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Science: In the Pursuit of Truth and the Furtherance of Understanding

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Recommended Citation
Wantland, Wayne Warde, "Science: In the Pursuit of Truth and the Furtherance of Understanding" (1961). *Honorees for Teaching Excellence*. 26.
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Science IN THE PURSUIT OF TRUTH AND THE FURTHERANCE OF UNDERSTANDING

Address by Dr. Wayne Warde Wantland
Chairman, Division of Science
on the occasion of the
Annual Century Club Dinner
held on May 16, 1961.
Dr. Wantland had been chosen by the faculty
as recipient of the
Century Club Award for 1961.

ILLINOIS WESLEYAN UNIVERSITY
Bloomington, Illinois

SCIENCE IN THE PURSUIT OF TRUTH AND THE FURTHERANCE OF UNDERSTANDING

On an occasion such as this I suppose one should seize upon the opportunity to display one's specific wares, expound upon the particular subject in which he considers himself best trained, and perhaps even hope to convert a fraction of his audience to a fuller cognizance and appreciation of the specialty. If I were to do this I would be forced to address you on some phase of the field of parasitology, to talk to you of "wee and sometimes not so wee beasties" which are wont from time to time to trespass upon our innards as well as the exteriors of our bodies; to present to you a treatise on parasitism, which subject, for many years signified something repulsive, dirty and having to do with worms and other sorts of creeping and crawling things. Indeed, not too long ago, when some well known and highly respected citizen was clearly demonstrated to have pinworms or to have become the unwilling and embarrassed host to body or head lice, it was a downright calamity, a situation justifying prompt, if not desperate measures, perhaps even an appendectomy in the first instance and at least a sojourn ostensibly to visit an ailing relative for the last named *affliction*.

While a presentation on parasites would be relatively easy and great fun for me and perhaps informative to you, I have decided to defer the tapeworm treatise, the protozoological parade and the arthropod array for some *before* dinner speech in order to better assure the proper prophylaxis as well as perhaps effect some saving in the portions of food consumed and resultant avoirdupois acquired. Of course, may I hasten to add, when such excellent cuisine is encountered such as we have experienced here tonight there would seem to be little hope indeed for the perpetuation of even the most persistent and sanguinolent species of etiological agent.

Yes, I have decided to forsake the subject of parasitology for tonight and have instead chosen, perhaps neither wisely nor well, an area of greater breadth and, I believe, greater interest to more people. In so doing it may be that the apparent importance and urgency of a better understanding of some of the things that have been learned more recently and are being diligently studied presently in the broader area have obscured the factor of personal incompetence. Let me assure you that I am quite cognizant of both a degree of redundancy in my title and a measure of audacity in implying in the latter words of the same, that I might be able to instruct or advise any of you in the furtherance of understanding. As a scientist, I feel some little confidence in describing and evaluating the scientific pursuit of truth, and as a teacher I would hope that through the years I have learned a few "tricks of the trade" both in stimulating young minds in the search for truth and in promoting understanding. If, in the course of trying to convey a message to you, I wade too far into philosophical waters may I ask the indulgence and patience of the trained philosophers in the audience as I attempt to paddle my way to the shore; and should I, in any literary attempts, embarrass or bore those who possess a greater propensity for composition and literature, please accept my apologies together with the reminder that a measure of incompetence in many areas as well as the desire to learn characterizes the average specimen of *Homo sapiens.*

The pursuit of truth and the furtherance of understanding are clearly not limited to the province of science. Yet science, perhaps because of the very nature of its development—its search for truth through investigation and experimentation—has established fact-finding within its structure more firmly and is thus better equipped to test ideas and hypotheses, than other branches of learning.

Aristotle, whose Natural Science dominated Western thought for 2000 years, believed that man could arrive at an understanding of truth and reality by reasoning from so-called "Self-evident Principles". For example he claimed that it is self-evident that everything in the Universe has its proper place. Thus one could deduce that objects fall to the ground because that is where they belong; or lighter than air gases go up because that is where they belong. The goal of Aristotelian science was to explain the *why* of things. Modern science was born when Galileo and Vesalius attempted to explain *how* things happen and initiated the method of controlled experimentation which now forms the basis of scientific investigation.

