looking forward to "Love one another as I have loved you." It is hard to find greater love than preparing children to love their God and the earth they will inherit.

The cosmos, the things of fire and of light, the clay and the sea, is the first manifestation of the presence of God ultimately to us. But God's presence is never to be found in generalities. It is to be discovered only in the particular elements of daily living. God did not become man to save humankind. He came to save John and Marie, Sarah and Timothy. They, not humankind, will go to heaven in glory.

We need faith, hope and love if we are going to love God as fully as He wants us to love Him. In the eschaton, in blessed unity with God, faith will yield to full vision. We shall see God "face to face", not like Moses who was permitted to see only God's "backside." Hope will yield to possession ("Do not cling to me, because I have not yet ascended to my Father" ... the clear implication is that when Mary Magdalene ascends to the Father it will be quite a meeting). Only love survives the transformation of "these wretched bodies" into copies of Christ (Ph. 3, 21). Only God's love for us and our love for Him will survive into heavenly joy.

If we can help by teaching children of God's love for us and of His desire that we love Him as well as of the mystery and beauty of creation — and, yes, its utility for humankind — we shall have accomplished much. We shall have set them on the road to a life fulfilled in their thanking, their praising and their glorifying Him who made all things for our benefit as well as His glory. We shall try to make the children "see" the glory they can give to God. But most importantly we may be able to share with them the love of God who made us and who wants us above all things. God be with you as we move down this road.

Robert Brungs, S.J.

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ANNOUNCEMENTS

1. Just a reminder: We noted in the last issue of the bulletin that ITEST will no longer retain the 221 North Grand Boulevard address. From now on please address all mail to:

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We have not moved to a new location; the Grand Blvd. address mail makes its way slowly through the St Louis University system; whereas, Lindell Blvd. mail is delivered directly to our office building.

2. The October 14-16, 2005 Workshop (*Biological Advance, Patenting And The Law*) is scheduled to be held on October 14-16, 2005. The ITEST Board of Directors considered various topics for this workshop and in the end agreed that these significant and timely issues were well worth revisiting. Our last workshop on *Biotechnology and Law* took place fourteen years ago and the Board felt that it was important to update our study of the technological advances made since then, such as fetal and adult stem cell research, cloning, gene patenting, and the application of principles of law relating to science and technology as they evolve in 21st century society. Ethicists and humanists working in the area of biotechnology will present arguments pro and con. We have secured the expertise of five essayists: Dr. Joseph Murphy, S.J. (Theology); Mr. David Saliwanchik, Esq. (Law), Dr. Randy Prather (Animal Research), Dr. Brendan Niemira (Agriculture) and Dr. Kevin FitzGerald, S.J. (Human Cloning and Stem Cell Research). Our Lady of the Snows in Belleville is the venue we've chosen for the weekend workshop. The formal invitation will be sent out in March or April. It might help now, though, that you include this workshop on your calendars. Contact S. Marianne Postiglione, RSM for information.

3. We have received a number of compliments on the design and content of our book, *Globalization: Christian Challenges*. Among them, our representative at Sheridan Books, noted that of the hundreds of books they print yearly, our artist's cover design is one of the best. Designer, Leonard Buckley, manages with each successive cover to capture the essence of the workshop in a single and unified image inviting the "browser" to explore the contents further. If you ever questioned Len's ability, wait until you see the design for the next set of Proceedings on *Computers, Artificial Intelligence and Virtual Reality*. We think it will "knock your eyes out." Copies of *Globalization* are available for sale at $19.95 each, postage and handling included.

4. Over the years we have tried to publish tributes about our members. Recently Salve Regina University in Newport, Rhode Island published an article on Sister Mary Brenda Sullivan, RSM in its Quarterly Magazine, *Report from Newport*. The author, Maria Ann Campo Kolarsick, among many other things, stated:

"I recently had dinner with my sister-in-law, Patty Kolarsick Meehan '66, who attended Salve Regina 10 years before me. This allowed us to swap and compare stories about the legendary Sister Mary Brenda Sullivan, our biology professor. We felt so fortunate to be able to share our fond memories of her and reminisce about what an excellent and approachable educator she was and still is....

".... Our memories of Sister Mary Brenda Sullivan are swift, loving and a testament to our great respect for her. Behind those twinkling Irish eyes and that devilish grin, she just pretended to instill fear into the hearts of her students. Looking back now, I recognize that this trait of hers was actually a playfulness she possessed and used with the single intent of connecting with every student entrusted into her hands.

"Through her devotion to her students and her recognition of her role as a religious educator, Sister Mary Brenda Sullivan has had a tremendous influence on a generation [ed: actually, two] of nurses and a countless number of their patients. What a powerful gift."

Way to go, Brenda.

If any of you have articles like this recommending you or other ITEST members, send them in. We'll publish them from time to time.

ARTIFICIAL INTELLIGENCE
THE EMERGENCE OF A NEW SCIENCE

Dr. Joop Schopman, S.J.

Dr. Joop Schopman was born in Arnhem, the Netherlands in 1937. He studied philosophy in Nijmegen and experimental physics in Amsterdam. He received his PhD at the Municipal University in Amsterdam in 1971. He worked as a research assistant and as a research scientist at the F.O.M, laboratory for Atomic and Molecular Physics in Amsterdam and later in the same position at the Institut de Chimie at the University of Liege, Belgium. In 1974 Dr. Schopman was appointed to the Central Interfaculty of the State University of Utrecht, where he specializes in the history and philosophy of science. He is co-founder and board member of SAIA (Social Aspects of Information and Automation), a Dutch subsection of IFIP. He is a member of the European Association for the Study of Science and Technology. He has published in physics, the history and philosophy of science, and in science-technology-society areas. [This presentation was first made at the ITEST Conference on Artificial Intelligence, March, 1984.]

Prologue

According to the sociological criteria Artificial Intelligence (A.I.) has taken its place among the sciences. It has its own scientific community. Since 1964 there exists the `Society for the study of Artificial Intelligence and simulation of behaviour' (AISB) which now has about 600 members. In 1965 an international meeting was held in Edinburgh as the first of a series of workshops; the proceedings edited by N.L. Collins and D. Michie with the title `Machine Intelligence' were landmarks in the development of the field. A series of international conferences started in 1969 as the International Joint Conference on Artificial Intelligence (IJCAI). The community had its own journal *Artificial Intelligence* since 1970. And finally, in 1982 the third and last volume of *The Handbook of Artificial Intelligence* was published under the redaction of Paul Cohen and Edward Feigenbaum.

As all new disciplines it took quite a while before A.I. got external recognition. One could say that the first to recognize the field politically was the Japanese government. Its 1981 decision to develop a fifth generation of computers gave A.I. a political status. Quite a few governments realized then that the results of A.I. research could have an enormous impact on their economies which had already had difficult times.[1] All this might not convince every one that A.I. has a scientific value. Let us therefore consider A.I. more closely.

I. *Artificial Intelligence, its scope and some of its history*

As in all young sciences -- still immature in the eyes of the established disciplines -- there is a lot of discussion about how to define the field. A not irrelevant fact because the title A.I. covers quite a variety of intellectual endeavours and it is not surprising that each one prefers to define the field from its own scope. As a working definition we could use: A.I. is the study of intelligence by means of computers.

