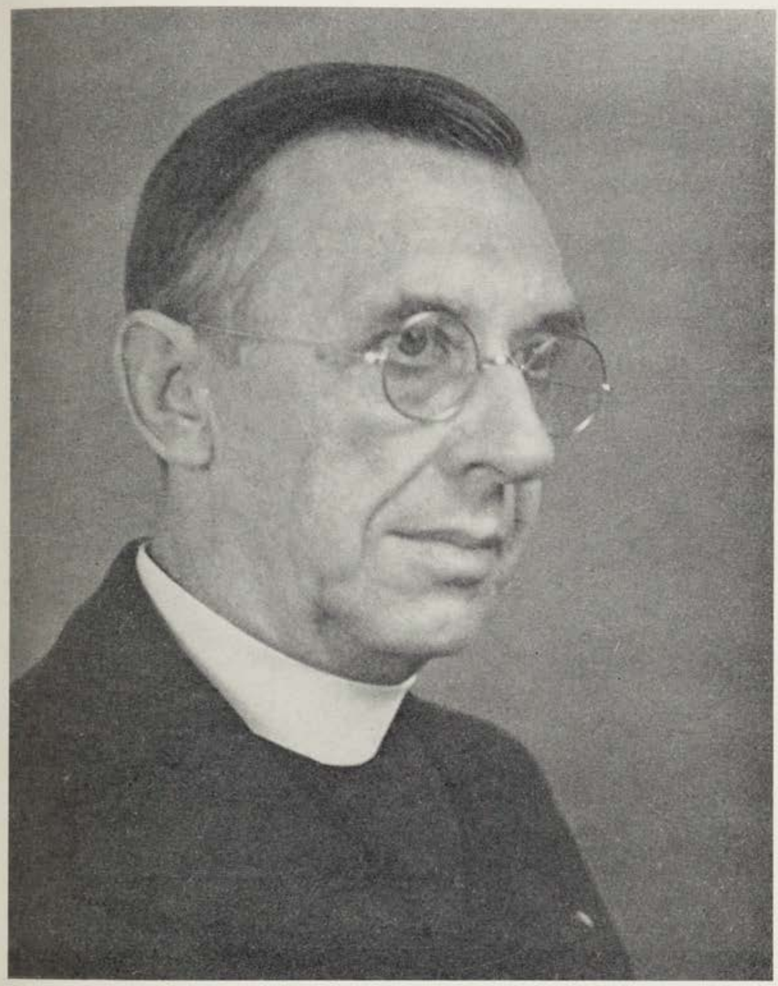

Rev. Charles E. Depperman, S.J.
(see page 48) *1889-1957.*

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NOTICE TO AUTHORS

Manuscripts are to be submitted to associate editors of the appropriate section and *may* be submitted directly to the editor in chief. Clear manuscript, preferably typed, with wide margin to the left, with double spacing between lines, is desirable. Please try to follow the typographical style of the most recent issue of the BULLETIN. Line drawings should be submitted on Bristol board, or similar material, and done in India ink. Figure number should be written on this in pencil. Titles for drawings, with figure numbers, should be typed on a separate sheet. Please try to minimize footnotes. Appended references and bibliographies, clearly so marked, should be done in the style of the A.A.A.S. publication, *Science*.

Manuscripts of NEWS ITEMS should be sent to the NEWS EDITOR: Rev. Bernard M. Scully, S.J., Cranwell Preparatory School, Lenox, Mass.

Obituary

REV. CHARLES E. DEPPERMANN, S.J., 1889-1957

REV. JAMES J. HENNESSEY, S.J.

"A group of us went to Puerto Rico in 1943 to assist the widespread tropical weather service of the army. Naturally, our studies were based on the existing standard literature. And it is no exaggeration for me to say that your Manila work supplied a large part of the foundation both for the research and teaching; and that any success that our work may have had would have been greatly retarded if not made impossible without the guidance provided in your publications."

The above quotation taken from a letter dated April 25, 1945 from Dr. Herbert Riehl of the University of Chicago to Father Deppermann points to the authority of the Jesuit priest in the field of tropical Meteorology.

Born in New York City, Charles Edward Deppermann attended public school No. 46 and the High School of Commerce. As a scholar, not much given to athletics, his marks were the highest in the class. In mathematics, especially, he excelled. His schooling was interrupted by four years of work as a typist in a law firm. Entering the Society of Jesus at St. Andrew-on-Hudson on the thirteenth of August, 1910, throughout the course of studies, he was always an interested and successful student. He never had the experience of teaching since he went directly from Philosophy to Theology at Woodstock. For that reason, too, he was the last to be ordained. Cardinal Gibbons ordained this group in Dahlgreen Chapel, Georgetown and died some months later. Consequently, Father Deppermann considered himself to be the last priest publicly ordained by the Cardinal. After tertianship, again at Poughkeepsie, he obtained his doctorate in physics at Johns Hopkins in Baltimore. His thesis explained his findings on the Stark effect.

Since our main interest is concerned with Father Deppermann, as a priest-scientist, his early life has been rapidly outlined. The scientific achievements of Father Deppermann may be divided roughly into three main categories: a) his meteorological work, b) his other scientific papers and c) his restoration of the Manila Observatory.

In order to form an estimate of Father Deppermann's contributions to tropical meteorology, either or both of two procedures may be followed. One way is to analyze his work and compare it with the body of meteorological data. Such an analysis would be profitable, illuminating and favorable to Father Deppermann. The other method is to select the statements of those who are recognized authorities in this field and let their citations serve as an analysis and an evaluation. To remain within the limits of a few pages it is necessary to follow the second procedure.

Meteorological Papers. The committee which selected the contributors to the American Meteorological Society's publication "Compendium of Meteorology" chose authorities in their special fields. Father Deppermann was asked to write one chapter but the losses of World War II prevented him from complying with the request. The name of Deppermann is found in this authoritative work not less than forty times in connection with tropical meteorology and more than a half dozen times in connection with cloud physics. A few brief quotations from the authors of that work will illustrate their opinion of his contributions. "Probably the most systematic analysis and compilation of the characteristics of tropical cyclones were those of Deppermann for the Philippine area", says Gordon E. Dunn of the U. S. Weather Bureau. And later on, the same author singles out Father Deppermann: "Tropical meteorology is deeply in debt to Father Deppermann for his painstaking assembly and analysis of typhoon characteristics in the Philippine area." In another chapter Herbert Riehl after several references to the papers of Father Deppermann states: "Deppermann is one of the few writers who has made a detailed effort to calculate radial and tangential velocity components." "Apart from Deppermann other writers have contented themselves with application of simple hydrodynamics." Charles F. Brooks, Blue Hill Observatory, quotes Father Deppermann frequently and cites him among others as follows: "For comprehensive discussions of aerological interpretation of clouds, the reader may refer to . . . the studies . . . of convective clouds in tropics by . . . Deppermann."

Meteorological Abstracts and Bibliography has by its selection and abstracting of his articles made of them a permanent source of information on tropical cyclones. When the adequate history of tropical meteorology is written the work and analysis of Father Deppermann will be included. His ideas are a permanent feature of the science.

Technical writings in science are read by only a few. Sponsoring agencies do not reissue such publications unless they perceive very special merit in the work. At least three different countries have issued anew Father Deppermann's meteorological papers. The meteorologists of Japan have translated nine of his longer papers into Japanese. It is not excessive to say that Father Deppermann had a profound influence on the ideas of Japanese weather men. The Royal Australian Air Force for a month carefully studied his article on "Upper air circulation in the Philippines and adjacent regions." Then, they borrowed it again—not from the author who was in a concentration camp—and this time they republished his paper. In returning the copy to Riverview Observatory, the Director of the Australian Meteorological Service wrote: "This work has proved so valuable to us that we have had it reproduced for general distribution to forecasting officers." The Forces of the United States did not fail to realize the significance of his work. They, too, reproduced, at least, four of his papers for distribution.

After liberation from concentration camp, as soon as he could stand the plane trip, "by order of General MacArthur", Father Deppermann was flown to the Pentagon in Washington for consultation on the weather. Who attended these meetings and what was discussed there was confidential at the time since the war with Japan was still in progress. At this time Colonel D. N. Yates of the Air Corps was Chief of the AAF Weather Service. It is neither secret nor confidential that a few years later when the same General Yates visited Clark Field in the Philippines he sent a special plane to Manila to fetch Father Deppermann for a brief conference.

Dr. Kazuo Ogasahara, author of several books on meteorology in Japanese has been quite lavish in his praise and admiration of Father Deppermann. "The Father has bestowed many suggestions and advices on me in my long studies and is regarded as my great benefactor in my researches of the South Sea meteorology." Doctor Ivan Ray Tannehill, now retired from the U. S. Weather Bureau says in one of his books: "Father Charles Deppermann, S. J., formerly of the Philippine Weather Bureau, did as much as any man to help people prepare for these catastrophes (typhoons)." Maurice A. Garbell, in autographing his book called "*Tropical and Equatorial Meteorology*" says: "with profound admiration and great respect, to Father Deppermann, the first to analyze and comprehend the mysteries of the Philippines and Tropical Pacific Sky." Even a brief survey of his book will indicate his dependence on the publications of Father Deppermann.

