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HUMAN NATURE IN SCIENCE[1]

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AMERICAN GEOGRAPHICAL SOCIETY, NEW YORK

THE Executive Committee has asked that emphasis be placed throughout this session of the association on "the indispensability of science for the future of civilization." This seems a little like putting the cart before the horse. If civilization were to disappear there would be no science, and science will contribute nothing to civilization if men of science fail to cultivate civilized qualities and respond to civilized motives. Hence, my talk to-day will bear, rather, on "the indispensability of civilization for the future of science." I shall invite your consideration of certain relationships between human nature, both individual and collective, on the one hand, and science on the other, and I shall illustrate some of these relationships with particular reference to geology and geography.

During their careers scientists acquire by bitter and sweet experience considerable information—even wisdom—concerning the influence of human nature on science. This they pass on to younger colleagues, who now and then give heed to it. Perhaps more heed would be given if the information itself were more "scientific." Actually most of it is gained hit or miss. Scrappy, unorganized and unsystematic, it breeds "pet theories."

The question of how human nature affects science is surely important enough to warrant a less personal and more systematic approach. Large quantities of data on the subject are available in published and unpublished documents relating to the history of science. From analysis of these data principles could be derived and illustrative examples could be drawn that would offend no one, as well might the use of examples taken from contemporary observation. Indeed, among the most valuable of the lessons to be learned from the history of science are those concerning the ways in

[1] Address of the retiring vice-president and chairman of the Section (E) on Geology and Geography of the American Association for the Advancement of Science (1943), Cleveland, September 13, 1944.

which science has hitherto reflected human nature and will doubtless always continue so to reflect it.

A Scientists' Macchiavelli

Macchiavelli wrote a manual for aspiring rulers of men. On the basis of research in history and in the biographies of persons who had succeeded or failed in the art of government, he composed his famous "Prince." I have in mind a sort of Macchiavelli's "Prince" for scientists—a manual that would analyze and synthesize those factors in human nature that contribute to success or to failure in the advancement of science. This manual, however, would not be "Macchiavellian" in its moral tone. It would deal with factors that contribute to the advancement of science rather than to the advancement of the scientist—not an unimportant distinction. Its writer, moreover, would have to pursue his biographical studies beyond the published "lives" of scientists, which deal largely with the successes of those who have been successful. Princes who fail create political havoc and hence their shortcomings are fully recorded. The shortcomings of men of science are more likely to be forgotten, though they may cause as much scientific havoc.

Let us assume that such a manual has actually been written by a Dr. Smith (a name which has no Macchiavellian connotations), that its title is "Smith's Manual for Scientists," and that the remainder of this address is a discussion of this imaginary work.

Like any good general introductory text-book in geology or geography Dr. Smith's book proceeds from the elementary to the more complex. Part I analyzes the several personal qualities that influence scientific research, somewhat as minerals and rocks are considered at the beginning of a geological text; Part II surveys the motives for scientific research, along lines comparable to the treatment of geologic processes—tectonic, erosional, etc.—; and Part III discusses scientific ideas much as formations of different periods are considered toward the close of the geological text.

Personal Qualities

The personal qualities discussed in Part I include judgment, common sense, honesty, diligence, energy, modesty, taste, intellectual curiosity, and many others, and also their opposites, which Smith calls anti-scientific qualities. Four qualities are stressed as having an especial bearing on science: originality, open-mindedness, precision and scientific consciousness.

Originality, with which are linked imaginativeness, creativeness, and the like, shows itself in the urge and the ability to find new fields of investigation, to invent new techniques of research and exposition and to devise new hypotheses. It provides the dynamic personal driving force in the advancement of science. The other three qualities provide governing controls that keep originality from running wild. As long as originality is held on the track, a man of science could scarcely have it in excess, whereas too much open-mindedness or too much precision may be as anti-scientific in their effects as too little.