The idea of simulating human (intelligent) behavior by machines dates from before any computer existed; the construction of sophisticated mechanical robots in the 17th and 18th century exemplifies that. But even the start of what is now called A.I. took place before any usable computer was available. Already in 1936 "Alan Turing claimed that there was a machine that could be built that would be a sort of `universal machine'. He said it could do every possible computation. By extension, it could carry out any operation that any other information machine could do, whether it was an abacus or an animal's brain. This was possible, he said, because this ultimate machine could simply take for its instructions a complete description of the machine to be imitated."[2] Before he started to realize his ideas (1946) there was quite some effort going on in the USA to actually build computers. The appearance of computers promoted the analogy between computers and the human brain. Work was done in this direction by the neurophysiologists Warren McCullock and Gray Walter, the physicist Donald MacKay, the psychiatrist W. Ross Ashby and the mathematicians Walter Pitts and John von Neumann.[3]

Ashby even tried to build `a self-organizing system', which he called a `homeostat'. "It's a cluster of four units, each unit able to emit direct current output to the others and to receive theirs in turn. Since definite values were assigned to various governing devices in the units, the homeostat would begin to exhibit definite patterns of behavior relative to the settings of those governing devices, always seeking to stabilize itself. Ashby extended this principle to living organisms, suggesting that their adaptive, learned behavior could be expressed as a system that organizes itself to seek stability.

He pointed out that his own aim and the aim of a person who designs `a new giant calculating machine' might both be described as trying to design a mechanical brain. But the latter wants a specific task performed, preferably better than a human can do it and not necessarily by methods humans might use, while Ashby's aim `is simply to copy the living brain. In particular, if the living brain fails in certain characteristic ways, then I want my artificial brain to fail too, for such a failure would be valid evidence that the model was a true copy' (1952).

Here Ashby articulated the distinction that would subsequently define two major branches of artificial intelligence: one aimed at producing intelligent behavior regardless of how it was accomplished, and the other aimed at modeling intelligent processes found in nature, particularly human ones. That division was to turn out to be less distinct than researchers in the 1950s imagined.[4]

Slowly more people got involved helped by the increased technical possibilities of the computer. For example John McCarthy heard von Neumann speak at the Hixon Conference (1949) and Oliver Selfridge (MIT) started a group to discuss A.I. in connection with pattern recognition. A talk by him at the Rand Corporation (1954) put Allen Newell and Herbert Simon on the A.I. track. At that time both were working there on organizational problems.

But more important than the quantitative growth was the change of attention, the different course. The comparison between brain and computer structure was left alone (and only quite recently taken up again (George Hinton, CMU). The emphasis was shifted to the writing of programs (and construction of hardware) to get the computer to behave in ways which resemble some human behavior. The Darmouth Conference in the summer of 1956 might be considered to have been the turning point and the start of the actual A.I. work. For that occasion the field was dubbed by one of the organizers, John McCarthy, as Artificial Intelligence. One of the remarkable events of that conference was the presentation by Newell and Simon of a program called `Logical Theory Machine' which could prove theorems of the `Principia Mathematica' by Whitehead and Russell.

Next to this type of problem a lot of attention was paid to games, not to the now popular war games, but to intellectual games which are clearly rule-governed: checkers and chess. Checkers, the rules of which are simple, was the first problem to be successfully attacked by Arthur Samuel. Playing chess proved to be much harder. Although the game is a neat problem, a few rules regulate the movements of some six different pieces, nevertheless, it seems a real intellectual game. As the computer scientists soon found out the number of possible moves is so large, that the game can not be calculated completely. So, the computer must, so to speak, imitate the human approach: develop a strategy, i.e., it had to calculate a limited number of steps in advance, which look most promising.

This is an interesting development. It shows that even a neat, not very complicated situation such as occurs in chess, can not be solved exactly. Only a reasonable approximation can be obtained. An appropriate strategy has to be developed because there is no general solution, only particular ones, adapted to the situation: i.e., external knowledge is needed (the so called "knowledge of the world"). The same proved to be the case with Problem solving. Initially one tried to develop a General Problem Solver. No chance.

But what resulted from this were methods, tools (like heuristics, search) which also proved to be very useful for other types of problems. But there were even more surprises to come. It turned out to be the case that the so called intellectual tasks like chess, logical reasoning are not the hardest to solve. Ordinary abilities like language, human vision, and human action are more challenging. With hindsight one can explain this. Those human capabilities are the results of a long evolutionary process, and therefore much more built in. They happen so to speak, unconsciously and are therefore much harder to formulate explicitly, if at all.

Those developments had an enormous impact on the A.I. ideology. Originally, the computer was seen as the model of human mind and some people still hold this point of view. "What can be done by cells, can be done by Integrated Circuits (I.C.'s)" Simon told me. But the above mentioned developments made a lot of researchers much more modest. They see A.I. and the tools it developed as tools for solving the problems in their own field, e.g., linguistics. It is a metaphor, several people told me, and we use it as far as it goes. The change became manifest in the appearance of a new name, "Cognitive Science." A journal called by that name started in 1977. Where Artificial Intelligence is often a part of Computer Science (as at Stanford and CMU), Cognitive science seems to cover the cooperation between Linguistics, Psychology, Philosophy and Computer Science.

One might conclude from this that the internal development with A.I. made the field no longer a competitor of the human being, but more a tool which can be used to get a better understanding of human intellectual abilities.

II. *Artificial Intelligence, the actual status*

1. Research topics[5]

History, personal interest and (inevitably) commercially useful applications have shaped the domain of research. The main topics are: inference and reasoning; search, planning and problem solving; natural language understanding and speech recognition; vision; representation of knowledge; learning (knowledge acquisition); expert systems and robotics.

Inference and reasoning: we have already met it. It has focused mainly on mathematical reasoning, theorem proving and deduction. A process which as we remember from our schooldays require quite some intellectual skill. There are many ways which lead to Rome, but finding the shortest (and most elegant) one is not so easy.

*Search, planning and problem solving: c*haracteristic for human behavior is that it has goals; that it wants to realize those goals. It therefore needs planning. As indicated in relation to the chess problem, even a simple, rule-governed situation has already too many options to be calculated exactly. One needs a strategy, to search and to evaluate the possibilities at hand, and to decide then which strategy appears optimal.

Natural language understanding (spoken language): the dream of automatic translation (from Russian to American) was one of the first efforts, and it proved to be a complete failure. Understanding spoken language proved to be too difficult a task. But even a much simpler (?) problem: the understanding of written language appeared to be very difficult. Several efforts have been made to understand sentences by syntactical analysis. It turned out to be impossible without a simultaneous semantic analysis. Even understanding of utterances concerning a very limited domain of human experience proved to be extremely difficult, because it nearly always presupposes an understanding of (some of) the rest of the world.

Vision: it runs into similar type of problems. In order to see, to recognize, i.e., to be able to attach meaning to the visual input a large degree knowledge of what one is seeing is needed. Here top-down and bottom-up approaches change as do fashions. Although there are some industrially applicable devices available as spin off of the A.I. work, they only operate in very simple (artificial) environments. (N.B. Both language and vision problems appear to be tractable as long as they are restricted, e.g., limited to `block worlds', i.e., to a limited amount of neat geometrical objects.)

Representation of knowledge: in particular the last two fields make clear that a `knowledge of the world' is necessary, but how can that knowledge be represented in a computer, so that it can perform the functions as human memory does. How do we do it? Several techniques have been developed, e.g., semantic networks.

Learning (knowledge acquisition): perhaps even more important is how those representative systems can acquire (or delete) knowledge. As you can imagine, this is about the culmination of all difficulties. Relatively less has been done in this area.