In November 1954 a UNESCO Symposium on Typhoons was held at Tokyo. Seldom, if ever before, had so many world authorities on this subject been assembled for discussion. Father Deppermann, with all expenses paid, headed the list of consultants. Dr. Simpson, the Chairman, introduced Father Deppermann thus: "Introducing Father Deppermann to this assembly is like introducing the president of the United States to his people."

When Major General W. O. Senter of the U.S.A.F. was leaving the Air Weather Service, quite spontaneously, he took the occasion to write the following in a personal letter to Father Deppermann. "Air Weather Service has benefited from many of the techniques you have developed and much of the knowledge you have recorded on tropical meteorology. Our work in the Philippines at the close of World War II was facilitated by your progressive and cooperative attitude."

The above quotations are really citations from those who know tropical meteorology and the place of Father Deppermann in that science. He has built his monument.

Other Scientific Papers. While the period of his life from 1933 to 1944 was devoted most successfully and exclusively to investigations of tropical weather conditions with special emphasis on frontology and air mass theory as applied to typhoons, before that period and after he published papers in a wide variety of fields. His doctorate work in physics was basic but after it he felt the need for direct training for his future work at the Manila Observatory. Proper training joined to his special genius made a superior combination. That is why he spent the year 1925-26 at the University of California and Lick Observatory. Nothing but the best satisfied him in the pursuit of his physical investigation. As a consequence, the astronomical divisions of the Manila Observatory with Father Deppermann as Chief improved in many ways. Very shortly after his arrival, he investigated both the longitude and the latitude of the Observatory and published his results. He led a solar eclipse expedition to Cebu (1929) and while weather conditions spoiled some of the hoped-for results, yet he was successful in other observations. He has written about these. One of his principal benefits in this period was the improvement of the time service. Due to him the Observatory, in this regard, was given a higher rating on the world scale. The nineteen-inch refractor telescope under his guidance gave its best scientific service with his studies of variable stars. During his early days in Manila atmospheric electricity and thunderstorms were investigated. His versatility at this period is the more appreciated since the publications in these various fields are solid works.

When with the illness of Father Coronas it became necessary for Father Deppermann to take over the meteorological division, he felt the need of special training for that function. He tried first the U. S. Weather Bureau but their work did not satisfy his wants so he went on to Norway. Here he acquired in a few months the Norwegian ideas which he introduced to tropical meteorology. A new trend was thus given to the science of tropical meteorology. The time out for training certainly paid well in research returns.

At the end of World War II, at Liberation time, 1945, the entire observatory—buildings, telescopes, library instruments—all were destroyed in the burning. The Observatory, building and equipment, had met its tragic end. But even as Father Deppermann was flown back to the States a few days after his own liberation, he had in his mind incipient plans for the restoration of the Observatory. He did not realize at once that the great work of weather would not be returned to the Jesuits. From March 1946 to March 1947 he was in Manila doing all over again a job once done but totally wiped out by the war. Throughout this year he daily took one picture of the clouds of Manila and on typhoon days several more pictures. These were used as a confirmation of theories on the weather.

Perhaps the biggest war casualty for himself was not his own health, nor the physical loss of buildings, but the complete destruction without possibility of repetition of NINE of his finest research papers. One of these had been printed and published but all were lost. They could not be redone since the original documents had likewise perished in the ashes.

A year or two after the cessation of hostilities it became clear that the Manila Observatory would no longer function as the Philippine Weather Bureau. Since 1865 Jesuit Fathers had been doing this service, with great renown in the Far East. But the Philippine Weather Bureau restored by U. S. funds was not to be staffed by Jesuits.

Not frustrated by this seeming loss of everything he had labored for, Father Depperman, a third time, devoted himself to preparation from new scientific work. At the age of fifty-eight, starting in the heat of a St. Louis summer he undertook studies in seismology, under for, Father Deppermann, a third time, devoted himself to preparation Father Macelwane, in order to pursue this new type of research at Manila. Thereafter, for five years he carefully analyzed the records at Baguio and gave himself to the study of various problems concerning both macroseisms and microseisms. The sheer weight of his example, in the pursuit of the arduous task of scientific research when he could have, with honor, engaged in other works shows the spirit and the heart of a true Jesuit scientist.

The Restoration of the Observatory. Religious Superiors wanted the Manila Observatory to resume its program of physical research. The human instrument who deserves singular credit for carrying out the wishes of Superiors in this regard is indisputably Father Deppermann. In prewar days, as early as 1932, he had been appointed assistant Director of the Weather Bureau. After the war, July, 1947, due to the failing health of Father Selga, he was made Acting Director and finally on February 13, 1948, Director of the Manila Observatory. These appointments gave him titles but, it seems, little more. The means for restoration were meager, at best. War damages were uncertain. There were no salaries for this work; no equipment; no library; no buildings. Apart from Father Deppermann, there were no plans. But his plans soon began to materialize. A well designed seismic vault with modern instruments, an ionosphere station with complete equipment on loan from the U. S. National Bureau of Standards and a residence for the Observatory Community were soon established at Baguio. All of these are the fruits of his careful planning. The third division of the Manila Observatory, the solar program, was already taken care of by the signing of a contract for the building of a coelostat and solar spectroscope in August 1955. God has blessed the efforts of Father Deppermann.

Father Deppermann died at Clinica Singian in Manila at 7:34 in the morning of May 8th, 1957. Conscious to the very end he was at peace and nodded his approval as the prayers for the dying were being said by the two priests who were so closely associated with him in the last years of his life. This scientist who knew so well the merit of preparation had all his life prepared for the merit of this moment. It is interesting to note that his body lay in state at the new Ateneo Law School Chapel. This very spot was the location of the prewar Manila Observatory where the toils and labors of Father Deppermann were fruitfully conducted for the Society, the Church and for God. He was buried at the Sacred Heart Novitiate in a tomb next to Father Selga, his predecessor as Director of the Manila Observatory.

LIFE OF FATHER CHARLES E. DEPPERMANN, S.J.

1889	Born March 28—New York City.
1902	Graduate—Public School #46.
1905	First Publication—August.
1906	Graduation—High School of Commerce—New York.
1910	Enters Society of Jesus—August 13 at Poughkeepsie, N. Y.
1914	Studies Philosophy—Woodstock College, Md.
1917	Studies Theology—Woodstock College, Md.
1920	Ordained Priest at Georgetown June 29.
1921	Tertian at Poughkeepsie, N. Y.
1922	Studies Physics at Johns Hopkins, Baltimore.
1925	Doctorate in Physics.
1925	University of California and Lick Observatory.
1926	Manila Observatory: Chief, Astronomical Division.
1929	Eclipse expedition to Cebu.
1931	Chief of Meteorological Division.
1932	Studies Meteorology: U. S. and Norway.
1932	Assistant Director of Weather Bureau.
1933	Meteorological researches and publications.
1941	World War II—in the Philippines—December 8.
1944	Concentration Camp; Los Banos—July.
1945	February 25, Liberation.
1946	Second Cloud Year—March-to-March.
1947	Studies Seismology—St. Louis University.
1947	Acting Director of Manila Observatory—July 19.
1948	Director of Manila Observatory—February 23.
1952	Residence at Manila Observatory, Mirador, Baguio, November 3.
1954	Unesco Typhoon Meeting, Tokyo, November 9-12.
1956	Director Emeritus—November 11.
1957	Death at Manila, May 8.

A LIST OF PUBLICATIONS OF REV. CHARLES E. DEPPERMANN, S.J.

