Progress in Canada

E. W. R. Steacie and Science in Canada. M. Christine King. University of Toronto Press, Toronto, 1989. xii, 243 pp. + plates. $35.

The British chemist Arthur Allmand had a favorite dictum: "A professor of one of the natural sciences. . . might be a great researcher, a great administrator or a great teacher. Sometimes he might shine in two of these categories but to do so in all three [is] unattainable for most people." Allmand managed the feat. So too did E. W. R. Steacie, the Canadian photochemist, a noted instructor at McGill University and successful president of the National Research Council of Canada.

Biographies of Canadian scientists are rare, and this one was written by M. Christine King of the University of Ottawa, who died just as her manuscript was completed. That the book is well researched and reads well is a tribute to her skills, but there is throughout a lack of detail that she might have been able to add in the editing, though Steacie unfortunately left no large body of personal papers.

Steacie was born in 1900 in Montreal into comfortable circumstances. He took his education at McGill and received his Ph.D. in 1926. McGill, to Steacie, was "the highly visible symbol of the English language community in Montreal, the epitome of its history, achievements and wealth"; it was also then the best Canadian university, and not just in the sciences. Steacie took a postdoctoral fellowship there, followed two years later by appointment as lecturer. These years are covered cursorily; so is Steacie's marriage to Dorothy Catalina Day "immediately after her divorce from a former marriage." In 1928 in the tight world of Anglo-Montreal, that must have been a sensation, but we learn nothing of it.

Steacie was a notable success as a teacher, clear, logical, succinct. His early papers were on solubility, and he was quickly into the textbook market, which suggests that the Depression pinched. The decisive experience in his scientific development seems to have been his trip to Germany and Britain in 1934 on a fellowship; he worked under Karl Bonhoeffer, initially measuring reaction rate in heavy water, "just the sort of thing I came here for." The chemistry was good, and so was Germany, "quite a pleasant place to be in these days." For an intelligent man, Steacie seemed remarkably unperceptive in his view of the first Nazi years. The coming of the war would change his immature perceptions.

By 1939, when Steacie became the director of the chemistry division at the National Research Council, he had 88 publications to his credit. Canadian science was far from world-class, but he himself had a substantial reputation in his field. The NRC had yet to make any such mark. Founded in the Great War, it had only moved into its own building in 1932, and its research work was diffuse. World War II changed all that, as C. J. Mackenzie, its president, led it into the Canadian and Allied war efforts. Steacie was Mackenzie's right-hand man, deeply involved in atomic research at McGill, in the creation of the Chalk River nuclear site, and other war projects, while trying to keep up his own research on photosensitized reactions. "On train journeys, between tasks, and especially at night, Steacie studied the scientific literature. . . ." He produced 23 papers and a book during the war, astonishing given his duties.

With the peace, Steacie developed the idea for the NRC's postdoctoral fellowships, bringing scientists to Canada on "princely" stipends. Many stayed to staff the expanding universities. In 1952, he succeeded Mackenzie and skillfully led the NRC through the "age of certainty." Canada was booming, money was plentiful, and the Liberal ministers with whom he had to deal were sympathetic. But all good times end; the economy tumbled in 1957–58, and the Progressive Conservatives came to power. There were soon attempts to bring the NRC into the civil service, bitterly resisted, and the free ride scientists had enjoyed was soon replaced by querulous questioning and demands for accountability. Steacie, for example, had been remarkably complacent about radiation hazards; his successors could not get away with that.

By the time of his death from cancer in 1962, Steacie was the greatest figure in Canadian science. He and Mackenzie had made the National Research Council into the engine of Canadian research, and Steacie had helped bring Canada "part of the way along the road from the ox-cart to the bulldozer." That was no mean achievement.

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The Language of Science

The Mathematical Tourist. Snapshots of Modern Mathematics. Ivars Peterson. Freeman, New York, 1988. xvi, 240 pp., illus., + plates. $17.95; paper, $10.95.