Finally, more directly application oriented area's are:

Expert systems: systems which try to make the knowledge of experts explicit. For example the knowledge of chemical structure and of the way the chemical substances split in mass spectrometers has been used to make this kind of chemical analysis automatic. It also has been applied to several medical fields and oil exploration. It seems to be a commercially promising spin off.

Robotics: here mentioned as a particular field (of application). It depends heavily on the outcome of the other mentioned fields, e.g., vision, but it also has a complete new problem, namely that of *action*, the performance of three dimensional movements, and the coordination of all participating fields. In particular the development of the fifth generation computer, i.e., an intelligent robot will need the support of all mentioned fields.

2. *Disciplines involved (and their interaction)*

Originally people were involved who can not be described as mono-disciplinary, e.g., Turing got interested in biology, von Neumann studied physiology. There were a lot of contacts between information theory, mathematics, management, logic, automatic theory, statistics, psychology, engineering, cybernetics, physiology. Now the participation seems to be limited to computer science, logic, psychology and linguistics (philosophy).

Computer science that will speak for itself: it provides the `interface' with the computer; how to handle the computer. A.I. is often a subdivision of Computer science, although the relation is not always harmonious.

Logic: in particular mathematical logic plays an important role in the writing of programs for computers. It is a powerful instrument for the analysis of problems, and for the formalization of theories (e.g., formal semantics). New kinds of logic have been developed to deal with problems particular for A.I.: e.g., fuzzy logic.

Linguistics: the Chomskian approach has initiated a whole series of efforts to formalize language. No acceptable theory has been developed so far. For some the computer proves to be a good tool to test the theories which they have developed. For others, the computer will give the final solution, because language is just information processing.

Psychology: like linguistics it does not have an appropriate theoretical basis. For some the computer model provides the desired model, `the computational paradigm'. For others, it is still to early to look for a general theory. There is not enough knowledge available.

Philosophy: A.I. advocates have made strong philosophical claims, in particular, in its earlier phase. So, it claims to have solved centuries-old philosophical problems, like the mind-body relation, intentionality. Few philosophers try to understand A.I. and to use it, some others have reacted violently against it: A.I. has nothing to do with intelligence at all. But most philosophers do not even notice its existence (the same is true for the bulk of the other disciplines).

Although it seems to be a project which requires interdisciplinary cooperation, that hardly exists except for some technical projects. Interdisciplinarity exists only in persons, e.g., a linguist who learns to program a computer, or a computer scientist who goes into psychological literature. Even interdisciplinary courses and centres are just an addition of disciplines. Recently Stanford has started a common research project with computer scientists, linguists and logicians.

11.3 Geographical situation

As described A.I. has its origin in the U.K. and the USA. And it has been restricted to the two countries until quite recently. In Edinburgh, Scotland, Donald Michie succeeded in creating the major center of the U.K., but growing difficulties resulted in a report by Sir James Lightfoot (1973) and in a dispersion of many researchers over other U.K. universities and over the USA as well. Outside the University of Edinburgh, Sussex and Essex became the centers. In the USA things started with individual people in different places; MIT was the most recognizable point. From there it spread to the Rand Corporation, Newell and Simon, who moved to Carnegie Mellon (1955). Several people from MIT moved to Stanford, where they started an A.I. section at the Computer Science Department (1963). These three, MIT, CMU and Stanford became the major centers, although at a lot of other places people did similar work (e.g., Maryland, Rutgers University, University of Massachusetts at Amherst, Cornell University). The last few years A.I. is taken up in Japan and in several European countries. The resistance to enter the field, which might have been caused by the extreme claims of some A.I. researchers, was put aside when the possible economic impact became apparent. But with the exception of the mentioned fifth generation computer project of Japan, at the Institute for new generation computer technology (ICOT) in Tokyo, there is no major A.I. research center outside the USA.

III .1. *Its impact: it will be enormous*

Its social impact: the impact on the productivity of labor will be large, but not revolutionary. It is a continuation of a trend which is changing our labor pattern since the second World War: automation - micro-electronics - robots - intelligent robots. It all will help to increase our labor productivity considerably and not only of the blue collar workers. E.g., by the introduction of micro-electronic devices (computers) the California Bank of America will in 1984 make 4000 of its employees redundant.

All the talking about the creation of new labor places is to a large degree just ideology, in the negative sense of the word. When we work, it will be so more efficiently, that we will have to work fewer hours (or fewer people will work, that is our choice). This in itself is not a negative development. I might even dare to say: it is a positive effect. Or better, it can be a positive effect, if we are willing to rethink the position of labour in our life and the distribution of income. Micro-electronics can have many positive effects, promotion of democracy for example, but it appears to become a threat to our privacy. The same is true of A.I. Intelligent machines can be tools to improve our existence, if... But there are many signs that the `if' - condition will not be fulfilled, or perhaps only after a catastrophic existence for many people. The tension inside societies will rise very high.

The increase in productivity and the thereby reduced need for labor, and in particular of skilled labor, can have a disastrous effect on the educational motivation of our youth; a trend which can already be seen. This means an enormous burden on our educational systems. Because on the one hand a utilization of the best minds will be needed to keep the industry competitive with other economies (otherwise the whole system will collapse); on the other hand it must be able to motivate people, and in particular the youngsters, to exploit their talents in a non-productive way.

Machines were only a threat to the skilled blue collar labor. This micro-electronic intelligent robot will take the place of many white collar workers as well. Now it is the bank employees who are fired, the next ones might be the medical people and teachers. The expert systems and communication networks will do their job better. Will they?

This development will have an enormous impact on the distribution of wealth in the world. Now, the labor shifts to the lower cost countries. But in the future there will be no lower cost labour force than the intelligent machines. So, the production can return to the rich industrial countries. Within those countries there are means to force some distribution of wealth, although the traditional unions will have no clout. But the third world countries do not have those means except war (or by being a threat to the economic system, as is happening at the moment).

2. *Its ideological impact*

Already the term `A.I.' or `intelligent robots' gives many people shivers. It is experienced as impersonal, unescapable threat. There were already some violent reactions against computers.[6] It can become that anonymous entity, which pushes you out of your job, which controls all your movements, statements and spendings. In short, it may create an Orwellian 1984.

The main thread however, might come from the inside -- so to speak -- and not from the computer activities themselves. Darwin had an enormous influence on our human thinking about ourselves, which could result in the opinion that man is just the next step in evolution: just a monkey with enlarged brain volume. But this reductive opinion is not the only possible one. The performance of A.I. might promote the idea, that a human being is just some piece of mechanics, albeit very complicated one, i.e., we are just information processors. But again, this is not the only possibility. Again it is the initial arrogance of A.I. which seems to promote the reductionist view. Here too the answer should be: let it make true its claims. That is the best way to demonstrate its shortcomings.

In the meantime the A.I. approach might have a tremendous impact, an impact which can hardly be overestimated by its pervasive character. (In this respect it can be compared with the pervasion of micro-electronics in existing techniques). Expert systems can become a real threat,[7] in particular by the clumsiness of the actual technology. Perhaps this stage is less dangerous because its shortcomings are more obvious.

The tone of this section is pessimistic. That is not because the impact of A.I. has to be negative. As a powerful tool its possibilities are as well for the best as for the worst. It is only that the lesson of history seems to indicate that the negative influence seems to prevail.[8] As long as we allow the development of science and society to be Darwinian,[9] I think this has to be the case.