A. Meteorological Papers

1. Typhoons of June and July 1933 in eastern seas. Monthly Weather Review, Vol. 61, p. 210. Washington, Government Printing Office, 1933.
2. Typhoons in the Far East, September 1933. Monthly Weather Review, Vol. 61, pp. 284-285. Washington, Government Printing Office, 1933.
3. Typhoons in the Far East during October 1933. Monthly Weather Review, Vol. 61, p. 313. Washington, Government Printing Office.
4. Typhoons in the Far East during November 1933. Monthly Weather Review, Vol. 61, p. 338. Washington, Government Printing Office, 1933.
5. The climate of the Philippines. Port of Manila Year Book. 1934. Pp. 25-30. Manila, McCullough Printing Company, 1934.
6. The upper air of Manila. Manila, Bureau of Printing, 1934. 29 pages and 13 figures.
7. Meteorology along the eastern front. Bulletin of the American Association of Jesuit Scientists (Eastern Section). Vol. XI, pp. 154-156. Baltimore, Loyola College, 1934.
8. Cloud photography at the Manila Observatory. Monthly Weather Review, Vol. 63, pp. 191-192. Washington, Government Printing Office, 1935.
9. Cloud photography at the Manila Observatory. Bulletin of the American Association of Jesuit Scientists (Eastern Section). Vol. XIII, pp. 84-86. Baltimore, Loyola College, 1935.
10. The mean transport of air in the Indian and South Pacific oceans. Manila, Bureau of Printing, 1936. 13 pages and tables, and 38 plates.
11. The contax and cloud study at Manila. Photographie und Forschung. Oktober, 1936. Zeiss Ikon Ag., Dresden. Pp. 282-296. 15 photographs. Published separate in English and German.
12. Outline of Philippine frontology. Manila, Bureau of Printing, 1936. 37 pages and 100 cloud pictures.
13. The weather and clouds of Manila. Manila, Bureau of Printing, 1937.
14. Temperature conditions in the eye of some typhoons. Manila, Bureau of Printing, 1937. 19 pages.
15. Wind and rainfall distribution in selected Philippine typhoons. Manila Bureau of Printing, 1937. 38 pages and 22 figures.
16. Are there warm sectors in Philippine typhoons? Manila, Bureau of Printing, 1937. 20 pages and 9 figures.
17. Die Photographie von Haloerscheinungen. Die Himmelswelt, Duemlerverlag, Berlin, September-October 1938. Pp. 172-177.
18. Typhoons originating in the China sea. Manila, Bureau of Printing, 1938. 51 pages and 37 figures. Reprinted by Weather Division, U. S. Headquarters Army Air Forces, July 1944.
19. Some comments on Father Gherzi's constitution of typhoons. Bulletin of the American Meteorological Society, November 1938.

20. Some characteristics of Philippine typhoons. Manila, Bureau of Printing, 1939. 143 pages and 122 figures.

21. Typhoons and depressions originating to the near east of the Philippines. Manila, Bureau of Printing, 1939. 44 pages and 23 figures.

22. Climate of the Philippines. Manila, Bureau of Printing, 1939. 31 pages.

23. Are thunderstorms around isolated island stations in the Philippines frontal. Manila, Bureau of Printing, 1939. Republished as U. S. Army Air Force Meteorological Note Number 29, August 1944.

24. Some interesting types of Manila clouds. Manila, Bureau of Printing, 1940.

25. Upper air circulation (1-6) over the Philippines and adjacent regions. Manila, Bureau of Printing, 1940. 64 pages and 60 figures. Reproduced at Melbourne, January 1943 for the Royal Australian Air Force.

26. On the occurrence of dry, stable, maritime air in equatorial regions. Bulletin of the American Meteorological Society. Vol. 22, No. 4, April 1941.

27. Some aspects of equatorial weather and of the typhoon problem. Transactions, American Geophysical Union. October, 1945, pp. 213-216.

Note to the above: This article very briefly reviews the publications and manuscripts, fully written and either printed or ready to be printed, completely destroyed during World II at Corregidor, Baguio and Manila. The lost papers are as follows:

a. Upper air characteristics (1-4 km.) of the Philippines and adjacent regions. Manila, Bureau of Printing, 1941. Circa 100 pages and 110 figures.
b. Wild roses of the Philippines. For each of 5 pilot balloon stations in the Philippines, and for each kilometer up to 15 kilometers, with commentary.
c. Upper air circulation around typhoons. Text with about 30 diagrams.
d. Energetics of typhoons. Circa 10 pages.
e. Barometric fine structure of Manila. Detailed study. 70 pages and many figures.
f. Origin of typhoons in the Marians and Carolines. Circa 20 pages and 12 diagrams.
g. The gusty southeast wind at Manila. Circa 10 pages.
h. Should virtual temperatures be used in the tropics? Circa 4 pages and 2 diagrams.
i. Distribution frequency of thunderstorms in Manila. 5 pages and 12 figures.

28. No weather reports today. Jesuit Missions, New York, July-August, 1945. Pp. 149-151.

29. Relative humidity gradient and the form of cloud bases. Bulletin of the American Meteorological Society. Vol. 26, No. 7, September 1945, pp. 267-270.

30. Is there a ring of violent upward convection in hurricanes and typhoons? Bulletin of the American Meteorological Society, Vol. 27, No. 1, January, 1946. Pp. 6-8.

31. Horizontal divergence and convective cloudiness. Journal of Meteorology, Vol. 4, No. 4, August 1947. P. 125.

32. Notes on the origin and structure of Philippine typhoons. Bulletin of the American Meteorological Society. Vol. 28, No. 9, November 1947. Pp. 399-404.

33. Notes on 35 mm. cloud photography at Manila. Bulletin of the American Meteorological Society. Vol. 29, No. 3, March 1948. Pp. 135-136.

34. Cirrus *stripes* and typhoons. Bulletin of the American Meteorological Society. Vol. 29, No. 4, April 1948. Pp. 166-174.

35. An improved mirror for photography of the whole sky. Bulletin of the American Meteorological Society. Vol. 30, No. 8, October 1949. Pp. 282-285, 2 diagrams.

36. Tropical meteorological factors with special reference to typhoons. UNESCO Symposium on typhoons. Tokyo, November 1954.

37. General features of Philippine weather. Philippine Studies. Vol. 2, No. 2, June, 1954. Pp. 102-115.

38. Microseisms as an aid to storm detection and tracking. Proceedings of the Eighth Pacific Science Congress, Quezon City, November 1953. Pp. 1087-1090. (In press.)

39. The origin and path of typhoons. Prepared for USIS, 1954. Widely distributed, translated into Bicol, and reprinted in daily newspapers.

B. Astronomical Papers

40. Determination of the longitude of the Manila Observatory by wireless telegraphy, October-November 1926. Manila, Bureau of Printing, **1927** 16 pages and 3 diagrams.

41. The latitude of the Manila Observatory by Telcott's method. Manila, Bureau of Printing, **1927**. 10 pages.

42. Star-map atlas adapted to the latitude of Manila. Philippine Education Company, Inc., Manila, **1929**.

43. Tests of the 19″ Merz refractor of the Manila Observatory. Manila, Bureau of Printing, **1929**. 14 pages and 5 figures.

44. The light that went out. Jesuit Missions, September 1929. Pp. 172-173; 190. New York, Jesuit Mission Press, 1929.

45. The Manila Observatory expedition for the total eclipse of the sun, May 9, 1929. Bulletin of the American Association of Jesuit Scientists (Eastern Section). Vol. VII, No. 2, pp. 24-30. Worcester, Holy Cross College, 1929.

46. Some eclipse hints (as learned from experience, May 9, 1929). Bulletin of the American Association of Jesuit Scientists (Eastern Section). Vol. VII, No. 2, pp. 30-32. Worcester, Holy Cross College, 1929.

47. Variable star observations, list no. 1. Manila, Bureau of Printing, **1931**. 13 pages.

48. Variable star observations, list no. 2. Manila, Bureau of Printing, **1931**. 21 pages.

49. The astronomical division of the Manila Observatory. Bulletin of the American Association of Jesuit Scientists (Eastern Section). Vol. VIII, No. 4, pp. 10-13. Baltimore, Loyola College, 1931.

50. The master clock of the Manila Observatory. Bulletin of the American Association of Jesuit Scientists (Eastern Section). Vol. IX, pp. 124-126. Baltimore, Loyola College, 1933.

51. The troubles with Father Time. The Science Counselor, September 1939. 7 pages and 4 diagrams. Duquesne University Press, Pittsburgh, Pa.

C. Atmospheric Conditions

52. Skip-distance on short wave wireless and the height of the Heaviside layer in the tropics. Asiatic Communication Bulletin, Dec. 1928. Pp. 5-10; Jan. 1929, pp. 16-17; Feb. 1929, pp. 3-4. Los Banos, Naval Radio Station, 1929.
53. Initial studies in atmospheric electricity at the Manila Observatory. October 1927-December 1928. Manila, Bureau of Printing, **1929**. 15 pages and 25 figures.
54. Atmospheric potential-gradient results at Cebu during solar eclipse, May 9, 1929. Terrestrial Magnetism and Atmospheric Electricity, Vol. 34, pp. 257-258. Baltimore, The Johns Hopkins Press, 1929.
55. Air potential registration at the Manila Observatory, October 1927 to December 1930. Terrestrial Magnetism and Atmospheric Electricity, Vol. 36, pp. 231-237. Baltimore, the Johns Hopkins Press, **1931**.
56. Thunder-storm problems in atmospheric electricity. Terrestrial Magnetism and Atmospheric Electricity, Vol. 37, pp. 179-181. Baltimore, the Johns Hopkins Press, **1932**.

D. Seismological Papers

57. Father Jose Algue, S.J. and microseisms. Bulletin of the Seismological Society of America. Vol. 41, No. 4, October 1951. Pp. 301-302.
58. It's the cat's whiskers. Earthquake Notes, Eestern Section, Seismological Society of America. Vol. XXV, No. 1, March 1954. Pp. 8-11. 1 diagram.
59. Microseisms at Baguio. Proceedings of the Eighth Pacific Science Congress, Quezon City, November 1953. Pp. 1099-1102 (in press).
60. Some notes on Philippine earthquakes. Proceedings of the Eighth Pacific Science Congress. Quezon City, November 1953. Pp. 765-770 (in press).