Innumeracy. Mathematical Illiteracy and Its Consequences. John Allen Paulos. Hill and Wang (Farrar, Straus and Giroux), New York, 1989. 135 pp., illus. $18.95.

In 1930 Tobias Dantzig, professor of mathematics at the University of Maryland, wrote a book entitled *Number: The Language of Science*, declaring that the subject "deals with ideas, not with methods." Adopting a historical approach, he elucidated fundamental concepts of mathematics for the general public so well that a fourth edition appeared in 1954 and is still in print. In the fourth edition, Dantzig added a second part to take account of "the prodigious changes that have taken place since the last edition of the book appeared." Since Dantzig there have been many books designed to inform the literate nonmathematician about mathematics. Those by Paulos and Peterson are two of the most recent and provide an interesting contrast, illustrating that the universe of mathematics is now so multifaceted that entire volumes can be written on mathematical concepts without overlapping.

Paulos directs his book to the educated innumerates, defining them as those with an inability to deal comfortably with fundamental notions of numbers and chance, by which he means statistics and probability. Early in the first chapter he explains scientific notation in six lines, mainly by giving a series of powers of ten followed by numbers with the requisite quota of zeros. This is followed by illustrations of facts that are expressed in scientific notation, such as the rate of growth of a human hair expressed in miles per hour, the number of cigarettes smoked each year in the United States, and the possible states of the Rubik cube. He goes on to more esoteric data, including the volume of all the human blood in the world, the number of subatomic bits that would fill the universe (less than 10^{125} by an "easy calculation"), and the age of the universe in tiny time units that approximate the chronon, although he does not use that term. Interspersed are somewhat more mundane data such as the per capita cost of the Defense Department budget, the ratio of the speed of the Concorde to that of a snail, and the chances of catching AIDS in a variety of sexual relations.

Paulos attributes a tendency to drastically underestimate the frequency of coincidences to innumeracy and proceeds from this to take some well-aimed shots at pseudoscience, in which he includes astrology, parapsychology, dream predictions, UFOs, drug testing, and numerology. He also gives some very practical applications of mathematics, showing that an item whose price has been increased 50% and then reduced 50% has had a net price reduction of 25% (something some investors don't seem to realize). He explains the law of large numbers that, in the long run (that is, as the number of cases increases), the difference between the probability of some event and the relative frequency of its occurrence approaches zero; and notes that despite statements in advertisements the incidence of maladies such as cavities cannot be reduced 200%. However, his penchant for startling, counterintuitive statements, many of which he admits are "psychological tricks," causes him to neglect more commonplace examples of innumeracy, such as the tendency of some journalists to decry as shameful the fact that more than half the students in some class or school are below the average of some academic standard or the use of "megawatt" in a recent issue of a national newsweekly to mean 100,000 watts, rather than a million. Overall, this is an interesting book, but the author's exhibitionism makes it not nearly as good as it could or should have been; and it is highly dubious that it will achieve its purpose of appealing to innumerates. A much more practical and appealing approach to the truly innumerate has been made by the ecologist Garrett Hardin in *Filters Against Folly* (1986), among various recent guides to mathematical reading for nonmathematicians.

In contrast, Peterson's tour of modern mathematics assumes the reader to be numerate to the extent of knowing scientific notation and elementary algebraic notation, but explains all concepts and calculations beyond this level. His story of developments in the last two decades begins with a brief verbal description of the fields of mathematics and proceeds to a detailed explanation of the significance of prime numbers and their practical importance to modern cryptosystems. Nearly all the developments discussed involve computers and graphic printouts, many of which are scattered throughout the text, further aiding comprehension by nonmathematicians. This leads Peterson to assert that experiment plays an important part in mathematical research, that number theorists cannot rely simply on deduction but, like other scientists, often must collect piles of data before they can extract the principles that account for their observations.