IV. *Suggestions*

Nuclear technology as a big scale technology may be thought of as a development which can be stopped, at least for a time, as is happening in several countries at this moment, yet that will be impossible in the case of a small-scale pervasive technology such as A.I. And I do not think that it has to be done, even if it could be done. What should be done is to promote the positive aspects and to supress the negative ones as much as possible.

1) As indicated already: decreasing the need for a productive labor force makes a rethinking of the status of labor and of the distribution of income urgent.

2) Education will become more important and will have to shift its attention from preparation for a productive labor force to the exploration of other human capacities, e.g., artistic. That by no means implies a degeneration of the function of education or a decrease of its level.

3) The development of A.I. will have to be critically followed, required to verify its claims, in order to prevent us from ending up with a reduced reality, in which only that becomes real, which can be handled by A.I. With critical review this research will not result in a degradation of the human, but rather increased insight will make more and more evident what a unique being the human is.

4) In particular, the applications of A.I. have to be evaluated critically. Not only do they influence directly our existence, but for economic (and science funding) reasons their potentials will be greatly exaggerated.

5) All the mentioned efforts presuppose a serious and honest reflection on our own existence. To this the contribution of religion could be essential and in its turn religion will be fertilized by scientific insight.

NOTES

1) An effort is made by Edward Feigenbaum and Pamela McCorduck to draw the attention of the American public and government. They published: The fifth generation computer; A.I. and Japanese computer challenge to the world. Reading, MA: Addison-Wesley, 1983.
2) J. Hilts, *Scientific temperaments*, N.Y.; Simon and Schuster, 1982, p. 212.
3) John von Neumann, *The computer and the brain*, New Haven: Yale Univ. Pr., 1958.
4) P. Mc Corduck, *Machines who think*, San Francisco: Freeman, 1979, p . 83.
5) A very readable account of the performances of A.I. research so far is: M. Boden, *AI and natural man*, N.Y.; Basic Books, 1977.
6) Hilts, p. 278.
7) J. Weizenbaum, *Computer power and human reasoning*, San Francisco: Freeman, 1976.
8) An additional reason for our suspicion is the fact that nearly all A.I. work is military founded, by ARPA.
9) Cfr. G. Boehme, W van den Daele and W. Krohn, "Alternativen der Wissenschaft," in: *Zeitschrift fur Soziologie*, 1 (1972) 312ss.

SENSUUM DEFECTUI

Faith is Everywhere, Including Science

by Thomas P. Sheahen

In the traditional Latin hymn *Tantum Ergo,* there is a line that goes *"Praestat fides supplementum, sensuum defectui."* Loosely translated (as songs usually are, to maintain meter and rhyme), this says "faith provides the supplement when the defective senses fail." Herein lies a cornerstone of Christian belief.

As Christians, we would nod in agreement with the premise that there is much more to our lives than what our senses can tell us. But nobody focuses on exactly what this means, nobody asks *in what way* the senses are inadequate, and we are too ready to tiptoe away when someone from the camp known as *scientific materialism* takes a strident position against our perspective.

This essay examines questions about how knowledge is gained, how measurements are made, and how sensory perception is limited.

1. *An experiment about eyesight*

A large number of people have eyesight defects and wear glasses (perhaps contact lenses) to correct their vision. Some people have better vision in one eye than the other. When their glasses are removed, objects look fuzzy and unclear. It shouldn't take much to convince us that eyesight does not necessarily give us full and complete knowledge of whatever we're looking at.

Someday when you're in church looking at the altar (perhaps during the elevation of the Host at the end of the Canon, take off your glasses or close one eye. With your vision thus impaired for a moment, pay careful attention to the state that you perceive: it is clearly inferior "knowledge" of what is really there, compared to whatever you can see under better circumstances. At that moment you realize that you are *not* seeing clearly, owing to other knowledge gained previously at a different time and place. The experience also brings out that your senses are defective, and in need of a supplement.

The purpose of this little experiment is to construct an analogy for the role of faith in everyday life. The role of "other knowledge" obtained by means unrelated to direct visual observation is very important, and too easily overlooked. The reality is that for the great bulk of things we say that we "know," there is a complicated scaffolding of other knowledge - usually including faith in the truth of what some other people have said -that provides the structure with which to interpret the meaning of one particular observation.

2. *Personal Knowledge*

In his now-classic 1958 book *Personal Knowledge*[1], Michael Polanyi carefully leads the reader through the progression of steps necessary to reach the judgment that "I know" something is true. One of the essential components is to place trust (faith) in the testimony of other human beings, because you cannot possibly go out and duplicate every observation that has ever been done. Another component is to make the personal commitment that a proposition is *true*. There is a mixture of *objective* and *subjective* actions that must combine to produce the state called "personal knowledge." Moreover, Polanyi shows that "personal knowledge" is the kind that matters -- not some abstract reality that is "out there" waiting to be discovered.

3. *Scientific Method*

Every new discovery in the entire body of human knowledge builds upon a previous collection of statements that are widely considered true by a large number of people. The pathway by which an assertion becomes "widely considered true" requires a considerable degree of discipline, following rules which themselves came into common acceptance at an earlier time. The regression goes all the way back to some "primitive concepts" that are considered to have no need of further clarification or definition.

Most people first take note of this characteristic of the way knowledge is structured when they take geometry in tenth grade. Various theorems are based upon axioms of geometry, but such "primitive concepts" as *line* and *point* are never further defined. The rules of logic, often studied in college, likewise follow paths through theorems and axioms, but terminate again in "primitive concepts."

In the *Scientific Method* of obtaining knowledge, the primitive concepts are very well hidden beneath a floor of assumptions and axioms that are virtually never questioned. In fact, for practical scientists trying to get anything done, several more layers go unquestioned: In a physics lab, an experimenter might check to see if the wall socket delivers 115 volts, but would trust the integrity of the voltmeter if the measurement indeed showed 115 volts; and in any case the experimenter would not question or challenge the basic existence of electrons. In a chemistry lab, when the water faucet is turned on, it might be well to check the purity of the water, but no one doubts that the substance coming out of the faucet is mainly H_2O, nor does anyone raise questions in chemistry lab about the existence of protons and neutrons in the oxygen nucleus.

The Scientific Method is rooted in a large collection of previous statements, now commonly agreed upon. All this involves placing faith in the statements of prior generations of scientists. The centuries-long process that led to common agreement has been forgotten. If Galileo showed up in a high school physics lab today, he would inquire about so many "trivial" issues that he would be labeled "disruptive" and thrown out. To engage in science, you have to "get with the program."

Because all this placement of faith is stored beneath the floor of the way science is done, people lose sight of it and quickly assume that today's science is totally objective. Visit a major particle accelerator (e.g., *Fermilab* near Chicago) and listen to scientists talking about fragmenting mesons, and you'll find yourself believing in the existence of mesons before you leave that day. Hidden from your cognitive attention will be the dozens of acts of faith that lead upward to that state of agreement; you take for granted the "commonly agreed upon" principles of the local research team. This is simply the way science gets done, and those who challenge the status quo of prior knowledge usually find themselves standing outside in the cold.

Every now and then, someone *does* challenge the established scientific beliefs, and an upheaval occurs. The word *revolution* comes from Copernicus' book about the way the planets travel around the sun, and that certainly challenged the established interpretation of science of his time. Einstein did likewise about a century ago; in more recent years the development of quantum mechanics, electronics, plate tectonics, information theory, molecular biology, DNA and so on have all resulted from occasions where someone found a better way to explain some observations than the prevailing scientific ideas of the time. The phrase *new paradigm* captures the notion of giving an entirely different explanation[2], based on different assumptions, on different choices of which "accepted" statements from the past to believe or disbelieve.