E. Miscellaneous Papers

61. Answers to Schultze's advanced algebra. Compiled by the author with the assistance of William P. Manguse and Charles E. Deppermann, Jr. The Macmillan Company, New York, **1905**.
62. Some studies of the Stark effect. The Astrophysical Journal, Vol. LXIII, No. 1, January 1926. Pp. 33-47.
63. The Manila Observatory rises again. Philippine Studies, Vol. 1, No. 1, June 1953. Pp. 31-41.

REPORT ON A RESEARCH COURSE FOR PRE-MEDICAL STUDENTS

REV. J. FRANKLIN EWING, S.J.
Fordham University

Previously, (1) I indicated in this BULLETIN, my hopes for results, in terms of problems of race and form, from a Research Course which I had instituted for *pre-meds* at Fordham. It is now my duty to indicate: (1) why I think the idea of a research course is still good; (2) and why I am discontinuing this particular course.

Genesis of the Course. The genesis of the idea for this course was a remark by Professor Hugh Stott Taylor, of Princeton, to the effect that he had instituted a research course for chemistry *majors*, during their senior year. He called these seniors in, and asked them to indicate the problem on which they would like to work. Thereafter, unless they met with some particular difficulties, he left them alone. These seniors, according to Dr. Taylor, uniformly achieved good results.

Starting from this suggestion, I instituted here at Fordham a research course for *pre-meds* (this is a term which we no longer use, inasmuch as we now have majors in biology or chemistry, who take all the necessary *pre-med* subjects), and I should like here to give certain technical details concerning this course, from the educator's point of view.

The introduction of this course was assisted by the discontent of our *pre-meds* with an eight-point course in physical chemistry. This course involved students who had no calculus, and therefore they studied physical chemistry from a very *cook-book* point of view.

The number of credits did not bother me particularly, nor did the possibility that marking would be difficult. I simply told the students, early in the course, that I should take an average of their science marks for the previous years, and use this as *base pay*. If they did well for me, I should up their marks; if not, down they would go. To this they all agreed. Nevertheless, as we use a numerical mark, based on 100, here at Fordham, I found it very difficult to give appropriate marks.

As I see it, there are only three possible notes that one can give for research. One can consider a student as outstanding, as mediocre, or as failing. Inasmuch as I asked the Pre-Medical Adviser to assign me only good students, marking was not as difficult as I had expected.

Rationale of the Course. First of all, I gave lectures on the evolution of man. These lectures, approximately two a week, stretched out to about a month and a half.

Then, I gave lectures on the scientific method. These lectures only took two weeks, because I assigned Wilson's book (2) on the scientific method, and gave quizzes accordingly.

At the end of the lectures on the evolution of man, having proposed a number of problems which could be attacked through animal experimentation, I assembled them and asked the students to think them over and then to pick their own problems.

This having been done, I asked them to write up a research design concerning the problem which they had picked. I went over these research designs with them personally. Then we started the experimental work.

It might be illuminating here to describe some of the problems involved.

When we anthropologists discuss the evolution of man, we necessarily have to indulge in a considerable amount of speculation, because we cannot undertake genetic experiments with fossils. And we cannot experiment with modern human beings as if they were guinea pigs.

Therefore, we are at a loss. But, if we could use animals to test many of our speculations, much good might be done.

For example: geographical evidence indicates that animals of similar or of the same species are quite different, if they live in temperate zones, or in the Arctic. Thus, we have Bergman's and Allen's rules. These rules state that animals in the Arctic have bulkier bodies and smaller appendages than animals of the same species living in temperate zones.

As far as human beings are concerned, these rules also seem to apply. But it is eminently possible that experimental work on animals could validate these rules, or the opposite.

Other leads need experimental scrutiny. Thus, a suggestion has been made by Marett, to the effect that mineral deficiency was one of the causes of the origin of the Mongoloid race (3). Other authors have emphasized the importance of a certain band of ultraviolet light in the origin of heavy pigmentation, especially in the negroid race (4).

This was the type of problem that I proposed to the students, and from a list of such problems, they were allowed to choose the ones that they wished to work on. They operated in groups of two or three.

Results to Date. At this point, we feel that we should make a summary report on the results of this research course.

We should state at the outset that these results are necessarily meager, because practically all of them depend on long-term studies of a number of generations of rats and hamsters. So far, we have not been able to carry these generations over the summers. This is a practical problem. We hope to solve this in the immediate future, by getting grants for this research, and hiring students to do the work during the year and during the summers.

At any rate, we have, with regard to many problems, cleared away some of the underbrush.

Thus, with regard to mineral-deficient diets, we have established the technique of giving the animals a diet completely deficient in the particular mineral (e.g., calcium), and then injecting the mineral. Calcium propionate was decided upon, after consultation with the biochemists, as the vehicle for calcium. Initial experiments resulted in considerable mortality among the rats, but eventually we found out how to give a definite amount of calcium to the rats. This would otherwise be very difficult, in terms of their diet, which is usually given in pellets, and no one in the world can tell how many of these pellets the rats eat.

We have also found out the lowest temperature at which rats breed. Therefore, in the future we know how to breed rats for the experiments involving low temperatures. For one thing, we shall put them into an artificial summer.

Some results have been obtained by submitting rats to high temperatures. We have found that a considerable shedding of fur occurs, and that, in autopsy studies, the rats exhibit a very considerably reduced amount of fat.

The experiments on ultra-violet light have been extremely interesting, but need more work, before we can give anything like a decent evaluation.

A number of other projects have yielded introductory results. Thus, there is need of a standardization of points on the rat skull, similar to those agreed to on the human skull. We cannot measure change in any direction, unless we have standard points of departure. We have made considerable progress in this respect.

Attempts at solving a number of other problems are so controversial that we shall not discuss them here. They remain problems for future consideration.

Variation on a Theme. Last year, an experiment within an experiment was tried. This involved sending some of the students down to a cooperating hospital, where they could do medical research.

While we are in no position, at this juncture, to give a detailed evaluation of this experiment from a scientific point of view, we feel that it was extremely valuable for the students (5). The reason for this will appear in our concluding recommendations.

Recommendations. The basic reason why the Research Course which we are discussing was not a success lies in the fact that we based our research on *our* problems, rather than on problems familiar to the students. Dr. Taylor, from whom, as we have said, we derived the original idea for this course, had dealt with chemistry *majors*. We had dealt with *pre-meds*, who knew nothing about human evolution (or, for that matter, the process of evolution in general).

We were interested in our own problems. Even logically presented, these problems remained ours, and not necessarily those of the students.

Almost a corollary of this was the fact that so much time was spent in the introductory lectures on evolution (not, however, necessarily wasted time for medical students) and scientific method (*ditto*) that research time was severely curtailed.

Also (because of other demands), we were not able to spend too much time with the students. It seems to us that, in order to proceed properly with such a course, or with any research course, the professor must spend considerable time with the students on the undergraduate level, because they are not well enough equipped with the background and the techniques of research to be left relatively alone (6).

Therefore, we recommend research courses for our undergraduate students, but we recommend them in terms of existing departments and interests.

Why a research course? Because American Catholic research scientists are in a minority.

Anne Roe (7) has pointed out that the distinguished research scientists she studied all got their interest in research through early participation in actual research. Once having *got their teeth into research, and tasted blood*, they were off—on research careers.

I do not think I have to justify the need and nobility and notable usefulness of research to the readers of this BULLETIN.

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(4) Coon, C. S., and S. M. Garn, J. B. Birdsell. *Races*. Springfield, Ill., Thomas, 1950. Also: Coon, C. Climate and Race. *Smithsonian Report for 1953*, pp. 277-298. Washington, 1954.

(5) During the discussion on the paper, as given at the meeting at Fairfield, it developed that others had the same idea. They were quite happy about sending *pre-med* students to medical men for research work, particularly inasmuch as this fitted in with the medical orientation of the students. Fringe benefits included contacts with medical researchers, a point in favor of developing future researchers among the students, in a practical way.

(6) Any program like this is bound to develop a few humorous stories. Thus, I bought a rather expensive ultra-violet filter for our lamp, and a piece of heat-resistant glass. I never thought to tell the students that the purpose of the glass was to shield the filter from the heat of the lamp. Thereupon, after a few moments of use, they reported to me that the filter had cracked. It seems that they had thought that the heat-resistant glass was there for the purpose of keeping the heat from the animals, and had put it on the outside of the filter, with reference to the source of ultra-violet light!

(7) Roe, Anne. The Making of a Scientist, New York, Dodd, Mead. 1953.

THE HIGH SCHOOL CHEMISTRY SYLLABUS

JAMES J. FALLON, S.J.

The sources for the remarks I am about to make are not such as to endow this paper with the aura of scholarship. Conversations with *Ours*, a small amount of experience, and a survey I shall refer to later are the only testimony to support it.

I would like to do two things: first, make a few criticisms and secondly, make a few suggestions.