Topology, a 20th-century development in the mathematics of space and shapes, has used such simple techniques as dipping model configurations into soapy solutions to study the contours of soap films and thus determine minimal surfaces for structures. Today, computer graphics can play the role of soap films, and computers can be used in situations where physical experiments aren't possible, such as determining infinite minimal surfaces. Thus, computer graphics has proved to be an indispensable tool for exploring hitherto unseen, and unimagined, geometric forms. Examples appear in the book in both black-and-white drawings and color illustrations. A limitation of this technique is that an explicit equation defining a surface or group of surfaces is needed to produce a computer picture; but visual exploration may furnish clues that suggest mathematical proofs and equations.

Discussing higher dimensions, Peterson shows that any set of four numbers, variables or parameters, can be considered either as a four-dimensional entity or as a string of numbers that can be manipulated. Einstein's fourth dimension represents only one of many different types of four-dimensional space; and going beyond four dimensions (as in modern string theory) is simply a matter of adding more variables. This presents a challenge to modern mathematicians in solving the ancient problem of classifying all geometric shapes. With topology inventing new shapes and geometry spreading into higher dimensions, mathematicians face "an unruly zoo of geometric forms," and classification now lags behind discovery of new forms.

A class of new forms, named by Benoit Mandelbrot in 1975, is fractals. These are irregular and fragmented self-similar shapes that contain structures nested within one another, each a miniature, though not necessarily identical, version of the larger form. Nature is full of such shapes, such as trees, mountains, or a coastline. Finer and finer scales reveal more and more detail and lead to longer and longer coastlines, until length can finally be considered infinite. Similarly, fractals can be created by taking away successively smaller parts of a line, plane, or cube, ending in a shower of dimensionless fragments that constitute a Cantor set. Astrophysicists confirm that this model accurately predicts the distribution of mass within the universe, of stars in a galaxy, and of galaxies in the universe, with large regions left empty. Fractals describe an astonishing array of other natural structures. However, mathematical fractals have properties not found in natural objects, as no real structure can be magnified an infinite number of times and still look the same, both because of the finite size of molecules and atoms and because at some magnification real objects abruptly shift from one type of structural pattern to another. So scientists taught to think of integers as the way to represent physical processes are beginning to see that noninteger exponents are just as likely to turn up in nature.

While Peterson discusses far more subtle and complex concepts than Paulos, he takes the reader through explanations and derivations of the concepts. Those with only a smattering of mathematics will have to read Peterson more slowly and carefully than the mathematically sophisticated, but they will be rewarded by learning more, and quite painlessly. This is not a complete handbook to modern mathematics, but it is a lucid and fascinating exposition of fields of recent development that should be instructive to all but the most advanced professional mathematicians.

Perhaps the most significant message of both books is that numbers and other mathematical symbols represent ideas; and that mathematical concepts can almost always be stated in words. Numbers are the language of science because they are more precise than words; but they are also more ambiguous, as each number may represent an infinite variety of phenomena. So descriptive mathematical equations cannot be fully formulated without words to specify the ideas which the numbers and other symbols represent. Peterson does this well for several fields of mathematics.

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Neoconservative Paleobiology

Arguments on Evolution. A Paleontologist's Perspective. ANTONI HOFFMAN. Oxford University Press, New York, 1989. xiv, 274 pp. $29.95.

This provocative book is a response to the last decade's excitement in evolutionary paleobiology. Like a number of recent works, it is concerned with the present health and primacy of neo-Darwinism: do short-term processes at the individual level ("microevolution") explain all evolutionary phenomena, including those observed in the fossil record? So baldly stated, this question is a bit outmoded. Even at the peak of the controversy the answer was very much in the eye of the beholder; for example, Will Provine has been careful to distinguish between the views of Sewall Wright and those of his strict neo-Darwinian contemporaries, whereas many staunch neo-Darwinists today view Wright as one of the giants in their field. Far more important, now that the rhetorical furor has abated, is that evolutionists, whether studying living fruit flies or fossil