4. *Measurements*

A cornerstone of scientific thinking is that *theory* is always subordinate to *experiment* or *measurement.* No theory, however grand or "mathematically beautiful," can stand if a measurement shows that it's wrong. Moreover, one of the rules for theories is that they must be *verifiable*, meaning that for a new theory to even be considered, there has to exist a means of testing it through experiment or observation. A theory that explains something no matter what the measurements show is considered no theory at all. Moreover, a theory that contains a lot of extraneous statements that (even in principle) cannot be observed is not accepted; it is either ignored or trimmed back to finite size, where it has some connection with measurable reality. The procedure known as *Occam's Razor* demands that scientific theories not be festooned with additional, unobservable claims. In the scientific method, faith is given out parsimoniously.

When a scientist seeks to verify or falsify a theory, (s)he does so by conducting an experiment or making an observation, using a measurement instrument of some kind. It is very important that it be possible for others to repeat the measurements, so as to check up on the claims of the first scientist. Having an experimental result repeated by another independent observer is crucial to convincing members of the scientific community to extend their faith to the initial claims. The ideal experiment is one that can be repeated by anyone at all, thus minimizing the amount of faith required by an inquiring mind. The laboratory portion of elementary science courses is intended mostly to elicit the response by the student "now I have seen it for myself." This pays tribute to the notion that scientific faith should only be extended cautiously.

Measurement methods acceptable to science have one central characteristic: sooner or later, they produce a signal that interacts with the human senses. When you can look at a clock or a meter stick or see a solution change color, that's pretty direct. Looking through a microscope at an insect demands relatively little faith -- belief that the optical components (lenses, etc) faithfully present the reality on the microscope stage. But for a great variety of modern measurements, the final connection to human eyesight is via a digitally displayed number -- which appeared after several intermediate electronic steps that followed a change that occurred in a sensor connected to the experiment itself.

There are some measurements that are extremely difficult to make. The existence of the tiny uncharged nuclear particle the *neutrino* was predicted by theory in 1931, but nobody could observe it in those days. Belief in *neutrinos* was maintained by an appeal to the beauty of theory, and that is always a precarious path to follow. Neutrinos were said to be all around us, passing through the earth and our bodies without interacting. A lot of people couldn't buy that notion. It was not until 1956 that experimental evidence for the existence of the *neutrino* was found, via a complex experiment that took place in a deep underground mine and trusted in considerable theoretical explanation to relate the observed data to the presumed *neutrino.* The theoretical explanation was plausible and did not affront existing quantum theory, so the connection to "commonly agreed" science was strong. Therefore, the interpretation given the measurements by the wider community of physicists was that indeed *neutrinos* were being observed. Because of this and subsequent measurements, today *neutrinos* are fully accepted in physics. The fact that a measurement is difficult does not disqualify its underlying theory, but it is quite common for scientists to withhold their extension of faith in a theory until convincing measurements are performed.

5. *Electromagnetism*

The human senses are very defective and limited. It is important to note that if a measurement is to connect with the senses of a human observer, sooner or later it must produce an *electromagnetic* interaction in order to have an output of the measurement device. Eyes, ears, neurons running to the brain, etc., all rely on electromagnetism for information to flow. Communications from instruments to people, or between people, in general take place via electromagnetic interactions. There *are* other interactions in nature (the four forces are gravity, electromagnetism, the strong and weak forces), but for a person to find out about any of them requires an electromagnetic interaction. Consider the tale of Newton sitting under the apple tree and being hit on the head: the slight temporary deformation of his skull sends an electromagnetic message of pain along neurons to his brain, telling him that something had happened. Thus *gravity* is detected via the route of *electromagnetism.*

The requirement of an electromagnetic link severely restricts the domain of what can be measured. When we look out at the stars and galaxies, we see only those that are lit up; electromagnetic radiation (radio waves, light waves, X-rays) is necessary for information about a distant location to reach us. There is speculation that about 90% of the universe is composed of *dark matter*: things that interact with each other via gravity, but give off no electromagnetic radiation capable of reaching us.

If we then ask "How do you *know* that it's there if you can't see it?", the answer involves reliance upon theory -- indeed, a treasured theory about how large bodies in the universe ought to behave and interact. Unless there really is dark matter out there, the theory of the *Conservation of Angular Momentum* would be violated, and nobody wants to abandon that theory, so it is considered more plausible to accept the existence of dark matter.

6. *Faith Within Science*

There is a substantial component of *faith* here: adhering to a theory in the absence of observational data is rooted in the belief that the same laws of physics hold in other portions of the universe as they do where we live. It is impossible to prove this assertion, but it is a very attractive article of faith; after all, a very basic principle of science is that the universe is a rational place which is capable of being studied. The appeal of mathematical beauty and symmetry in equations is likewise very strong.

Scientists have become comfortable with beliefs of this type, and don't attend to the faith component of them. "It just makes sense" "The story hangs together" "That's the way it has to be" are some of the phrases used to justify the collection of fundamental beliefs about the laws of nature. Similarly, scientists are uncomfortable with anyone who opposes their belief system. "What else could it be?" is the slogan used to challenge anyone else to come up with a better explanation. The experience of Copernicus, Einstein and others shows that such challenges are occasionally sustained, but such events are rare exceptions. There is safety in the status quo today, just as there was 400 or 1000 years ago.

7. *Scientific Materialism*

The domain of thought known as *scientific materialism* holds that nothing exists except material, and all claims to knowledge other than scientific knowledge are faulty and unsustainable. This viewpoint is rooted in a failure to discern the very large component of faith inherent in every claim about scientific knowledge. The pathway to reaching this faulty state has several steps: First, agree to the articles of faith in science; second, take them for granted; third, elevate their status to the level of "axioms" of science; fourth, assume that everything else necessarily must follow the same restricted pathway of thought; fifth, exclude from consideration anything that doesn't match this way of thinking.

To anyone who steps back and examines the entire process by which humans obtain knowledge, perhaps by reading Michael Polanyi's *Personal Knowledge*, the arrogance of the *scientific materialism* position is evident. However, not all that many people do so. Among many religious persons, there is a tendency to just retreat in silence rather than fight back. That's a real mistake, not at all warranted by reality. The disadvantageous outcome of retreating is to leave the playing field to the shrill champions *of scientific materialism*, which gradually becomes the dominant voice. Soon the peer-review system reinforces this collection of beliefs, and it becomes hard to find any articulation of other views. This situation is very prevalent on college campuses.

There are numerous examples from history of instances where religious and scientific views were in conflict, where in the long run the scientific view prevailed. These examples are often cited to bolster the case for the scientific method. With the hindsight of many generations, the origin of the struggle often can be traced to the "establishment" religious position being overly precise, incorporating additional beliefs that didn't belong there in the first place. When organized religion assumes that God has some of the same limitations as humans, it makes expansive and unwarranted statements that lead to trouble later on. Science as a way of thinking tries to take note of its assumptions and avoid overstepping its bounds.

Nevertheless, science does blunder occasionally, as the cases of *phlogiston* and *the ether* illustrate. The boundaries are not always easy to recognize, especially if the scientific establishment supports one particular theory -- which of course is built on a scaffolding of faith in other scientists, and faith in their interpretation of observations. It is well to remember that Newton devoted much of his life to alchemy, and undoubtedly took with him a lot of lesser scientists whose names are now long since forgotten. It is very easy to construct an elaborate science based on faith in an incorrect fundamental axiom or belief. Later, after a correction, science prefers to forget that it ever went down a wrong path at all. It is interesting to speculate today about what contemporary scientific beliefs will one day be antiquated -- parts of biology? Psychology? Economics?