Open-mindedness, to which critical acumen is closely related, is the disposition to give full consideration to all the evidence and to all reasonable hypotheses that bear on any problem. Excess of open-mindedness may inhibit the scientist from adopting any hypothesis at all; it may lead him to see so many sides of a problem that he fails to espouse any one, contenting himself with "impartially presenting the facts and leaving it to the reader to interpret them." This is a not uncommon weakness, especially in the social studies today, where the facts are bafflingly complex. Dr. Smith hazards the opinion that excessive open-mindedness explains why the output of a good many geographers has been primarily descriptive rather than explanatory or interpretative, and that geologists as a group are freer from this failing. Not being a geologist I don't know whether he is correct in this. Closed-mindedness, he maintains, is a more definite anti-scientific quality. It shows itself in violent denunciations of hypotheses, or sometimes even in unwillingness to recognize data that contradict a pet theory. When combined with originality, energy and vanity, closed-mindedness has been known to produce fanatical devotion to pet theories—especially when they are a scientist's own beloved brain children.

Precision, with its little sister accuracy, is as necessary a quality in a scientist as is sharpness in an edged tool. There is no excuse for inaccuracy that springs from sheer carelessness, and Smith advises well-meaning but "congenitally inaccurate" persons to avoid scientific pursuits. They do not always do so. There can, however, be too much precision. One does not cut down forests with razors, and, similarly, degrees of precision are often possible that may far exceed what is needed for a specific task in hand. Striving to attain such super-accuracy yields diminishing returns by reducing production without commensurate improvement in quality. Fussy and over-meticulous men of science do less for science than those who know just where to call a halt to their perfectionist inclinations. Excessive zeal for precision has delayed the publication of the results of researches until after the date when they would be of greatest use.

A scientific investigator might possess all the foregoing desirable qualities and yet be subject to the influence of undesirable motives. The fourth essential quality, therefore, is ability to discriminate between motives. This quality is "scientific consciousness" or the possession of a scientific conscience, which Dr.

Smith maintains is merely a special aspect of social conscience.

MOTIVES

To do justice to the very broad and important subject of motives, which is taken up in Part II, Dr. Smith concedes is a task that could be adequately performed only by an exceedingly wise man—a combination of scientist, historian and philosopher. He ventures into this field with some trepidation, which I confess to sharing with him.

He cites Webster's definition of "motive" as "that which incites to action." Every motive is either pro-scientific, anti-scientific or non-scientific, depending upon whether it promotes, retards or exerts no effect on the advancement of science. Every motive, moreover, is either a personal, a group or a disinterested motive, depending on whether it springs from a desire to serve individual interests, group interests or the interests of no particular individuals or groups. Dr. Smith illustrates these kinds of motives as they might operate concurrently in the case of a volcanologist in studying an active volcano. Curiosity as to how the volcano works and the desire to make some money in doing field work on its slopes are personal motives; an impulse to discover facts that might benefit the villagers living near the volcano and a wish to collaborate in a research program of a volcanological institution would constitute group motives; a desire to add to the general fund of scientific knowledge of volcanoes would constitute a disinterested motive. These are all pro-scientific motives. Anti-scientific motives would be exemplified in the volcanologist's fear of collaborating with a colleague lest the latter might steal some of his ideas, or in the cruder fear that might cause him to throw away his notebook and camera in his hurry to get away from an eruption.

PERSONAL MOTIVES

As regards personal motives, Smith does not dwell on that of making money, since this motive is in no way distinctive of scientists, and his subject is motives as they affect science itself rather than as they affect the fortunes of those who profess it. He does, however, analyze with considerable care the motives that spring from two personal desires—the desire to satisfy intellectual curiosity and the desire to be well thought of.

INTELLECTUAL CURIOSITY

Cats, he says, feel an absorbing curiosity regarding mice. While they are lured by scents and signs that indicate the proximity of the latter, they are immune to the allurement of dogs. So also, different scientists are susceptible to different allurements. Geographers are responsive to what they call the lure of place and the lure of the map.

The lure of place is an attraction that localities exert on the imagination—a curiosity concerning the nature of things as they exist in different places and regions. The lure of the map is the attraction of the shapes, forms and arrangement of things on the earth's surface, a geometrical curiosity concerning concepts that are, or might be, shown on maps. The lure of place Smith compares with the musician's sensitivity to tone or the painter's to color; that of the map with the musician's feeling for rhythm or the painter's for design. The "born geographer," if such there be, derives personal satisfaction from responding to these lures, just as the chemist derives personal satisfaction of a different sort from responding to chemical lures to which the geographer is indifferent. Dr. Smith's analysis of the psychological nature of the various scientific allurements makes an interesting digression.

