

The Spirit of Research

**Whether we ever reach the ultimate is not nearly so important
as that we maintain inquiring minds**

Research begins with curiosity—a manifestation of man's love for understanding things. It is not confined to men in laboratories; the educator is doing research when he studies the community so as to match his efforts to the needs of his potential clientele. Characteristics of the research that are identified that are pertinent at whatever level of simplicity or complexity an inquiry may function. Their pertinence is not restricted to the career "researcher." Perhaps even more important are the characteristics of the research-minded person—characteristics that are useful at any level of operation and that are required of any person who is alert to and concerned with his surroundings.

RESEARCH is not confined to men in laboratories. The information on which we conduct our professional and private lives, and on which we base our plans for the future, is a catalog of the results of a vast number of experiments. The smallest piece of research will be the better for application of the principles that guide the biggest. Every business and professional man, politician, engineer, teacher, and homemaker acts in the scientific spirit when he examines his actions in an objective way.

What does research mean in terms of everyday life? A woman is doing research when she tries detergent after detergent until she finds the one that works most efficiently under her conditions of washing clothes, her equipment, the sort of water that comes out of the tap, and the kind of soil to be removed. The educator is doing research when he studies the community so as to match his efforts to the needs of his potential clientele in a manner that stands a chance of being productive.

Nothing is easier to start than a fruitless debate on the issue of

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pure versus applied science. It is not very important to most of us to pin labels on laboratories. We lump together science and technology, making the word "science" cover astronomy and medicine, radioactivity and synthetic chemicals, automobiles and radio-active electric toasters and space flights. But scientists designate as "pure" or "fundamental" or "theoretical" such things as Einstein's relativity, the constitution of matter, and the electro-magnetic theory of light and heat; while to applied science or technology, they assign all the instruments and machines used in industry and the home—paints, plastics, electric lights, and even the atomic bomb.

From the labors of those who were interested only in advancing knowledge have come the ideas and the instruments which have created new industries. But neither branch would be possible without the other, for without the advance of science the techniques would fossilize into unchanging crafts, and without the stimulus of products of technology science would become a vain display of learning.

Has the course of history been changed by scientific research? Certainly our way of living has been. Scientists' discoveries in the past half century—turned into inventions by innovators and put into productive shape by technicians—have raised people's expectations to the level of fantasy. And so, while the urge to reach the moon may be essentially research of a high order, the necessity of cleaning rocket fuel to unprecedented standards is producing techniques which may one day be embodied in the household washing machine.

It would be stupid not to make good use of the discoveries of others, but if we rest upon those without seeing and discovering for ourselves we are denying ourselves expression of the greatest human attribute. Despite the advances in organized research, the creative power of the individual still counts most. "It would be a disaster," said Prince Phillip, "if the individual inquirer working in his own laboratory were discouraged out of existence."

CHARACTER OF RESEARCH

Research is the challenging of self-evident truths. It seeks systematized positive knowledge. It wants not only to explain some part of the whole, but to see the pattern entire, and determine how the parts hang together. It glories in the lucid beauty of a solution reached after effort.

Research begins with curiosity—a manifestation of man's love of understanding things. It is one of the most permanent and certain

characteristics of a vigorous intellect. Curiosity must be active and must lead to asking questions which yield significant answers. Nine-tenths of us imagine that because we are wondering about something we are considering it. A really restless mind has wrenched itself from its fixities and is challenging things hitherto accepted as being obvious. Anything that is unknown is important.

Research must be objective. Objectivity is not a property of the evidence gathered but of one's attitude toward the evidence. The wise man is wary of his inclination to view any fragment of evidence in the light of facts and suppositions and old wives' tales he had previously acquired.

Research is good for the mind and spirit. If one is engaged in research, whether scientific, social or commercial, operational, or simply looking for a way in which he can live more happily, he is less likely to sink into a series of third-rate things. Research is an activity in which truthfulness is essential; in fact, truthfulness is the measure of its success. Truth cannot co-exist with vagueness and ambiguity but insists upon definiteness and completeness. Truth refers to the way things are, and it is the job of the researcher to find it out.

Research is ongoing. Static thought is knowing where Darwin stopped his theories; constructive thought is linking these theories together so as to learn how he arrived at conclusions. Research thought is starting where Darwin ended and going on from there.

CHARACTERISTICS OF THE RESEARCH-MINDED

To suspend judgment with patience, to meditate with pleasure, to say "it is finished" with caution, to abhor imposture: these are some of the characteristics. Experience, observation, and experiment enable one to single out the essential factors in a situation and to see how they are related to one another.

Observation is a prime requisite in research. Our intellects are not their own true selves when they are talking or chopping logic, but only when they are seeing and ascertaining, providing us with facts to be explained. Galileo's way was to choose his vantage point for looking and then to describe as simply as he could what he saw. He perceived the unwelcome facts as well as those which suited his suppositions.

The researcher is not a myth-maker. Either his hypothesis survives as a verified fact or valid principle or it dies a clean-cut and final death. He has to be his own "devil's advocate," conducting his

own cross-examination of his findings. Research invites the detection of error and welcomes it, even though the discovery upset complacency. A theory, whether about distant stars or family life, is untenable if it embraces even one false principle.

