1.2 million new chemical compounds in 10 years

Nowhere is the rapid advance of scientific knowledge more dramatically evident than in the field of synthetic chemistry.

A new study by analysts at the Institute for Scientific Information in Philadelphia shows that in the 10-year period from 1960 to 1969, a total of 1,188,354 new chemical compounds were added to the published scientific literature.

Note the scholars: "By the end of the Second World War, there were approximately 1 million known chemical compounds in existence, so the new compounds reported between 1960 and 1969 are more than in the entire history of chemistry up to the end of the war." Between 1945 and 1959 another 1 million compounds were reported.

In 1969 alone, the last year of the study, nearly 173,000 new compounds were reported. The literature of synthetic chemistry is growing at a rate of 8.7 percent a year, the study found. At this rate it is doubling every 8.3 years.

The study analyzed reports in *Current Abstracts of Chemistry and Index Chemicus*, a weekly abstracting service covering published journal articles reporting primarily new chemical compounds, new reactions, or new syntheses. The publication started in 1960 as a monthly, became a biweekly in 1961 and a weekly in 1967.

Other interesting findings: English gained as the leading scientific language of synthetic chemistry (in 1960, 50 percent of the reports were in English; in 1969, 61 percent were). Russian, German, French and Japanese were next in line. Although 12,000 journals are monitored for the abstracts, two-thirds of the new compounds were reported in only 27 journals.

The study is reported in the March 30 NATURE by Eugene Garfield, Gabrielle S. Revesz and Joanne H. Batzig. □

Ten major innovations: Keys to success

Has today's technologically oriented society managed to reduce the time lag between conception of a new idea and its successful innovation as a usable product or process? The answer, according to a new study prepared for the National Science Foundation, is no.

"From the small sample of innovations studied, there is no evidence that the time period from conception to realization is becoming shorter," concludes the study. "In fact, two of the more recent innovations (input-output economic analysis and the heart pacemaker) involve the longest time spans."

The study by the Battelle Columbus Laboratories examined the case histories of 10 major innovations (see chart). The shortest interval between conception and realization was six years for the video tape recorder. The longest (for the heart pacemaker) was 32 years. The average duration of the innovative process was 19 years.

DURATION OF THE INNOVATIVE PROCESS FOR TEN INNOVATIONS

Innovation	Year of First Conception	Year of First Realization	Duration, years
Heart Pacemaker	1928	1960	32
Hybrid Corn	1908	1933	25
Hybrid Small Grains	1937	1956	19
Green Revolution Wheat	1950	1966	16
Electrophotography	1937	1959	22
Input-Output Economic Analysis	1936	1964	28
Organophosphorus Insecticides	1934	1947	13
Oral Contraceptive	1951	1960	9
Magnetic Ferrites	1933	1955	22
Video Tape Recorder	1950	1956	6
Average Duration			19.2

The difference in duration between the longest and the shortest, concludes the study, was caused mainly by a difference in availability of technology for the two innovations.

In 9 of the 10 innovations, a key element leading to success was the presence in the performing organization of a "technical entrepreneur"—one person who champions a particular scientific or technical activity. (For the "Green Revolution" in wheats it was Norman E. Borlaug, who has since won the Nobel Peace Prize for his work. For the oral contraceptive it was Gregory Pincus of the Worcester Foundation for Experimental Biology. For electrophotography, it was J. C. Wilson, who directed a difficult and complex effort culminating in the first commercial photocopy machine, the Xerox 914.)

The importance of the technical entrepreneur "is the strongest conclusion that emerges from the study," says the report. "In fact, in three innovations [electrophotography, video tape and the heart pacemaker] the technical entrepreneur persisted in the face of the inhibiting effect of an unfavorable market analysis. If any suggestion were to be made as to what should be done to promote innovation, it would be to find—if one can!—technical entrepreneurs."

This and other evidence of the importance of "inventive or creative activities that do not lend themselves to detailed planning" lead the panel to a final note: ". . . We are forced to conclude that innovation cannot be completely controlled or programmed." □

Citing innovative engineers, inventors

Election to the National Academy of Engineering is one of the highest honors that can be awarded an engineer in the United States. Prior to this year's election only 359 members had been selected since the NAE was established in 1964. In recent years, however, the NAE has been criticized for shining its light too much on high-level corporate administrators and not enough on working engineers.

Last year, perhaps in search of balance, voting procedures were changed so that a certain number of negative votes would automatically eliminate a candidate, with the result that only 11 new members were elected—but seven of them were from universities.

Following that election, a special committee was set up by the NAE to try to make the Academy's selections more representative of the engineering community. The committee evaluates engineers cited by other organizations, consults the National Society of Women Engineers and in general tries to fill the gaps.

The result this time is the second highest number of new members in the Academy's history, 70. Of these, 13 are from government, 32 from corporations and 25 from universities, including a number elected for their original innovations and developments rather than their skill in managing large or prestigious programs.

Robert Mario Fano, for example, has been at Massachusetts Institute of Technology ever since his undergraduate days, and was personally active in developing the first interactive time-sharing computer system. Burton Brown of General Electric was cited for original contributions to radar design, including parabolic antennas for search radar and innovative circuit design. From the Navy, Grace Murray Hopper—only the second woman ever elected to the Academy—is credited with the basic work in the invention of the compiler concept, a fundamental technique for letting humans speak to computers in comparatively natural languages. Morgan Sparks of Sandia Laboratories developed much of the basic structure of bi-polar transistors. William B. W. Rand, now retired from Submarex Corp., invented a variety of novel deep-sea coring devices and shipboard deep-drilling rigs. C. P. Ginsburg of Ampex, the "technical entrepreneur" for the video tape recorder (see adjacent story), was cited for invention of instant television replay.

Finding award-worthy engineers from a range of responsibility levels took a special effort, the NAE admits, and the effort needs to continue. □