We are more concerned here with his discussion of the controls that scientific conscience exerts upon the motives of satisfying intellectual curiosity. A well-developed scientific conscience, he argues, vetoes the waste of time, energy and talent upon studies that satisfy curiosity but do little more besides. Care in the accumulation of data, brilliance in their comprehension and exposition, and ingenuity in the development of theories are to little purpose if the facts and theories are of meager concern to anybody but the man who gathers and expounds them. A geographer might be impelled by a burning desire to make an intensive study of a very small area, when some one else has already made a similar study of a similar area in the same region. If the geographer has a scientific conscience it will warn him against yielding to this temptation unless he is firmly convinced that something new and of substantial value to others than himself will come from his study. To add embroidery to concepts and principles already well established may be enjoyable, but a scientific conscience warns against doing so when there are more pressing needs for other types of geographical research. Of course, Smith admits, it sometimes happens that an investigation which seems utterly useless at the time it is made, later turns out to be of far-reaching value, but he feels that the slight probability of this occurring must be weighed against the more obvious social needs for the services of scientists and against the fact that there are none too many scientists to meet such needs.

THE DESIRE FOR GOOD REPUTE

Scientists, he goes on to point out, are not unlike other mortals in their desire to be thought well of and their motives are strongly influenced by the opinions of others. Scientific conscience tells the scientist which opinions to heed and which to reject. There have been

times when it demands resistance to the opinions of persons who have it in their power to ruin a scientist's career or even to take his life, and science, like religion, has had its martyrs.

Smith shows that opinions or judgments of the relative worth of scientific investigations are of three main kinds: "formal" opinions, based on criteria of form and substance; "qualitative" opinions, based on criteria of scientific quality; and "pragmatic" opinions, based on criteria of effectiveness. As an example he asks us to suppose that three scientists are asked to express views as to whether or not two books should be published. The first book is a treatise on contemporary geopolitics, carelessly written, poorly arranged and wholly unsound in its reasoning. The second book deals with the historical geography of ancient Siam; written in a beautiful style, it is based on profound erudition and is thoroughly convincing in its handling of all the available evidence. Scientist A says: "Publish the first book since geopolitics is more vital than historical geography." This would be a formal judgment. Scientist B says: "Publish the second book because it is so much better in quality," clearly a qualitative judgment. Scientist C says: "Don't publish either, since neither will exert much influence, the first because it is so bad, the second because it is so recondite." This is a pragmatic judgment.

Formal Opinions

Dr. Smith comments on the propensity of certain men of science to express sweeping judgments of whole fields and whole methods of scientific investigation. While these judgments are often penetrating in their insight and exert a beneficial effect, sometimes, on the other hand, they reveal a distinctly lower order of scientific thought than would normally be used by those who propound them in their own specific researches. When such opinions crystallize into widely and uncritically accepted clichés Smith believes they may be harmful, and that they are likely to be particularly harmful when based primarily on formal rather than primarily on qualitative or pragmatic criteria.

Among such clichés founded primarily on formal criteria he cites the view that experimental research and first-hand studies in the field are inherently more "scientific" than researches in libraries; also the opinion that quantitative studies yield more genuinely scientific results than those in which quantitative measurements are not feasible. Another formal cliché judgment, he says, is unconsciously expressed when certain works are damned with faint praise as "mere description," "nothing more than compilation," "simply a matter of techniques."

Science is founded on the assumption that the universe is governed by laws, and the goal of science is to discover and formulate these laws. Dr. Smith, however, with some justification, regards as a cliché the rating of those forms of scientific investigation which yield precise and reliable statements of laws as necessarily more scientific than those which do not. Some of the laws of astronomy have been formulated so accurately that eclipses may be predicted thousands of years hence. The laws of economics barely permit the prediction of what is going to happen next week. But to regard astronomy as therefore more worthy of scientific respect than economics, Smith believes, is to take a narrow, formalistic view of the scope and nature of science.

Geographers may be interested in what Dr. Smith says about certain formal clichés concerning their subject, though not all of them will agree with him. Not so long ago, he points out, geography as a whole was criticized because a number of geographers were prone to give unlimited scope to their imaginations in the matter of generalization. The whole discipline was condemned for the excesses of some of its devotees. This helped instil in certain other geographers a horror of generalization and reluctance to generalize. In other words, these latter geographers adopted a formal cliché about the nature of generalization. Rather than take risks of generalizing, they turned to "safe" quantitative studies, to microgeographical researches and to emphasis on the accumulation rather than on the interpretation of facts. This, in turn, gave rise to yet another formal cliché on the part of non-geographers, that geographers are sterile in ideas and narrow in vision.