The scientific researcher takes no account of likes or dislikes, of parties or sects or nationalities. His business is to find out the truth, to discover exactly what things are and how they work. The scientist distrusts the plausible and the easy and the customary, not because he believes it is not so but because he knows it may not be so and he seeks ground on which to firmly plant his feet. He knows that the results may not turn out to his personal liking, but he hears Socrates saying: "Either we shall find what we are seeking, or at least we shall free ourselves of the persuasion that we know what we do not know."

Imaginative and Creative

Creative thought may begin with an urge to do something, to develop something, create something, improve something, facilitate something, accomplish something. One should give imagination loose rein and let it roam around his objective. Though many of us have difficulty in moving from one idea to another—perhaps a conflicting one—research compels us to think new thoughts. No matter how small the idea or supposition may be, it requires some originality to take the idea and formulate specifications of how to bring the idea into reality. Even the wildest ideas may be turned into the best behaved and most profitable through imaginative and original thinking. Ideas are not always the outcome of beating down on a problem. H. P. Maxim was asked how he got the idea for his Maxim silencer. "By watching the way water behaved when it went down a drain," he replied. A new twist, a different look, or an added idea may open a wide vista.

It is evident that research is not merely the classifying of information: one must think, even if it hurts. The ability to seek the causes of phenomena is what makes man supreme among animals. Many creative thinkers reach the solution of the problem long before they work out any logical proof. Karl Friedrich Gauss, great mathematician, confessed: "I have had my solutions for a long time, but I do not yet know how I am to arrive at them."

If the imagination is to yield any real ideas, it must have received a great deal of material from the external world, and it must have retained much of the freshness of outlook associated with childhood. Imagination can be as simple as that of Anne of Green Gables.

can picture herself in a beautiful dress, or it can be as sophisticated as that of Copernicus when he put the sun in the center of the solar system and saw all the planets moving in orderly and simplified orbits.

Experimental

Sparked by imagination, our minds become subject to sudden insights into problems they have worked on. Sometimes things viewed up in this way seem to point to one conclusion, but a little shift in point of view may find them pointing to something entirely different. That is why it is wise, in all matters where judgment is called for, to walk around the proposition and see it from every side. In other words, the insight must be subjected to a test of its validity and worth.

Scientific thinking includes these steps: determining the problem; collecting facts for and against through observation and experience; forming an hypothesis or scientific guess after discarding what is thought to be irrelevant; testing the hypothesis by patient experiment.

One should not allow himself to be discouraged by the all-too-common sneer that greets an hypothesis. What more is there to hide one in nine-tenths of the affairs of one's daily life than hypotheses? The important thing is to test the hypotheses before acting on them: it is of the essence of scientific method that one does not employ hypotheses which cannot be tested. This evaluation should be done with a fresh eye. Hypotheses must not become unshakable sacred cows. Research is a history of mistakes, but the mistakes have led to exactitudes and the exactitudes have led to the computer and interplanetary flights.

Even when an hypothesis fails to meet the test and must be discarded, the negative information it yields is not useless. It has narrowed the range, and by so much has increased the probability of finding the truth. Darwin's writings are for all time a model of refusal to go beyond the direct evidence, and of careful examination of every possible hypothesis.

Warning Student

Effective research does not arise from going into a laboratory or a field or an office and saying "what shall I look for now?" It does not construct something out of nothing. It requires knowledge gained by an idea. A great deal of solid foundational work ap-

appears under every discovery. This is the real reason for accumulating knowledge: so that one may have an abundance of material in his mind upon which an idea may alight and germinate.

The research man needs to be a good pupil, but he has to go further. The pupil picks up information; the student casts the facts into new forms; the philosopher-scientist energizes the facts with new ideas. This is not a pursuit for shallow wits or timid hearts with dragging feet, because it implies a leap taken by the mind across a dark gulf of nothingness into new regions of thought, and the establishing there of a bridge-head. It also demands effort and energy. Coming out of an intense creative experience a man may feel his mind all bruises. No one has yet devised an accounting system that will produce a clear-cut balance after adding up the research man's joy in success and his agony in defeat; his frustrations and setbacks and the occasional, indeed, very rare entry that marks a spot where results came readily and proved out perfectly.

Discovery is made easier today by the fact that research people have access to computers and other mechanical aids, but great discoveries have been made under harsher circumstances. Western European people have, over the years, done an immense amount of fruitful work with apparatus which a Canadian high school teacher would scorn as a "hay wire and binder twine" contraption. Intelligent improvisation has its proper place. The research man should be able to cope with the unexpected, the unpredictable, and the non-existent through originality and ingenuity.

RESEARCH IS CUMULATIVE

Science is a pedestrian, step-by-step advance from lowly beginnings. It is sufficient for the scientist to penetrate a few millimeters further into the darkness. It has taken many people and thousands of years to add these into the 14-day orbit of Gemini VII.

Obviously, research demands patience, and that is a virtue belonging to the strong. The person who truly wants something does not snatch. He carries on systematic inquiry, and is grateful if he is able to draw aside a corner of the veil that hides truth.

The world does not stop when the researcher pulls out his piece of discovery, nor should he stop. Every successfully completed experiment is a challenge. There remains much work to be done. Every discovery, every question answered, forces new questions upon us. At the uttermost reach of our discovery there arises the question: "What lies beyond?" Whether we ever reach the ultimate is not nearly so important as that we maintain inquiring minds.