When people look back historically at cases of conflict between religion and science, it is extremely rare to see such cases examined in terms of conflicting beliefs based on different axioms. Rather, it is more common to see the tactic used in which the scientific view is labeled "rational" and the religious view labeled "superstition." Still, the often-successful exploitation of that tactic cannot change the basic underlying fact that the conflict is between different fundamental systems of beliefs.

8. *Alternate Pathways*

It is certainly possible to take a more balanced view of what it means to "know" something.

The scientific method provides one very important component of obtaining knowledge. Measurement really does count for a lot; but another part of the scientific method is deciding when to believe the information being stated by other people. There is widespread general agreement about what it means to read an article in a scientific journal, and moderate agreement about the proper set of things that should be included when writing such a journal article. To the extent that all parties adhere to those rules, information is communicated reliably, and readers are able to evaluate what they read. The anomalies that do occur usually arise because an "established theory" is being undermined by new observations, and such events provide the most exciting times as science progresses.

There are several other pathways to knowledge, and these have been discussed at length over the centuries. Music, poetry, art, literature have all earned acceptability. The experience of living in a family conveys knowledge of several virtues in unspoken ways. The religious road to knowledge elicits different reactions from different people: some people hesitate to trust in statements by those going down that road, because it is strewn with landmines associated with one or another choice of religious doctrines. Other people find fellowship and contentment sharing the journey. Mystic experiences are even less accepted, because of the difficulty of communicating about the experience.

What is important in all this is to maintain a proper balance among the possible pathways. The personal commitment enunciated by Polanyi is present in every case. There is an element of faith in every case, too; in any particular group, all members share the same faith. This is just as true in science as in other areas: the faith shared by scientists is so well-accepted that it is almost never explicitly recognized, but it is still there. As stated above, it is usually "hidden beneath a floor."

There are limitations to every pathway, as well. For example, limiting one's study to the Bible alone places a boundary around one branch of Christian study and investigation. When a scientist insists on the primacy of measurement over theory, a definite boundary is being set up. Furthermore, the boundaries shift as a field advances: in the literary arts, you wouldn't go to a poetry reading and complain "but it doesn't *rhyme*"; and in physics, you wouldn't object to a particle-physics experiment that only collects data for a micro-micro-second.

The pathway of science has the major limitation that it must eventually connect with human sensory perception, and this in turn means it has to relate to electromagnetism. That sweeps off the table of scientific investigation a whole series of questions for which we can legitimately seek answers. But the rules of scientific measurement guarantee that those answers will not be found within the realm of science.

The reason science has gained supremacy as a basis for knowledge is that its rules of investigation -- the rules about when you "know" something is true -- are easy to grasp and agree to. But it does not follow that no other pathway is valid. That is the mistake made by the *scientific materialists*.

9. *Living with Defective Senses*

The "Optics" experiment that began this essay now has a clearer significance. Trying to see something without corrective lenses, or with one eye closed, is an excellent analogy for the condition of having *only* the path of science available on one's search for knowledge. If many years were to go by and you never put your glasses back on, you might forget that a better view had ever been possible. A lot of scientists have made that mistake. By its very nature, scientific measurement is a "defective sense." Because measurements must involve electromagnetism, it forces knowledge of other aspects of nature (e.g., gravity) to be indirect, imperfect, limited and dependent upon theory, which in turn depends upon faith in other people. This limitation extends to other areas of knowledge as well, far beyond physics, chemistry and biology. In fact, assigning primacy to sensory perception places a roadblock in the path of learning about interactions between people, meaning in life, love, and many other intangibles that don't match the criteria of scientific measurements.

The proper balance merges the several pathways to knowledge. The scientific pathway is a very important one, but not the only one. It is an error to forget about or conceal the role of *faith* on any of the pathways. The defective senses always need the supplement of faith in order to progress along any path toward knowledge.

[1] M. Polanyi, *Personal Knowledge,* (Harper Torchbooks, Harper & Row: 1964)

[2] T. S. Kuhn, *The Structure of Scientific Revolutions*, (University of Chicago Press: 1962, 1996)

WAS THE DISCOVERY OF PENICILLIN A MIRACLE?

by

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In today's world of science, editorial practices generally exclude conjecture but there are situations in which opinion or supposition might be instructive. It is in this vein that I ask ITEST members to consider the possibility that the discovery of penicillin was miraculous. This premise is based on the succession of highly improbable events that were necessary for penicillin to be discovered, to be found effective and non-toxic, and to be produced commercially. What prompts this postulate is the recognition that God is all powerful, and that His love for mankind is without end. Would it not be within His plan to provide a discovery that would improve the health of the whole world? Typically, medical miracles involve immediate cures of dreaded diseases on a rather instantaneous basis. To consider penicillin as a miracle requires, instead, the fortuitous sequence of several improbable events over an extended period of time. The narrative to follow was constructed from a reading of the sources listed at the end. Slight variations can be found among these writers but the essentials were agreed upon.

Penicillin was discovered accidentally by Alexander Fleming in old St. Mary's Hospital in the Paddington section of London, in the summer of 1928. But the story begins considerably before that, and an appreciation of its importance depends on an awareness of the relatively undeveloped state of medicine around 1920. Doctors had at their disposal only a few treatments they could prescribe. I am aware of aspirin as a pain killer, ether as an anaesthetic, iodine as an antiseptic treatment for flesh wounds, and quinine for the treatment of malaria, and a few other medications. But there were no antibiotics, no sulfa drugs, and virtually nothing for the treatment of specific diseases. Attempts to find a Magic Bullet that would kill germs but not the patient, had been mostly unsuccessful. In 1921, however, an unheralded accident took place that might well have been a necessary precursor to the discovery of penicillin.

Fleming was prone to having colds and, while examining a culture of *Staphylococcus*, the dripping from his runny nose fell onto the agar plate in which it was growing (if he had still been a student, he should have gotten an "F" for such poor laboratory technique). Subsequently (probably the next day) he noticed that the bacteria were dissolved at the place where the drippings fell. This was a total surprise because it marked the first known time that the human body produced a compound having antibacterial activity. Upon repeating the test, he was surprised to find that the result was reproducible. Later, a test of a tear drop had the same effect. Alert that he might have discovered something important, he devoted the next two years to a study of the phenomenon and was able to show that it was caused by an enzyme which he called lysozyme.

The Discovery:

Came the summer of 1928, when Fleming once again was working with an agar plate on which Staphylococcus was growing, and noticed a contaminant that had begun to grow at the edge of the agar. This was not unusual because such contaminations occur quite often. Fleming threw the plate away because he was going on vacation the next day and wanted to dispose of such a useless item. Rather than putting the plate in an autoclave which, presumably, would have been his normal procedure, he tossed it into a shallow glass dish containing lysol. Upon returning from his vacation, he noticed this plate. The bacteria had been lysed (dissolved) and, in its place was what appeared to be a growth of fungus. The contents of the plate had never touched the lysol because the dish was so full! The growth on the plate had not been destroyed even though Fleming had thrown it away.