The more intensely we apply controlled experimentation to problems confronting us and the farther one goes into the study of Life and the Universe—the more of a Wonderland is found—the more arbitrary, contrary, unexpected and improbable some processes and phenomena seem, while others become more certain after many trials and the passing of time. The method of science is the accumulation of facts, partly by direct observation and measurement and partly by experimental procedure. The attempt is then made to organize and correlate these facts in an orderly manner and to establish a body of principles that are considered valid and true at the time by the scholars in the field. Thus a given body of principles and statements of fact become the science of physics; another group of facts and principles become the science of biology; another chemistry and still another astronomy. These various groups of principles and facts are fast becoming more and more dependent upon one another; more and more interwoven; vital parts of the totality of science with less and less emphasis upon, or reference to, compartmentalized science. This is evidenced for example in the more recent and rapid growth of such areas as biochemistry, biophysics, cytochemistry, biological ultrastructure, chemical genetics and radiation biology. No longer can a major in physics, chemistry or biology restrict his training in science to any one of these areas alone and compete favorably in the complexities of modern day scientific activities. Rather may he be counseled to delve as deeply as time and energy permit into the whole of science and in addition acquire as further support, ample experience in the field of mathematics.

To the query "what is truth?", science can only provide facts pertinent to any given phenomenon as they are known today and attempt through teaching to promote correct interpretation and understanding. Tomorrow the answer may be quite different as new variables are encountered, as new results are achieved and as new data complicates or simplifies the picture.

Some persons with little or no real awareness of the nature of science and scientific investigation find it somewhat difficult to understand why the scientist cannot inform them as to "the truth, the whole truth and nothing but the truth." The majority are curious if not the possessors of a deep interest as regards scientific experimentation. This curiosity is highly desirable most of the time. Yet there are times when in spite of his desire to share his findings with others, the research scientist, if he is to realize accomplishment, finds it necessary to seek refuge from repeated and persistent enquiries as to the nature of his work and the importance of his results.

During World War II multimillion dollar plants employing many thousands of workers were difficult to hide. In place of hard looks and admonitions (though these were at times used) some government employed scientists found a more effective defense against curiosity by hanging up signs such as "Cat fur to make kitten britches" or "Blackout paint for lightning bugs." At Oak Ridge an anonymous person wrote a burlesque secret document which was circulated among thousands of workers. It read: "PROCESS—They are taking plumscrate, raw plumscrate mind you, and putting it into ballisportle tanks. These are called ballisportle tanks because the inside is coated with quadrelstitle and this preserves the full strength of the plumscrate. Next, this is taken to the sarraputing room where only the most expert sarraputers are employed. At this point thungborium is added, the ingredient which causes the entire masterfuge to knoxify; and then following the addition of spurndazzle the entire product disappears. This invisible compound is later transferred to the abbelsnurting building where glass snagglehooks are applied for carrying. This completes the manufacturing operation and delivery is the next problem. At 12:20 on the third Tuesday night of each month 800 men known as shizzlefrinks (temporarily decerebrated individuals) are lined up in single file, each given two ingots of oustenstufftingle (name of the finished product) and away they march over the hills to Fakima where they trade the finished product for enough raw material to make another batch of oustenstufftingle."

This kind of humorous explanation of highly secret projects apparently caused little ill-will and gave the curious either something to joke about or to puzzle over during off duty hours in an attempt to decipher into something of significance.

The aim of science is to describe and more adequately explain the world in which we live. The term "explain" however, often undergoes a seeming contradiction with man's every quest of reality. Science, while having made and while still making great and rapid strides in the pursuit of truth, still cannot completely explain such things as electricity, magnetism, chemical dissociation, light, gravitation, the nature and movement of planets and stars or the beginning and unfolding of a new life. One may spend years in the study of developmental mechanics or embryology and still not be able to fully explain all of the processes that have culminated in a new baby—a new bundle of life:

A Bundle of New Life

Ten little fingers and ten little toes,
A chubby face and cute little nose;
A whimper, a gurgle and then a frown—

You've guessed it—a new baby has come to town.
Tiny new being, brimful of life—
No cognizance yet of worldly strife.
Cuddly, squirmy—and smelling sweet,
Wee waving arms and wee kicking feet.
A brand new baby, an armful of joy,
What matters whether 'tis girl or boy!
Yes, a brand new baby with dimpled chin,
Eyes of blue and soft, pink skin.
Where did you come from, baby dear?
And what do you make of it, now that you're here?
Could you tell us the changes you've just gone through—
All about the origin of eyes so blue?
How did it start—that grimace and pout?
And your heart beats—were they rationed out?
Just what did happen—little one—
How did God guide you, once He had you begun?