Since the whole purpose of science is to establish general principles, an irrational fear of generalization *per se* is anti-scientific. What is to be shunned is unsound generalization. Similarly microgeography *per se* is not necessarily narrow and without vision—only microgeography that yields little larger fruit. But when generalization is condemned for unsoundness the judgment is qualitative, not formal, and when microgeography is condemned for leading nowhere the judgment is pragmatic—not formal. Dr. Smith shows, however, that judgments in which little or no account is taken of quality or effects are easily and often made.

Qualitative Opinions

That qualitative judgments of the worth of scientific investigations are fairer than formal judgments, Smith holds to be obvious. A qualitative judgment takes account of the degree of good sense, originality, accuracy, open-mindedness, and so forth, to which a study bears witness. It also takes account of the suitability of the form and substance to the solution of the problem in hand. Thus field studies would be rated

higher in quality than library researches only in cases where better evidence can be secured by the former than by the latter. While field observations provide the primary data for geology and geography alike, it would be ridiculous for a geologist or geographer to expect that he could solve many of the larger problems that confront him, problems involving synthesis and correlation, by investigating them in the field alone.

While the goals of science are the discovery and formulation of laws, a lot of work has to be done before laws can be formulated, and this preliminary work, in Smith's opinion, is quite as indispensable, quite as "scientific," as are the subsequent processes of interpretation to which it leads. Part of the preliminary work consists in "mere" compilation, description and development of techniques. Qualitatively such procedures, as long as exacting, critical and original scholarship is devoted to them, rate higher than speculative attempts to establish laws on the basis of faulty reasoning from insufficient evidence. To Dr. Smith an economic law is fully as scientific as is the law of eclipses, provided all available evidence is used in developing the economic law and used with the same degree of rationality as that attained in developing the astronomic law. That the actual probability of the economic law is less he regards as immaterial to its scientific quality.

Whole broad domains of science are cultivated not for the immediate purpose of formulating general laws but in order to understand specific conditions and processes. This is especially true of geology and geography, where the first objective is to explain the origins, nature and relationships of particular land forms, rock formations, types of settlement, routes of trade, and what not, as they exist in particular regions. These studies prepare the way for the formulation of geological and geographic laws sometime in the future, but the way may be long. If the scientific merits of research are judged formally according to the degree to which they succeed in stating general laws, rather than according to the quality of the work devoted to such research, a large part of our two sciences of geology and geography would be denied scientific merit—something that we may unite with Dr. Smith in regarding as absurd.

Pragmatic Opinions

Pragmatic opinions, as distinguished from formal and qualitative opinions, are those which rate scientific researches in terms of their effects. While it is usually true that the better the quality, the better are the effects, this is not invariably so. Smith shows that incomplete and even careless studies of little understood but important phenomena may exert more far-reaching and more beneficial effects than studies of higher quality that deal either with inconsequential matters or matters already well understood in their essentials. Great works of compilation often rate extremely high from the pragmatic point of view because of the innumerable practical purposes that they serve and because they furnish the stimulus for the development of scientific theories. Even "outrageous hypotheses," as the late Professor W. M. Davis pointed out, may have pragmatic worth by providing means of testing the validity of other hypotheses.

The pragmatic opinions that others hold of the effectiveness of his work are largely instrumental in fashioning the nature of a scientist's response to *group* motives. This subject Smith takes up in the next chapter.

Group Motives

Here he states that science is the product of human gregariousness and that it would be hard to conceive of a scientific investigation not motivated in part at least by a desire to serve the interests of some group of people—be it an organized group, such as a university, a society, a community, a corporation, a nation, or largely unorganized, such as the geological or the geographical professions, or the people who happen to dwell on the slopes of a volcano, be it actual or figurative. But while this desire, combined with personal curiosity, has brought science into being, certain group motives have also constituted serious obstacles to the advancement of science, and it is with these anti-scientific motives that Dr. Smith is most concerned.