The contaminant was identified as a member of the *Penicillium* genus, which was why the ultimate name given to the product was "penicillin". Fleming's enthusiasm for the finding was not shared by his associates. Several scientists in his immediate area were not impressed, nor was the medical profession in general. One reason for its subsequent, aloof, attitude was that Fleming was not able to reproduce the experiment. When he inoculated an agar plate with both *Staphylococcus* and *Penicillium*, each organism grew independently of the other. In fact, there was no feasible explanation made until 1966 (thirty eight years later) when Ronald Hare, by studying the effect of various temperatures on the growth of the fungus, *Penicillium*, and the bacterium, *Staphylococcus*, developed an hypothesis that seemed reasonable. In short, there had to have been a particular sequence of temperatures in London at that time in order for this accidental discovery to have taken place.

An optimum temperature for fungi would be in the neighborhood of 15° C, but bacteria thrive at temperatures in the upper-30 degrees. Moreover, studies made of bacteria showed that penicillin did not kill bacterial colonies but, rather, prevented the formation of new cells. This being the case, if there were a low initial temperature it would impede the growth of any bacterium but would favor the growth of fungi. Then, if the temperature were to be raised to initiate the bacterial growth, the presence of the already-formed fungi would inhibit the formation of bacterial cells. With this scenario, a temperature sequence of low, then high, might make a *Penicillium* culture toxic to bacteria. This would explain why the simultaneous inoculation of an agar plate with *Penicillium* and *Staphylococcus* had allowed both to grow. When the temperature records for London were examined, it was found that a low/high sequence had occurred when Fleming went on vacation in 1928! In retrospect, we see that there might not have been such discovery if the temperature of incubation had been constant. Therefore, had air conditioning been available in 1928, this accidental occurrence may not have taken place.

Progress after the Initial Discovery:

Serendipity played an important role in subsequent events. A name intimately associated with penicillin, Howard Florey, came into the picture in January, 1929, under unusual circumstances. Florey had digestion problems and, after seeing an article written about lysozyme by Fleming, visited him to discuss his health. Specifically, he wondered whether lysozyme might destroy the mucus that he imagined was responsible for his stomach disorder. By May, 1929, when Fleming submitted an article describing his penicillin research, to the *British Journal of Experimental Biology*, Florey happened to be the editor and he printed Fleming's article. Several years later, in 1935, Florey was appointed to the prestigious post of Chairman of the Pathology Department at Oxford University, with the mandate to invigorate that Department. He chose to make an intense study of lysozyme and, in fact, succeeded in making crystals of the pure product. One of the men he recruited was Boris Ernst Chain, a refugee from Nazi Germany who was to play a key role in the development of penicillin. At the time of his hiring, penicillin was not the matter of interest - - it was lysozyme. Conversations with Florey, however, involved various microbiological subjects and Chain thus became interested in penicillin. One would imagine that such an interest would result in a contact with the originator, Fleming, but Chain was under the impression that Fleming had died. Therefore, he contacted Margaret Campbell-Renton, whose laboratory was just down the hall from Fleming, and she supplied him with a culture of *Penicilhum notatum* (the initial identification of the species had been *rubrum* but later studies showed it to be *notatum*). For this reason Fleming was unaware of the ensuing research on penicillin after he had dropped the subject because repeated efforts on his part to interest the medical profession were so discouraging that he had given up the fight.

Chain's contribution was of great significance because he made available a concentrated source of penicillin. During the fermentation process, penicillin was the active ingredient being sought, but its concentration in the culture was so low that it lacked potency. Chain decided to try the process of freeze-drying as a means of making a more concentrated product, and he was very successful in doing so. Using this concentrated product, which was much more potent than the initial culture available to Fleming, he demonstrated the effect of penicillin on three sets of mice infected with *Staphylococcus, Streptococcus*, and *Clostridium* species. To use the phrase of Andre Maurois, the results "smacked of the miraculous" and were published in the journal, *Lancet*, in 1940. One particularly serendipitous aspect of this study was that mice were used rather than guinea pigs. Subsequently, it was learned that guinea pigs, so often used in studies of this type, were sensitive to penicillin. Had guinea pigs been used in these early studies, and died, it may have been the end of the penicillin story. Fleming visited the new team after he read of their work in the literature, very much to their surprise.

Penicillin showed great promise, but still there was the problem of producing it. Several commercial firms had been unable to do so. To meet the need, Florey decided that the only option was for the William Dunn School of Pathology at Oxford to assume the task. Estimates made at that time were that the production of 500 liters of culture per week would be sufficient for the treatment of only five or six patients; the efficiency of the production process was on the order of only 0.0001%. Norman Heatley was put in charge of the process and, by January, 1941, enough product was on hand to carry out a clinical trial. It still was unknown to the Oxford team whether penicillin was toxic to humans, although work done by M.H. Dawson of Columbia University had already shown that it was not. As an extension of the potential problem with human toxicity, it was decided to try the antibiotic on a person with an incurable disease, who had nothing to lose and everything to gain. The subject chosen was a woman suffering from cancer and, although she eventually died, it was clear that penicillin was not toxic. Next was an attempt to save the life of a policeman who was dying from an infection that had progressed for two months. His condition improved dramatically but there was insufficient penicillin available to save him. Other cases followed in which clinical successes were achieved, even though in some instances the patients died of other causes.

In June, 1941, Florey turned to the United States for help, and the Rockefeller Foundation in New York City agreed to pay expenses for Florey and Heatley to visit this country for an extended period. Their first success was in a meeting with Charles Thom of the U. S. Department of Agriculture, who understood the great promise of penicillin but also appreciated the enormous task at hand. Florey and Heatley calculated that the treatment of one severely ill patient with penicillin would require 2,000 liters of culture. They were aware of the magnitude of the problem but would put up with the volume requirement if they just had adequate fermentation equipment. The most likely site was the new USDA Northern

Regional Research Laboratory (NRRL) at Peoria, IL, where large fermentation equipment was available.

The timing of this choice, as it turned out, could not have been better. In that same year, there was a bumper corn crop in Illinois and the Agriculture Department was seeking extra uses for the corn in order to increase the farmers' incomes. Research on corn led to the development of what was called "corn steep liquor," and USDA scientists were anxious to determine its effect on anything imaginable. Why not add it to the cultures being tested for the production of penicillin? Research performed by Dr. Andrew Moyer at Peoria showed some stimulation of growth with the addition of 0.3 to 0.5% corn steep liquor, but at concentrations as high as 4 - 8%, the yield was increased ten-fold. Moyer also found that the *Penicillium* mold could be grown in submerged cultures containing lactose (rather than glucose).

All along, the organism used had been Penicillium *rubrum*, the contaminant responsible for the early studies. Dr. Kenneth Raper investigated all nearby possible sources of *Penicillium*, and of all the hundreds of strains tested the most productive was the one credited to Mary Hunt, a Peoria woman whose enthusiasm for the search earned her the nickname of "Moldy Mary." On a summer day in 1943 she brought in a moldy cantaloupe, from a Peoria fruit market, on which grew a fungus with a `pretty, golden look.' It became known as *Penicillium chrysogenum Thom*, designated NRRL. 1951.B25 or, more popularly, the cantaloupe strain. The broth titres associated with it were more than twice the yield of the best strains available.

Subsequently, effects of bombardment with X-rays and UV light on various strains were determined. By 1970, improvements in culture media and process control raised industrial penicillin yields to 20,000 units per milliliter (at the time of Fleming's work, the potency was around 50 units per milliliter).

By the end of 1943 some penicillin was made available to the armed services, and in 1945 Fleming. Florey and Chain were awarded the Nobel prize for their monumental achievement.