The object of my criticism is a combination of methods, teachers, textbooks and the syllabi based on them. I think, for the young teacher at least, present day textbooks are the bane of his teaching. The textbook is the basis of the syllabus and is so written as to imply the method the teacher is to use. The young teacher, being unwilling to take liberties with the syllabus, especially since his charges will be examined upon it, will follow the text more or less rigidly. This I consider to be one of the reasons for the deficiency in our high school chemistry training.

Permit me to develop this further. We consider our educational process successful if we turn out people with understanding of the basic principles of certain areas of knowledge and the ability to turn their understanding to specific *ad hoc* problems. Understanding is the primary object. It is true, however, that we do not overlook the specific problems, but we use many of them as typical of the principles involved. But we would not feel that we had done a student the service we should, if all he could do was to parrot back the memorized solution to a specific problem. Not that memory is to be deprecated, but in sheer memory the element of mind training is absent.

Understanding of the basic principles of chemistry should be our ultimate object in high school courses regardless of what the immediate object is. Immediate objects may vary from person to person and place to place. Some in one place will be in chemistry merely to see what it is like so that they may decide whether or not they will continue it in college. Some will take the course just to get a gentleman's knowledge of the field, so that they can read a newspaper, so filled with science these days, and understand. Some will be in chemistry because they have already made up their minds that they want to be chemists and wish to get a solid preparation for their college work. A course which can satisfy all three types effectively is one which really and truly imparts a basic understanding of the fundamental principles.

Although the author of the textbook and the teachers will admit this objective, in practice they depart from it. Science is supposed to be a field in which a person draws conclusions on the basis of experimental evidence. Rarely do teachers or texts in high school chemistry give evidence and rarely do students draw conclusions. A *hodge-podge* of terms sprinkled throughout the text are conglomerated in the students' memory. What is an element? What is a compound? What is a molecule? Perfectly pat answers are given by the honor student to these questions. But ask him, how could Dalton postulate atoms when he was weighing out grams and ounces and pounds? How could he speak of a sub-visible level of reality when only the visible and mensurable were within his grasp? These questions require a small amount of thought on the part of the student but small as it is, it *is* thought and it breeds a personal, real understanding of scientific deductions concerning the constitution of matter. It is precisely this understanding which I feel is not engendered in the students.

In answer to those who say they are too young to understand, I say, if they know what a proportion is and can distinguish between red and blue balls, it seems to me they can follow an intelligent explanation of the fundamental laws of chemistry.

My suggestion as to how the note of intelligibility can be introduced into the matter of high school chemistry is that the syllabus be arranged according to a definite and intelligible *rationale*. The rationale, the intelligible pattern underlying the arrangement, is partly historical, partly logical, and partly phenomenological, if you will. Throughout it is conducive to practical demonstrations. For instance, in the first section, the student is confronted with the vast assortment of the materials of the universe. In his then present state of mind he has never tried to bring it into an orderly division nor tried to analyze its behavior. He is somewhat like primitive man gaping around at rocks and plants and animals knowing no more than what the surface of things reveals. His job is now to probe into the materials and to find out what they can be made to do for him and under what conditions. One man in one generation does not discover all the workings of nature. Many men over many centuries labor to do this. But we can now stand at the crest of time and assimilate the thought processes of all preceding generations of men. This process, which we will communicate to the student, as outlined in section I,A is something like this: there is a multiplicity of materials about us. Yet there is a unity—many things having an exact similarity. Materials are mixed or plain. Sometimes one can separate the different plain materials from a mixture. Under certain conditions the plain materials change. Sometimes the change is merely one of state, sometimes it is a radical change resulting in new plain materials. And so on until all the fundamental concepts of chemistry are developed which were in the possession of Dalton in the beginning of the nineteenth century.

Using an arrangement of topics like this the teacher can present the evidence for each step as it occurs: stimulate the students to draw conclusions; present the conclusions actually drawn by scientists; describe new experiments and evidence which lead to the next step. In this manner the student will be thinking out the evolution of scientific thought and will not be accepting blindly little formulas to memorize.

Let me add that the selection of topics here conforms to what the majority of chemistry teachers of 100 colleges polled by the University of Missouri High School think essential to high school chemistry.

As another example of how the syllabus may be used to make matter intelligible, let us look at I,C.

If we were to ask a bright student who has finished the present course in high school chemistry what a relative atomic weight is he would answer that it is the weight of an atom of an element relative to the weight of an oxygen atom arbitrarily set at 16. But if we asked him what makes it possible for us to assign an atomic weight to an element, he would most likely not even understand the question. With the type of approach I am suggesting he would see that even after Dalton's Law had been used to explain the Laws of constant proportion, multiple proportion and reciprocal proportion there was still a great deal of difficulty ahead. The theory on the atoms would have no practical value until the atomic weights could be determined. But the quantities were hard to come by. Even if it was known with certainty that, say, methane contained close to 25 percent hydrogen and 75 percent carbon, who was to say what ratio of atoms this represented? But, unless the ratio of atoms were known, the atomic weights could not be known. Suppose it were known that there were 4 atoms of hydrogen and one of carbon. Then setting the weight of hydrogen at 1 would automatically set the value of carbon at 12. If there were 2 carbons, then each would have a value of 6. If three carbons, each would have a value of 4, and so on. If there were 8 hydrogens and each was assigned a value of 1, then the value of carbon would have to be 24 if there was only one atom present. So the whole problem of assigning atomic weights comes down to knowing how many atoms there are in a molecule.

Historically we know that confusion reigned from the time Dalton and Berzelius in about 1819 began compiling atomic weights without knowing the number of atoms in a compound until about 1860. In the intervening period chemists had thrown up their hands in despair of ever learning the answer to the problem. Indeed, Liebig, an eminent German organic chemist, reflected able opinion of his time when he said, "The exact number of atoms which combine to form one . . . equivalent will never be known." However, in 1860 a meeting of chemists was called in Karlsruhe to discuss the problem. At this meeting Stanislao Cannizzaro distributed a pamphlet which finally cleared away the confusion. Within a few years the problem of atomic weights, except for their accurate determination, was settled for all times.

His method, as you know, was first to determine the molecular weight of a compound by the method of Avagadro which had long been tested and proven. This was done for a series of compounds containing the same element, say carbon. Then a quantitative analysis was performed on all the compounds. Thus we could know how much of the molecular weight represented each element. This weight would be the weight of one, two, three or some integral number of atomic weights of the element. In a whole series of compounds the lowest number which ever occurs for an element may be taken as its atomic weight.

There are many other sets of questions like this whose answers make sense, which have intelligibility only in the light of a historical process. How do we know the mass and charge of the electron? Why do we say that the nucleus is positively charged? Why do we say it is made up of protons and neutrons? These are questions to which there are intelligible answers and which I believe the high school student is capable of understanding.

Despite my claim that these things are objectively intelligible, I do not think they can be made so to the student without a great deal of minute planning as to method. The pattern of evolution of chemical thought can only be made clear with a number of pedagogical tricks which the teacher will have to work out for himself. Hence it is evident that a great deal of work and imagination has yet to be exerted before the ideal of an intelligent high school chemistry course can be worked out.

PROPOSED HIGH SCHOOL CHEMISTRY SYLLABUS

I. *Fundamental Laws of Chemistry*

A. *Material and its Behavior*

1. Heterogeneous and homogeneous materials
2. Physical states and transitions
3. Physical reworking of natural materials, extractions, separations, etc.
4. Chemical reactions, fermentation, production of metals from ores, alchemy, etc.
5. Phologiston (opt.)
6. Synthesis, combustion (Rey, Lomonsonov)
7. Decomposition (Priestly)
8. Metathesis, substitution, etc.
9. Elements and compounds (Davy, Cavendish, etc.)
10. Chemical energy, potential and kinetic energy, heat, electrical energy, heat of formation, heat of reaction, heat capacity, e.m.f.
11. Physical and chemical properties and changes

B. *Behavior of Gases*

1. Boyle's Law, absolute temperature
2. Charles' Law
3. Combined Law
4. Ideal gas Law, molecular weight determination
5. Gay-Lussac's Law
6. Avagadro's Law, Avagadro's number
7. Molar volume, molecular weight determination
8. Kinetic Molecular Theory

C. *Quantitative Laws of Chemistry*

1. Law of conservation of matter (Lavoissier)
2. Law of constant composition (Berthollet, Proust)
3. Law of reciprocal proportions (Berzelius, Richter)
4. Law of multiple proportions (Berzelius)
5. Dalton's atomic theory
6. Cannizzaro's method of determining atomic weights
7. Law of Dulong and Petit
8. Symbols, formulas, naming compounds, equations

D. *Valence and Chemical Bonding*

1. Combining and equivalent numbers (Berzelius)
2. Ionic charge, conductivity (Faraday, Arrhenius)
3. Ionic bonding (Kossel)
4. Covalent bonding (Lewis)
5. Coordinate bonding
6. Wave interpretations of bonding (opt.)
7. Electrolytes and non-electrolytes, acids, bases, salts, amphoterism, neutralization, etc.
8. Solutions, solubilities, el. of b.p., dep. of f.p.