Anti-scientific group motives spring from competition and conflict among groups—from the ambition of groups to get the better of one another and from their fear of being got the better of. These conflicts, moreover, are on many levels: they range from quarrels between or within departments in a single university to world wars between coalitions of nations. They give rise to three types of anti-scientific practice: the wilful distortion of truth in order to mislead rival groups; the suppression of the results of scientific research in order that rivals may not benefit by them; and the use of the results of scientific research to injure rival groups.

That the first of these practices—the distortion of truth—is the negation of science is self-evident, but that the second and third are anti-scientific Dr. Smith believes to be less obvious. It has been argued that science is advanced whenever scientific research is conducted whether or not the results are suppressed, and that the use of the results is of no scientific concern—in other words that these are questions of morals and not of science. Dr. Smith, however, seeks to demonstrate that ethics and science are inextric-

ably linked and that unethical practices are not only anti-social but anti-scientific.

He argues that the advancement of science demands the continuous discovery of new truths and the continuous development of new hypotheses. For this the fullest and freest possible interchange of knowledge already acquired is prerequisite and anything that hinders this interchange retards the advancement of science. Indeed, the very word "science" connotes something that can not be hoarded in secrecy. While one says "my knowledge" or "the government's knowledge," one never says "my science" or "the government's science." Science, unlike knowledge, is indivisible in the sense that no part of it can be the exclusive possession of an individual or a group and the whole of it is the common property of humanity. When we make a "contribution to science," we donate some of our knowledge to humanity. Knowledge may be scientific in quality, but as long as it is kept locked in files marked "secret," "confidential" or "restricted," it remains mere knowledge. It does not become science until it is made at least potentially available to any one who wishes to use it.

Much scientific research has been conducted for the express purpose of applying its results to the injury of other groups. Wars have produced such feverish bursts of scientific activity and have so greatly accelerated certain discoveries and inventions that it has even been maintained by some that war has accomplished more than has peace to promote the advancement of science. Smith emphatically rejects this doctrine. That human enlightenment in the long run can have benefited more than it has suffered from group selfishness, conflict and fear he regards as an "outrageous hypothesis" of no pragmatic value.

Disinterested Motives

The last chapter of Part II of Smith's manual deals with disinterested motives in science. These are the incentives to scientific endeavor, which, because they do not spring from the needs or interests of specific individuals or groups, are necessarily incentives to serve the general needs of humanity.

Scientific work is never motivated solely by disinterested purposes—never without any trace of the influence of desires to serve personal or group interests. Disinterested motives operate concurrently with rather than to the exclusion of group and personal motives, and one of their principal functions is to counteract or nullify the anti-scientific influences of selfish and destructive group motives. By inciting men of science to resist anti-scientific and anti-social practices disinterested motives operate, Dr. Smith says, somewhat as do the preservatives put in foods to prevent their spoiling. They have, however, a more positive function—that of inspiring men of science actively to seek out those lines of endeavor that will be of service to mankind.

Science and War

We come now to Part III of Smith's manual, which deals with the nature of certain larger problems in science in the light of the various qualities and motives analyzed in the two preceding parts. Time does not permit me to dwell here on more than two of these problems—those of the effects of war upon science and of the reconstruction of scientific endeavor after the war.

While he regards the institution of war as detrimental to the advancement of science in the long run, he is far from regarding war as an unmitigated evil in its effects upon science. War gives complete priority to a particular group motive—that of helping one's nation to win. In wartime all other motives —personal, group and disinterested—are overshadowed by this one, which produces an intensity of thought, a passion for hard work and a collaborative spirit among scientists that are seldom equalled in peacetime. It also leads to rapid advances along certain specific lines of research. This is the bright side of the picture. The darker side is that scientific effort as a whole is regimented and hence distorted. In times of peace the pioneer fringe of scientific knowledge advances more or less evenly along a broad front and in the open, where all who wish to look can see its advance. In war long stringy arms shoot ahead into the unknown, while large segments of the frontier remain at a standstill and many of the most rapidly advancing arms are blotted out by clouds of censorship. The operation of disinterested motives is not only weakened but often entirely prevented.