Penicillin was of huge importance, but its influence became even greater when research on other antibiotics proliferated with spectacular results. Almost concurrent with the discovery of penicillin was that of streptomycin which was credited to Selman Waksman, though there are many who would credit Albert Schatz with the most important contribution. Waksman's quest began even earlier than Fleming's, having started in 1915 when Waksman searched for, and found, a soil-borne organism that could degrade the coating of Type II pneumococcus cells. Much serendipity was involved in that whole scheme, also.

To complete the narrative of penicillin, stress must be laid on the succession of improbable events that had to take place in order for this momentous discovery to take place. A nose dripping falling on a growth of *Staphylocococcus*; the contamination of a *Staphylococcus* culture with just the right organism; the observation of that effect being made possible because the plate never made contact with the lysol for which it was intended; the proper sequence of temperatures in London in 1928; Florey's stomach problem that led him to a contact with Fleming; his importation of a German refugee, who concentrated the penicillin cultures with the freeze-drying process; the use of mice as test organisms rather than guinea pigs, that would have died from the penicillin; the timing of the bumper corn crop in Illinois that led to the development of corn steep liquor; the discovery of a rotting cantaloupe in a fruit market. All of these were necessary for the development of penicillin as a powerful antibiotic, the first of its kind.

Was the discovery a miracle? There probably is no way of telling. There are many highly improbable events that do take place, such as winning a lottery where the chances may be one in hundreds of millions. Perhaps the probabilities involved here were not that great individually, but the succession of them might have been even greater.

Footnote:

Fleming was awarded the Nobel prize for his discovery and a grateful world paid him homage. During his triumphant visit to the United States, after he had won the Nobel prize, one of the tour stops was a new state-of-the-art pharmaceutical laboratory where extreme measures were taken to isolate various sections of the laboratory to reduce the risk of airborne contamination. Microbiologists understandably insist on limiting their studies to sterile cultures, and the safeguards instituted at this new facility were optimum in that regard. Fleming was properly impressed but was heard to make a remark, upon leaving the building, that the laboratory was wonderful but, if he had worked in a place like that, he wouldn't have been able to discover penicillin.

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STEM CELLS AND THE PRESIDENT'S COUNCIL ON BIOETHICS

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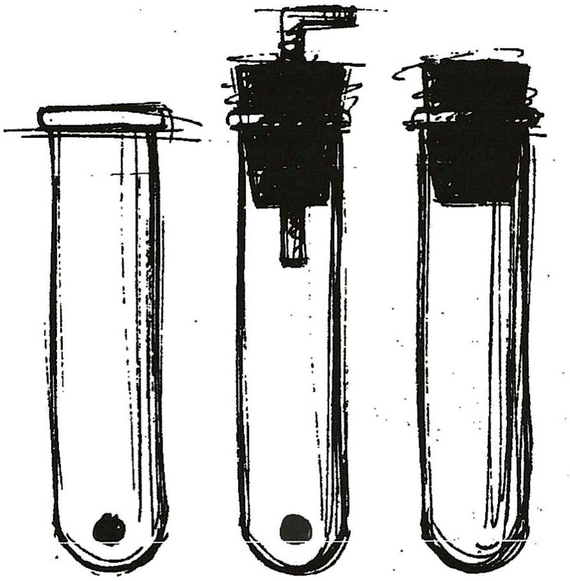
Dr. Paul Doolan, a long-time member of ITEST, is a retired physician who is now living in Phippsburg, Maine. His interest is recombinant technology and science. He is currently interested in stem cell research and has written extensively on the debate. This article is reprinted from the Phippsburg Times Record, October 8, 2004.

The council has given the president three wide-ranging, in-depth, thoughtful reports

On April 2, 1953, the journal *Nature* published the Watson-Crick model of DNA, the scaffolding of life and its continuance. Biology replaced physics as the most exciting science and the double helix became the banner of the age.



LOS ANGELES TIMES SYNDICATE

OPINIONS on stem cell research vary. Some people advocate complete freedom; others, controlled research; still others, a total ban.

On June 26, 2000, with the virtual completion of the sequence of the human genome, President Clinton and Prime Minister Blair announced "the most important, most wondrous maps ever produced by mankind." Craig Venter chose to emphasize our commonality with all living species while it put Walter Gilbert in mind of the Holy Grail, and within months we learned the legend was alive in the form of human embryonal stem-cells.

These are cells whose virtual immortality and developmental potential we can study in detail and then coax or even direct. Cells that might heal hearts, restore memories, supply insulin, erase tremors, replace parts and prolong life. In the process, research would ensure our nation's pre-eminence in big-medical science and spur economic development.

Could there be any reason for the federal government to withhold immediate support for a challenge as exciting as that of Sputnik and worthier than landing on the moon? Some claimed there were, beginning with treating a human embryo as laboratory stock. In addition, the enthusiasm given the biological commitment borders on an imperative too powerful to worry about human dignity, or shifting the trajectory of human development.

The questions were profound and the issues sensational, so on Aug. 9, 2001, President Bush addressed the nation. He allowed work with existing cell lines to continue but halted federal funding for new lines and, most important, he announced a President's Council on Bioethics with Leon Kass, M.D., Ph.D. (biochemistry), as chairman.

Some thought creating the council was a cunning tactic by a conservative president who preferred to think about government and religion rather than separation of church and state. They worried about his capacity to appreciate that "rational objectivity, moral tolerance and personal choice were the cultural absolutes of our times,"(Louis Dupré) as evidence with his opposition to an abortion policy deemed lax on access and sinister in its late-term extreme. Most, however, were reassured. Kass is known for his depth and range of erudition and respected for his style, which Whitehead claimed "the ultimate morality of the mind." Kass assembled a group representing basic biological science, ethics, government, social theory, medicine, law and a syndicated columnist. Each was formidable in his or her own field, mature and persuasively, even eloquently, presented very different opinions.

There were sharp differences on the moral status of the embryo, "one of us" " inviolable; a clump of cells or a reminder of "human indebtedness"; the moral and biological equivalence of an embryo made with an ovum whose nucleus had been replaced; the accuracy or fairness of the term cloning if the embryo is never to be implanted; the use of the excess embryos obtained with *in-vitro* fertilization and those in storage already donated for research; assisted reproductive technologies monitoring, improving success rates, the reproductive possibilities that alter biologic relations and longterm health; pre-implantation genetic diagnoses for disease markers, sex selection, screening and tissue compatibility.

In these issues, metaphysics gave way to the realities of state laws, FDA regulations and the standards set by professional organizations. There are the legalities of patenting, transfer agreements, commodification of human tissues as well as matters of personal recognition and distribution of credit. The question of equal access to these services was listed as morally vital as that of moral status of the embryo.

The council has given three reports to the president: Human Cloning and Human Dignity -- an ethical inquiry; Monitoring Stem Cell Research -- a text; and Reproduction and Responsibility -- assisted reproductive technologies. These are the most wide-ranging, in-depth and thoughtful public discussions of the issues.

The initial worry by some that creating the council was out of step with the genius and vitality of the age has been replaced by the general recognition of a work in progress. It is one needed now that we are on the brink of germinal choice technology, regenerative medicine, accelerated evolution and blithely accepting that technology is our destiny.

The council has informed the nation; its members should be very proud and the staff congratulated.

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IN MEMORIAM

Father Eugene Dehner, OSB
James Cardinal Hickey

We ask your prayers for ITEST members who are ill. May they feel the restoring hand of the Lord.