With ever increasing zeal men and women of science have more recently broadened markedly the horizons for continued search for truth and furtherance of understanding. Where only a relatively few years ago we were employing mu and millions of light years in measuring parts of the microcosm and macrocosm respectively, we now speak in terms of Angstrom units and tiny protons and electrons in describing constituents of the former and relate rather incomprehensibly that according to one modern astronomer (Harlow Shapley) the known Universe is now estimated to be somewhere in the neighborhood of 32,000,000,000 (32 billion) light years in diameter. Another (Sir Arthur Clarke), compares the number of solar systems in our own galaxy with the number of grains of sand in a ten quart pail and then the number of galaxies in the Universe to the number of said grains in a similar container, roughly 100 million galaxies. In this comparative study of the microcosm and macrocosm, one is reminded, albeit on a somewhat lesser scale, of the infinite number of sizes of fleas as depicted in a poem by Augustus De Morgan:

Great fleas have little fleas
Upon their backs to bite 'em,
And little fleas have lesser fleas,
And so ad infinitum.

And the great fleas themselves, in turn,
Have greater fleas to go on;
While these again have greater still,
And greater still, and so on.

Paralleling the acquisition of additional knowledge concerning the size, shape and constituency of both the micro- and macrocosm, a number of outstanding scientists, biochemists and biophysicists preponderantly, have through both mathematical processes involving improbabilities and certainties and experimental *in vitro* procedures recently arrived at new concepts relevant to the origin and distribution of life itself.

George Wald of Harvard, Hans Gaffron of the University of Chicago, J. D. Bernal of the University of London, A. E. Needham of the University Museum, Oxford and A. I. Oparin of the A. N. Bakh Institute of Biochemistry in Moscow for example, are modern proponents of the revival of a modified theory of spontaneous generation of amino acids, nucleotides, nucleic acids, proteins and perhaps even protoplasmic aggregations which could be regarded as simple forms of life. The origination of a living organism is very probably a series of step by step epigenetic phenomena each step with a particular probability and precise conditions of trial. Organic molecules from the simplest fats through the starches and glycogens, the nucleic acids and finally the proteins present us with a tremendous array and variety of possible combinations of truly bewildering complexity. To fashion even the simplest kind of living organism requires the bringing together of the right substances in the right proportions, the proper arrangement and under the right conditions of temperature and pressure. This is not likely to be accomplished in the test tube by man tomorrow or within a lifetime. But it is virtually a certainty that this did occur at least once in the history of the cosmos. According to Wald and Gaffron, in considering the probability that an event occur at least once, there is the fundamentally significant point to remember that, however improbable the event in a single trial, it becomes increasingly probable as the trials are multiplied. Eventually the event becomes a near certainty. Suppose we consider for a moment an event with a reasonably high improbability say 1/1000. The chance that this will not occur in one trial then is 999/1000. The chance that it will not occur in 1000 trials is 999/1000 multiplied together 1000 times. Wald states that this product when reduced proves to be 37/100 and concludes that the chance the event will happen at least once in 1000 trials is therefore 1 minus 37/100 or 63/100, a little better than three chances out of five—quite a high probability. If the number of trials is increased to 10,000 the chance that the particular event will occur at least once comes out to be 19,999/20,000—practically inevitable.

Prevailing ideas pertinent to the probability of spontaneous formation of amino acids were changed almost overnight when S. L. Miller and Harold Urey of the University of Chicago became interested in the degree to which electrical discharges in the upper atmosphere may promote the formation of organic compounds. Recently these scientists performed the following experiment: Through an electric spark field was circulated for one week a mixture of water vapor, methane (CH_4), ammonia (NH_3) and hydrogen—all gases believed to have been present in the early atmosphere of the earth. At the end of the week paper chromatographical analysis of the solution revealed the formation of two amino acids (glycine and alanine) in quantity as well as traces of another, namely, aspartic acid. True, these substances here synthesized were only amino acids and three of the simpler ones at that—yet nevertheless organic compounds.

While it is true that all organic compounds with almost negligible exceptions are produced by living organisms including the amino acids produced in the above mentioned experiment and the historically significant synthesis of urea by Friedrich Wohler in 1828 (for certainly Wohler was and both Urey and Miller are very much alive) it is the negligible exceptions that assume great importance in the thinking of the proponents of spontaneous generation. While organic processes and the production of organic materials are catalyzed by enzymes produced by living organisms it does not follow that the chemical reactions would not take place *in time some place* without the catalysts.