E. *Kinetics*

1. Reversible and irreversible reactions, equilibrium
2. Law of Mass Action (Guldberg and Waage), ionization constant (opt.), hydrolysis constant (opt.), solubility product (opt.)
3. Le Chatelier's Principle
4. Catalysis

II. *Structure of the Atom*

A. *Elementary and Sub-atomic Particles*

1. Atoms (Dalton)
2. Electrons (Crookes, Thomson, Millikan)
3. Protons (Rutherford)
4. Neutrons (Chadwick)
5. Positrons (opt.) (Anderson)
6. Neutrinos (opt.) (Fermi)
7. Mesons (opt.) (Yukawa)
8. Hyperons (opt.) (Rochester, Butler)

B. *Arrangement of Nuclear Particles*

1. Theories of light, corpuscular (Newton), wave (Hugens), electromagnetic (Maxwell), wave-particle (de Broglie)
2. Emission spectra, hydrogen spectra (Balmer)
3. Quantum theory (Planck)
4. Proton-neutron nucleus (Rutherford)
5. Quantized electron orbitals (Bohr)
6. Split quantum levels (Fermi, Pauli, etc.)
7. Quantum numbers and distribution of electrons
8. Atomic number, atomic mass, mass number, isotopes, isobars, isotones

III. *Classification of the Elements*

A. *The Periodic Chart*

1. Prout
2. Dobereiner
3. Knowlands
4. Mendelejeff
5. Mosley
6. Bohr

B. *Periodicity of Structure and Properties*

1. Electronic orbitals: inert, representative, transition, inner transition types
2. Activity, oxidation states, ionization potential, electron affinity
3. Size, density and state
4. Melting points and boiling points

IV. *Families and Series in Periodic Chart*

A. Hydrogen
B. Halogens
C. Alkali Metals
D. Alkaline Earth Metals
E. Inert Gases
F. Oxygen Family
G. Carbon Family
H. Nitrogen Family
I. Boron Family
J. Coinage Metals
K. Zinc Family
L. Transition Elements
M. Inner Transition Elements

A-M

1. History (opt.)
2. Occurrence
3. Preparation
4. Properties
5. Uses
6. Tests (opt.)
7. Principal Compounds

V. *Atomic and—Nuclear Phenomena*

A. *Orbital Electrons*

1. Absorption spectra
2. Emission spectra
3. X-rays, Brehmstrahlung (opt.)
4. Phosphorescence
5. Photoelectric effect (opt.)

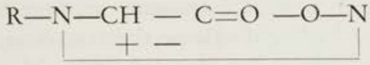
B. *Nucleus*

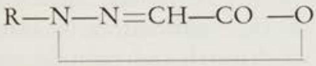
1. Natural radioactivity (Becquerel)
2. Induced radioactivity (Joliot-Curie)
3. Induced nuclear fission (Fermi, Hahn, Strassman)
4. Spontaneous nuclear fission
5. Spallation (opt.), fusion (opt.), capture (opt.)

THE SYDNONES

Charles J. Thoman, S.J.

Sydnones are a new class of compounds distinguished by the presence of the meso-ionic sydnone ring (I). Extensive physical proof has been accumulated indicating that this is its probable form—with a trivalent carbon and divalent nitrogen atom—rather than such conventional forms as (II) and (III).


(1)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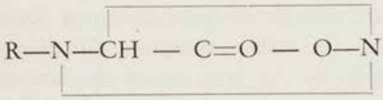
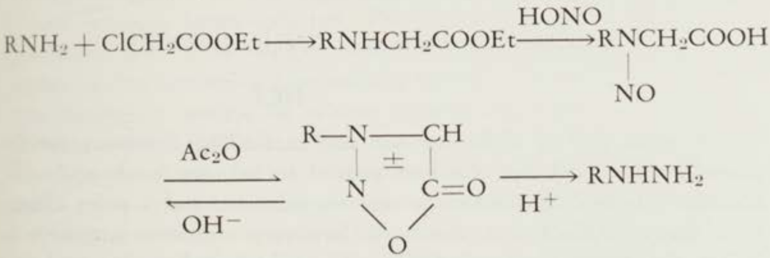

(III)

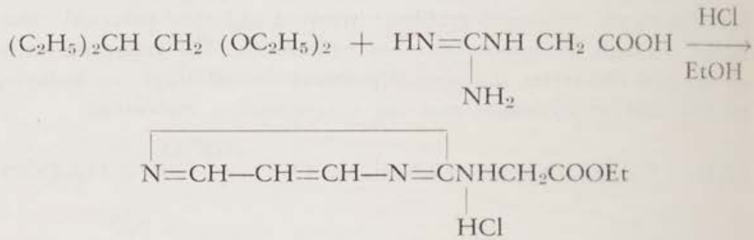
Since their discovery in 1939, interest in the sydnones has been high due to the structural problems involved and their practical value in the synthesis of monosubstituted hydrazines. The following series of reactions illustrates the normal pathway for all alkyl- cycloalkyl-, arylkyl- and arylsydnones and the corresponding hydrazines.



In 1955, Dr. I. Moyer Hunsberger, now of Fordham, attempted the synthesis of a heterocyclic sydnone and discovered that the N-substituted glycine could not be made as described above. After finally surmounting this difficulty, he obtained 3-pyridylsydnone, which surprisingly proved to be phototropic; it originally precipitated as pure white plates, but on exposure to direct sunlight turned to a deep blue in a matter of seconds. Heating to a temperature of about 70 degrees or isolation in the dark for about eight hours effected a reconversion to the white form. Both forms give identical infra-red spectra, and attempts are still being made to determine the cause of the color change.

On the theory that the phototropism might be due to the heterocyclic nature of the substituted moiety, the author attempted the synthesis of a similar but even *more heterocyclic* compound, 2-pyrimidylsydnone. As was the case with the pyridine, N-(2-pyrimidyl) glycine ethyl ester hydrochloride could not be made in the conventional manner, so attempts were made to do it in the reverse manner, i.e. by the condensation of glycine ethyl ester hydrochloride and 2-chloropyrimidine. The latter was produced by the diazotization in cold concentrated hydrochloric acid of 2-aminopyrimidine, but all attempts to condense it with the hydrochloride or the free ester failed.

Finally, a new course was decided upon: the formation of the pyrimidine ring itself in the condensation by reaction of malondialdehyde, in the form of its diacetal, and guanido-acetic acid. It is interesting to note that, though of quite common occurrence in the biochemical laboratory, a rather extensive literature search has indicated that this might be the first use of the latter compound in synthetic work. The reaction can be shown as follows.



A great deal of difficulty was had in finding a solvent for the guanido-acetic acid, but the best proved to be very weak acid. The reaction was first attempted in aqueous solution, and a color change to a deep red-black was observed; however, numerous attempts to isolate the product proved futile. The substituted amino acid was found to be even more soluble than sodium chloride and intimately mixed with a deep brown impurity, which was proved to be a tar resulting from the decomposition of the malondialdehyde liberated by the action of the acid.

Success was achieved by a shift to an alcoholic medium. The guanido-acetic acid was placed in ethanol and hydrogen chloride gas introduced until the organic acid had just dissolved. At this point, the malonaldehyde diacetal was added and the solution allowed to reflux gently under the action of the hydrogen chloride gas for an hour, during which time the same color changes were observed. Then, on refluxing on a steam bath for an hour, the color of the solution changed to a dark green. Concentration of this solution resulted in the precipitation of pure white plates which on purification proved to be N-(2-pyrimidyl) glycine ethyl ester hydrochloride, m.p. 160-2 degrees.

The conversion of this product to the N-nitroso-N-(2-pyrimidyl) glycine was accomplished without incident. However, thus far the formation of the sydnone itself, which had previously been the easiest step, has proved impossible, the only product being an unidentifiable red-orange tar. Numerous changes of dehydrating agents and conditions have been of no avail.

The work of the sydnones is being sponsored by the Air Force and the Cancer Institute of the National Institutes of Health, the former because of the possible use of phototropic compounds in color photography, and the latter because of the anticarcinogenic activity which they have been shown to possess. An independent synthesis of (I) has also been undertaken in order to prove that it is really the structure of the sydnone ring.

NOTES ON CHEMICAL LITERATURE

Subscriptions to the *Fifth Decennial Index to Chemical Abstracts* are now being solicited. This is a nineteen volume index for the years 1947-1956 which includes author, subject, formula and patent entries exceeding two million listings. *Chemical Abstracts* has now become a service in which volumes are leased to subscribers. Termination of the lease of this index comes at the end of 1971 when these volumes become the subscribers' property. Members who sign a restrictive use agreement can subscribe for $400. Library subscriptions are $500. Industrial subscriptions are much higher. After January 31, 1958, orders may be placed at a $100 higher rate.