Dr. Smith makes it clear that the problems that a nation faces in getting into and in getting out of a war are often more difficult of solution than those of actually waging the war itself and that this is true no less in the realm of science than in other realms of national life. While a war is in progress, much scientific work can proceed smoothly "according to plan." The most serious difficulties are encountered in making the transitions from peace to war and *vice versa*. Smith believes that it is none too soon for American scientists to give thought to the readjustment that they will have to make when the compulsions and the restraints of wartime are removed.

As a car must be refitted in the spring for warm-weather driving, so the machinery and organization of scientific investigation will require reconditioning for peacetime operation. For one thing, steps will

have to be taken to reestablish the fellowship of men of science throughout the world—a fellowship in which the nationalistic impulses of aggression, fear and suspicion can be made partly if not wholly subordinate to the disinterested service of science. Within each nation anti-scientific restraints—censorship and censoriousness, in particular—must be abolished with the utmost possible dispatch. In this reconditioning of scientific endeavor, the benefits of its wartime operation must be preserved in so far as possible, especially the spirit and means of collaboration that the war has developed. The artificial academic barriers that this collaboration has done so much to break down must not be permitted to arise again. Men of science must make concerted efforts to forestall the loss or destruction of the masses of information that have been accumulated in government offices and elsewhere for wartime purposes. Peace will bring a widespread let-down, an inertia that will have to be overcome if this latent science—as it might be called—is to be saved and released promptly for use.

Imperative as will be this reconditioning, it is merely a means to an end. Just as the end in the case of the automobile is to drive it somewhere, so in the case of scientific research it is the production of needed types of science, and the larger problem is what the mechansims of scientific research shall be made to produce when peace returns.

Some might say that it should not be *made* to produce anything in particular—that compulsion stifles originality and initiative, and that scientists should be free to study whatever they please in whatsoever manner they wish. Dr. Smith thinks there is wisdom in this view, provided one important qualification is made. While freedom of science is fundamental, like freedom of speech it is a freedom that imposes responsibilities. It is freedom to investigate whatever one wishes, subject to the dictates of scientific conscience. A developed and enlightened scientific conscience will always incite its possessor to select from among the innumerable subjects by which he is attracted in his chosen field, those in which his abilities can best be employed toward meeting the greatest human needs.

Along with many other contemporary observers, Smith maintains that science has given men a mastery over nature so extensive and so skilful that, if uncontrolled, it may lead, not to making the world more civilized, but to the destruction of civilization itself. This will happen unless an equal degree of mastery can be achieved over the forces, both good and evil, in human nature. Hence Dr. Smith believes that the most urgently needed of all forms of science is that which will contribute to increasing the will and the power of human groups to collaborate with one another instead of cutting each other's throats. The development of this will and this power has traditionally been considered a task for experts in morals rather than for men of science. Good motives, however, whether on the part of an individual or a group, can not be inculcated by moral precepts alone. A child is more likely to behave if given a rational—a scientific, in other words—explanation of the undesirability of ill behavior, than if merely told that such and such conduct is bad. The child ordinarily misbehaves because he feels injured or thwarted, not because of the machinations of Satan or the promptings of original sin. Similarly groups cut each other's throats because they feel, rightly or wrongly, that they are thwarted or imposed upon by other groups possessing greater advantages. Science can often disclose whether such sentiments are founded on fact or fancy, and if they are founded on fact, science can seek for and test out measures of amelioration.

Many of the largest and toughest roots of man's inhumanity to man are embedded in the circumstance that certain groups enjoy advantages over others because they occupy or control particular areas of the earth's surface. There are inter-areal conflicts within every village, every state and every nation, and, worst of all, between nations. Neighbors quarrel over fence lines and wandering cattle; nations fight over boundaries and the control of vast territories. Hence, those branches of science which deal with areas, their occupants and those who control them in terms of their relative advantages and disadvantages can do much to lay bare the roots of human conflict—and the laying bare of roots is a necessary preliminary to their removal. Areal, or regional, research lies partly within the provinces of geology and geography. Hence Dr. Smith believes that our two sciences afford immense potentialities of service to perplexed humanity and that geologists and geographers are in a peculiarly favorable position to produce scientific fruit indispensable for the future of civilization.

OBITUARY

A. H. REGINALD BULLER

A. H. REGINALD BULLER, emeritus professor of botany at the University of Manitoba, Canada, died in Winnipeg on July 3, 1944, after an illness lasting five months. He was nearing the end of his seventieth year.