Once again the basic factors of the problem are time and space. When the complexities of protoplasmic structure are reviewed by the present generation the probability of the proper assembly of molecules by natural phenomena to form a living organism seems decidedly small. But the origination of life never has been restricted to a period of one generation nor a thousand generations of men. We are dealing here with eternity—with infinity of both time and space. Modern astronomy and physics teaches us that the formation of a planet such as Earth with the temperature, light, pressure et cetera that we perceive is a rare event in the Universe. Yet though this probability is small the total Universe is so vast that astronomers conservatively estimate there are at least 100,000 planets like the earth in our galaxy alone. Since some 100 million galaxies lie within the range of modern powerful telescopes there may be as many as 10,000,000,000,000 (ten trillion) planets like Earth in the Universe.

Who knows? We may not be the only representatives of our kind in the Universe. Indeed, in the light of more recent concepts it seems to me we would be highly supercilious, dogmatic and intolerant if we persisted in the claim that we were the only form of life in this vast Universe that had attained some marked advances in both cephalization and civilization. There is at present no good reason to believe that constituents of either organic or inorganic compounds are put together in any greatly different manner, wherever they exist.

Given time wherever life is possible it has occurred or will arise; and from perhaps a single event in each instance has undergone and will undergo change after change so that as once stated by Marcus Aurelius "Nature which governs the whole will soon change all things which thou seest and out of their substance will make other things and again other things from the substance of them in order that the world may be ever new."

Perhaps man's most recent probes into space given such great impetus with the launching of the first sputnik and achieving such remarkable feats as the physiological observations of: mice, dogs, a chimpanzee, on the 12th of April this year the Russian Astronaut, Major Yuri A. Gagarin and less than one month later on May 5, our own United States Astronaut, Comdr. Alan B. Shepard while hurtling at tremendous speeds, miles above our continents and oceans, will tell us more of the truth. But we will need to travel much much further than to Mars or Venus or even Pluto to see and learn about even a small bit of the total Universe. It will indeed take much of man's time in the further pursuit of truth and still more of his time devoted to the furtherance of understanding in order that the truths learned and the wisdom gained by the few may be explained to and experienced and shared by the rapidly increasing multitudes that have appeared in the twentieth century population explosion.

Let us consider for a few moments the increasingly great and challenging task facing the modern day teacher. I am referring now to all teachers but particularly to the teacher of science. Not only does this teacher need to become acquainted with many new developments in his specialized area, but he is annually presented with new problems pertinent to the efficient handling of more and more students. Last year (1960) the population of the world increased by about 100 million people—roughly equivalent to the total present population of Japan—and the rate of population increase continues to accelerate. With present trends continuing the total population of this relatively tiny globular mass will grow from the present figure of almost 3 billion to a total of from 8 to 10 billion by the year 2000. We are given various figures from time to time with reference to numbers of students we can expect to have in our schools ten or twenty years from now. A conservative estimate of increase would presently seem to be from 2,000,000 to possibly 6 or 7,000,000 within the next ten years. Clearly there must be developed new and more efficacious methods of instruction—new workable techniques which must turn out more and better trained graduates who will be more efficient, more appreciative and more understanding in their total dealings with their fellow men. This is not going to be an easy task, but it is going to be a challenging one, not just to the teacher in the classroom or laboratory, but to all of us because all of us are, or should be, teachers in the sense that we are willing and anxious to learn and to help others in whatever ways we can with the talents that have been bestowed upon us and that we have had the good fortune to develop.

With increasing enrollments we will find ourselves facing many new problems as we have in a lesser degree in the past. Following the last great war we were faced with a rather sudden increased enrollment in our colleges and with returning service men and women came problems not just pertinent to greater numbers of students but problems related to different habits and different practices acquired by some of our former students while doing a job for their country. We gave ground and accepted change in some cases but in other instances held fast to long established regulations. In the immediate years ahead we must be ready to study and evaluate the changing times and exercise our very best judgment in effecting those changes which seem to be most necessary and expedient for the promotion of education.

Somehow we must find ways that will fit into the pattern of the increasing complexities of a broadening horizon to further promote the search for truth and to further understanding among the peoples of the world. Scientists in collaboration with teachers of all other areas will need to continue to strive evermore diligently to develop in our students the following:

1. A scientific attitude toward the end that they will (a) show a desire to search for scientific explanation without prejudice, (b) show a willingness to change opinion on the basis of new evidence, (c) have the ability to distinguish between fact and theory and (d) have a concept of functional relationships.