A *Bibliography of Bibliographies in Chemistry and Chemical Engineering*, similar to earlier works such as *West and Berolzheimer*, is the latest project of A.C.S. Division of Chemical Literature, under the leadership of Fred J. Bassett, 3826 Alamo Ave., Kalamazoo, Mich. He is seeking volunteers to contribute regularly to this project in a manner similar to volunteer abstracting for *Chemical Abstracts*.

A systematic structure index of aliphatic chemicals by their functional groups as reported in the chemical literature up to January 1959 constitutes another project on a voluntary basis under the leadership of Wm. J. Wiswesser, 3103 River Rd., Reading Pa. Reimbursement in the form of one or other of the volumes to be published is offered.

Elsevier's Encyclopaedia of Organic Chemistry has only issued volumes 12, 13, 14 and a supplement to vol. 14 from 1946-1956. With the completion of one more volume, publication is likely to cease, according to *A Guide to the Literature of Chemistry* by Crane, Patterson and Marr, 2nd ed., Wiley, New York, 1957. Ed.

EXTREMAL METHODS IN ANALYSIS

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1. Introduction. Many problems in analysis can be solved by posing a suitable related problem in the calculus of variations, solving this variational problem, and then showing that this solution also provides a solution to the original problem. Important applications of this procedure are to be found in proofs for the Riemann mapping theorem of complex analysis, for the existence of a solution to the Dirichlet problem of potential theory, and, in the domain of algebra, for the possibility of orthogonal transformation of a quadratic form to principal axes. It is the purpose of this paper to illustrate the method and to discuss some of its properties.

2. Rolle's Theorem. The well-known theorem of Rolle studied in elementary calculus may be used as a first illustration of extremal methods. The theorem states that if $f(x)$ is continuous in the closed unit interval $(0, 1)$, and possesses a derivative in the open unit interval, and if the functional values at the end points coincide, then there is an interior point t at which the derivative vanishes. To prove this theorem we pose an extremal problem: Where does $f(x)$ attain extremal, i.e. maximum or minimum, values? First of all, we note that the extremal problem makes sense since a continuous real-valued function on a compact set not only is bounded but also by a theorem of Weierstrass attains its upper and lower bounds. Hence the extremal problem *has* a solution. Now if the continuous $f(x)$ is not identically constant on the unit interval then since $f(o) = f(l)$ there must be a point *q interior* to the closed unit interval where $f(q) \neq f(o) = f(l)$. Without loss of generality we may assume that $f(q)$ is greater than $f(o)$ and $f(l)$ so that there are interior values greater than the end-point values. Hence $f(x)$ not only takes a maximum in the closed unit interval, but it takes this extremal value at an interior point, call it t. This then is the solution to the extremal problem. It is easy to see that the solution to this problem provides the proof of Rolle's theorem. For since by hypothesis $f'(x)$ exists in the open unit interval it follows that a necessary condition that $f(x)$ have a maximum at the interior point t is that $f'(t) = 0$. The case where $f(q)$ is less than $f(o)$ and $f(l)$ is obviously treated in an analogous manner. Hence Rolle's theorem is proved since the case for $f(x)$ identically constant is trivial.

3. **Analysis of the method.** Our method of proof had the following steps: (i) An extremal problem was posed, (ii) the extremal problem was shown to have a solution, and (iii) the solution of the extremal problem was shown to imply the proof of Rolle's theorem. The importance of step (ii) cannot be minimized. A simple example due to Perron indicates its necessity in the process. Thus we state and prove the

THEOREM: Every positive integer except 1 is less than 1.

PROOF: We pose an extremal problem: Determine the largest positive integer. We designate M as the largest positive integer, i.e., as the solution to the extremal problem. Let us suppose that M is not 1 and hence that M is greater than 1. Now $M \times M = M^2$ is a positive integer and since M is greater than 1, M^2 is greater than M so that M' is not the largest positive integer. Hence $M = 1$ is the largest positive integer and every positive integer is less than 1, which proves the theorem.

The obvious fallacy in this argument lies in the assumption that the extremal problem which was posed actually had a solution. Hence if we are to use extremal methods successfully we must be sure that the extremal problem has a solution. Of course the existence of such a solution is oftentimes a delicate matter in the calculus of variations. By way of historical example we may cite the case of Riemann who in his doctoral dissertation of 1851 proposed a solution to the Dirichlet problem of potential theory using an argument based on extremal methods. However he assumed the existence of a solution to the extremal problem involved on intuitive grounds alone and without rigorous justification. Later in 1870 his proof was discredited by Weierstrass who gave an example in which the extremal problem could not have a solution. As a result such methods were looked upon with great suspicion by mathematicians from that time until 1900 when Hilbert's treatise on the Dirichlet problem gave the theoretical justifications for use of extremal methods under certain circumstances and provided the basis for contemporary techniques of direct methods in the calculus of variations.

4. **Hadamard's Inequality.** Our second example of the use of extremal methods will be in the proof of an inequality due to Hadamard which plays a key role in the Fredholm theory of integral equations. This inequality states that if $A = \det(a_{ik})$, $i,k = 1, 2, \ldots n$, where the a_{ik} are real, then

$$A^2 \leqslant \prod_{i=1}^{n} \sum_{k=1}^{n} (a_{ik})^2 .$$

The proof is obtained by posing an extremal problem in the following manner. Let the elements a_{ik} vary, keeping however $\sum_{k=1}^{n} (a_{ik})^2 = C_i^2$ fixed $(i=1,2, \ldots n)$, thus limiting the variations of the a_{ik} in a definite way by these *n* conditions. Then consider A^2 as a function of the n^2 restricted variables a_{ik} and determine when it attains its maximal value. Here we note that since A^2 is a continuous function of n^2 variables each ranging over a compact set, the generalized Weierstrass theorem is applicable and we can conclude that A^2 actually attains maximal and minimal values as the a_{ik} vary in the prescribed manner. Let A^2_{max} be the maximum of A^2 under these circumstances.

By an elementary theorem on determinants, $A = \sum_{i=1}^{n} a_{hi} A_{hi}$ where A_{hi} is the cofactor in A of a_{hi} and h is a fixed row $(1 \leqslant h \leqslant n)$. Next we apply Schwarz's inequality to get

$$A^2 \leqslant \sum_{i=1}^{n} (a_{hi})^2 \sum_{i=1}^{n} (A_{hi})^2 = C_h^2 \sum_{i=1}^{n} (A_{hi})^2, \quad (h=1, 2, \ldots n),$$

where the inequality holds if and only if the a_{hi} are not proportional to the A_{hi} for all *h*. Hence A^2 cannot have its maximum value unless the a_{hi} are proportional to the A_{hi} for each row *h*. This is the solution to the extremal problem and it will now be shown to provide a proof of Hadamard's inequality. For if we multiply A_{max} by itself we get $A^2_{max} = \pi \, c_i^2$ by reason of the multiplication theorem for determinants, the fact that in A_{max} the a_{hi} are necessarily proportional to the A_{hi} for all *h*, and the theorem that

$$\sum_{i=1}^{n} a_{hi} A_{ji} = \begin{cases} A & \text{if } h=j \\ o & \text{if } h \neq j. \end{cases}$$

Consequently the original determinant satisfies

$$A^2 \leqslant \pi_{i=1}^{n} c_i^2 = \pi_{i=1}^{n} \sum_{k=1}^{n} (a_{ik})^2,$$

which is precisely Hadamard's inequality.

This example, more subtle than the first, indicates the need for imaginative and creative thinking in mathematics. For the use of extremal methods in analysis demands that the mathematician have the insight and ability to set that extremal problem whose solution will also provide a solution for his original problem. Generally there is no *a priori* for determining what this variational problem will be.

5. **The Riemann Mapping Theorem.** Our last example will be a result which is one of the most important tools in the development of complex analysis and its related fields. This is the Riemann mapping theorem which states that if we are given any simply connected region R of the complex plane which is not the whole plane, and a point z_0 in R, then there exists a unique analytic function $f(z)$ mapping R one-to-one onto the unit circle and subject to the normalization conditions $f(z_0) = 0$ and $f'(z_0) > 0$. All proofs of the theorem are quite difficult and so we shall restrict ourselves to an outline of one proof which utilizes the extremal methods which we have been discussing.

The proof may be sketched as follows. First of all, the uniqueness of $f(z)$ is had by showing that a second mapping function $h(z)$ would combine with $f(z)$ to give a mapping of the unit circle onto itself. The normalization conditions on $f(z)$ and $h(z)$ would then demand that the composite mapping be the identity mapping of the unit circle onto itself, and consequently that $f(z) \equiv h(z)$.