2. An increased ability to recognize and analyze problems which they will face every day of their lives.

3. A recognition of the value of experiment over argument.

4. An increased ability to clarify and justify answers to questions; to get down below superficial, carefree answers; to think things through more carefully, critically and thoroughly.

5. An ability to indicate and to *find* needed additional and reliable information pertinent to problems; and

6. A greater appreciation of nature; a fuller understanding of the inter-relationships among living things; and a greater understanding of other people's reactions and thereby a tendency to get along better with others.

We must increase the output of better trained teachers. Somewhere along the line we must develop a better method of early selection of those who really want to teach and then with every bit of leadership that we may possess, instill within the hearts and minds of these potential teachers a cognizance of the greatness of the profession of teaching, an awareness of the importance of the task to be performed and a realization of the many, many compensations for a job well done.

A year or so ago one of my major students who was preparing to teach asked me to put down on paper what I considered to be a workable formula for a good teacher. After considerable deliberation I wrote the following and gave it to this student. I should like to pass it on to you for whatever it is worth and with full cognizance that any one of you could very probably write a much better formula.

Formula for a Good Teacher

1. A good full measure each of *Patience, Understanding, Courtesy, Tolerance* and *Tact.*

2. A full cup of *Drive.*
3. A full cup (running over) of *Faith* in God and fellow man.
4. Several full measures of *Knowledge* increasing in amount to a point of apparent saturation followed by the addition of smaller bits from time to time according to taste.
5. Blend thoroughly into the above, liberal portions of *Responsibility, Leadership* and *Health.*
6. Add a cup or two each of *Humility, Firmness* and *Wit.*
7. Stimulate with *Warmth* and *Zeal* and serve with *Confidence* and *Satisfaction.*

I have tried this evening to give you some views of one scientist with reference to the pursuit of truth and the furtherance of understanding. I entertain the hope that I have widened somewhat our horizons of thinking and endeavor. I wish fervently that I may have kindled some sparks, stimulated some further action on the part of all of us to meet our increasing responsibilities with more determination, with greater awareness and recognition of opportunity. The world is full of changes and truth, as we see it today and tomorrow is a part of our world. The truth about a given structure or phenomenon can and often does change with time. The scientist is not surprised at such change. As a member of the human species he is full of curiosity concerning the nature of things and is, in part, spurred on in the pursuit of truth by this curiosity. Moreover, he has faith that the various truths which he may have helped to establish can be arranged in an orderly, meaningful fashion. And I believe that most scientists have a deep concern for the welfare of their fellowmen and throughout their investigations are constantly filled with the hope that the results of their efforts will prove beneficial to mankind.

I should like to conclude my presentation with a bit of verse in which I have attempted to depict the changes in concept of truth, its relativity and its totality as progressively experienced first in childhood and then at more advanced age levels.

The Relativity of Truth

At three or four or maybe five
It isn't just quite clear
The moon and the stars above my head
Were very, very near.
Why, if on my tiptoes, I would stretch

Just a wee bit; I could soon
Take right hold of the edge of Mr. Moon!
And on the other side, I could see—the cow—
And the dish—and, maybe, the spoon!
Fourteen, sixteen, twenty-one;
Now I know that I know galore
The answers to a host of things
That I didn't know before.
I'm certainly glad that I'm so well read;
And the rich experiences,—too—
Make it so much easier for one to know
The things that are really true—
Well—at least often true—exceptions few.
Thirty, forty, fifty-five,
Truth, did you say, my son?
Why it's—it's relative—yes, that's it—you see
A thing depends on—if—and so on.
Truth we pursue—and the speed is great;
The Archives are swollen and rich
With the thousands of things men have measured and weighed—
Objectives, experiments, results arrayed—
Doctrines and laws and deductions made;
And truth is, of course, in part, portrayed.
And then one night as I gazed again
At the Firmament, above—
It occurred to me—that to KNOW the TRUTH
I must first know FAITH and LOVE:
Faith in the Order and Nature of Things,
And Love for my fellowman;
Then on mystery, phenomena, strange and uncouth
Unshackled Energy could be focused—forsooth
Then I could learn and weigh the truth;
And costumed ugly or fair—
I could steadfastly face—I could tell—the truth
With a bit more grace and care.

WAYNE WARDE WANTLAND