For the existence proof itself we study the family F of complex-valued functions $g(z)$ with the following three properties: 1.) $g(z)$ is analytic and univalent in R (i.e. if $z_1 \neq z_2$, then $g(z_1) \neq g(z_2)$); 2.) $|g(z)| \leq 1$ in R; and 3.) $g(z_0) = 0$ and $g'(z_0) > 0$. Using the hypotheses of the theorem it may be shown that the family F is not empty. The existence proof will consist of the usual three steps. In the first step we pose the extremal problem of determining the function f in F for which the derivative $f'(z_0)$ is a maximum. In the language of functional analysis the problem is to determine the f in F for which $J(g)$ is a maximum where J is the continuous functional on F defined by $J(g) = g'(z_0)$ for g in F. In the second step we show that the extremal problem has a solution by showing that the family F is normal and compact. Then by an analogue to the Weierstrass theorem cited in the first two examples in which the compact set is replaced by the normal and compact family F and the continuous function is replaced by the continuous functional J, we know that the extremal problem has a solution f in the family F. Finally in the third step the properties of f as an element of F are utilized along with the hypothesis of the theorem to show that the solution f of the extremal problem is the (unique) mapping function we seek. The details of this proof which are somewhat involved may be found in L. V. Ahlfors' book *Complex Analysis.*

This example also illustrates the fact that extremal methods may only yield existence theorems for the solutions rather than specific solutions. For it is still an unsolved problem to get the actual mapping function of any specified simply-connected domain onto the unit circle even though the existence of the function is guaranteed by the theorem. The same difficulty also occurred in the first example when we learned that there were extremal values in the interior of the interval but had no way of determining them exactly.

6. Conclusion. The ideas introduced in this paper have been used in many other profound investigations of analysis and its related fields. Among the works employing extremal techniques mention should be made of Courant-Hilbert's *Methods of Mathematical Physics*, Bergmann's AMS treatise *The Kernel Function and Conformal Mapping*, and Nehari's text *Conformal Mapping.* For a non-technical treatment Courant and Robbins' book *What is Mathematics?* provides an excellent introduction to these and other variational methods. Finally, a brief historical survey of such methods can be found in E. T. Bell's *Development of Mathematics.*

THE PORTLAND, MAINE EARTHQUAKE OF APRIL 26, 1957

John E. Brooks, S.J.

At approximately 6:40 o'clock (EDT) on the morning of April 26, 1957 the city of Portland was jarred awake by an earthquake which was felt throughout many sectors of Maine, New Hampshire, Massachusetts and Vermont. The earthquake was the second occurrence of seismic activity in New England within a three-day period, a slight shock having been felt in the St. Johnsbury, Vermont area on April 23rd.

Historical records indicate that earthquakes in Maine have not been numerous.[1] During the past one hundred years, forty-seven earthquakes are believed to have had their epicenters within the state of Maine and three others were located off the coast. Of the latter, two of the disturbances were relatively close together, being off the coasts of Portland and Kennebunkport. The third was located on the inland side of Deer Island. Within the state, the major zones

[1]Heck, N. H. *Earthquake History of the United States.* Part I, Continental United States (exclusive of California and Western Nevada and Alaska); U. S. Coast and Geodetic Survey, Ser. No. 609 (1938).

of seismic activity appear to be Cumberland-southern Androscoggin Counties (10 earthquakes), southern Piscataquis County (7 earthquakes), the Calais-Eastport area in Washington County (4 earthquakes), Kennebec County (4 earthquakes) and Penobscot County (3 earthquakes).

Among the residents of Portland, reactions to this most recent earthquake varied considerably with geographical location. The following are a few of the more typical reactions which were reported in the Portland *Evening Express* on Friday, April 26, 1957.

a) People near the airport thought that a plane had crashed.
b) A harbor pilot believed that a tanker had exploded.
c) One man believed that the rumbling was due to a train passing by on the tracks which ran behind his home.
d) Many people thought that their furnaces had exploded.

In general, persons in the immediate vicinity of Portland described the shock as a *sharp explosion* while residents of adjacent and nearby towns referred to it as a *rumble*. It was reported that dogs at the Animal Refuge League and in many private homes began barking when the disturbance occurred. One man, walking near East End Beach, was further startled when the area was suddenly vitalized with a horde of rats which had abandoned their rummaging in loose fill to seek more stable land.

Damage in the city of Portland was slight. The New England Telephone and Telegraph Company and the Central Maine Power Company reported no damage. From the downtown sectors of the city it was reported that canned goods and other merchandise were toppled from store shelves and several residents testified that articles were knocked off the walls of their homes and from garage shelves. One man claimed that he had been toppled from his bed in one of the city's hotels. The general effect was a shaking of houses, a rattling of chinaware and furniture, and the opening and closing of doors. It seems reasonable to conclude from this evidence that an intensity of V on the Modified Mercali Scale is the maximum intensity which can be assigned tod this shock in the Portland area.[2] It is quite probable that it was stronger at the epicenter.

In their preliminary determinations of the epicenter, New England seismologists were not entirely in agreement. In the Waterville *Sentinel* on April 27, 1957, one report located the epicenter "somewhere in a mountainous region of New Hampshire," while another placed it ten to twenty miles off the coast of Yarmouth, Maine. This

[2]Wood, Harry O. and Neumann, Frank. *Modified Mercali Intensity Scale of 1931*, Bull. Seism. Soc. Am., 21:277-283 (1931).

discrepancy prompted the author to make a more intensive study of the earthquake. Records of the disturbance were generously made available from the Canadian Dominion Observatory Stations located at Halifax, Ottawa, Seven Falls and Shawinigan Falls and from Fordham. Arrival times were obtained from Columbia and Harvard. It was finally decided to make use of the readings from Halifax, Ottawa and Weston as these stations give us somewhat of a triangular arrangement around the suspected epicenter. As a further check, the arrival times from Harvard were used and seem to verify the result obtained from the use of the records of these three stations.

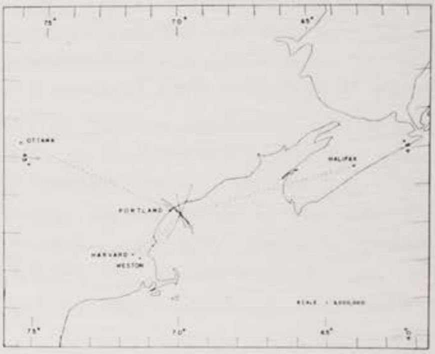

FIG. 1. Instrumental determination of the epicenter of the Portland, Maine earthquake of April 26, 1957, by distance-arc intersection. Epicenter: 43.6° North, 69.8° West.

Using $S_{II} - P_{II}$ intervals, the arcual distances, $\triangle$, were obtained from the travel times computed by Dr. L. D. Leet of the Harvard Seismographic Station and the $\triangle$-circle for each of the stations was then drawn on a polyconic projection. The epicenter, the point of intersection of the $\triangle$-circles, was calculated to be 43.6° North and 69.8° West, or approximately twenty-four miles off the coast of Portland, Maine. This result confirms the location initially determined at Weston by using all three components of the station's seismograms. The origin time was calculated to have been 11h 40m 06s GMT. Table I lists the stations and the data obtained and interpreted from their seismograms. Fig. 1 is a map showing the intersection of the $\triangle$-circles and the location of the epicenter.

On the day following the occurrence of this earthquake a certain amount of speculation was aroused as to the possibility of New England entering a period of more frequent seismic activity. Table II shows the frequency of Maine earthquakes from 1847 to 1875 and for twenty-five year intervals from 1876 up through this most recent disturbance.

TABLE I

Station	Location		Arrivals				Distance
	Lat. N.	Long. W.	phase	h	m	s	
Halifax	44.6	63.6	iP_n	11	41	20.9	320 mi.
			iS_n		42	14	
Harvard	42.5	71.5	iS_n		40	54.5	112 mi.
			iP_n	11	40	34	
Ottawa	45.4	75.7	iP_n	11	41	13.2	315 mi.
			iS_n		42	05.5	
Weston	42.4	71.3	iP_n	11	40	33.6	109 mi.
			iS_n		40	53.7	

TABLE II

Years	Frequency
1847 - 1875	10
1876 - 1900	3
1901 - 1925	9
1926 - 1950	28
1951 -	1
Total	51

It will be observed that more than fifty percent of these earthquakes have occurred since 1926. This is precisely what one would expect inasmuch as tremendous advances have been made in the design and operation of seismographs in the last twenty five years. Therefore, it can hardly be concluded at this time that the frequency of earthquakes in Maine is on the increase. Undoubtedly, there were weak tremors in the middle and late nineteenth century whose epicenters were incapable of being determined even by testimony to say nothing of instrumental determination. In general, the frequency of earthquakes in New England has declined considerably in the last decade. However, this is not to be interpreted as meaning that northeastern United States is becoming seismically inactive. Seismologists have not yet penetrated adequately the baffling problem of the causes of earthquakes and consequently are in no position to make predictions about future disturbances. All that one can say at the present time is that where earthquakes have occurred in the past, they are likely to occur in the future—and northeastern United States has been the center of more than eight hundred earthquakes since 1635!

SEMIAUTOMATIC METHODS IN SPECTROSCOPY AT GEORGETOWN OBSERVATORY

REV. M. THEKAEKARA, S.J.

Most of the basic work in spectroscopy is that of wavelength measurement. It is well known that many of the spectra, especially the more complex ones are quite unsatisfactorily presented in existing literature. The earlier measurements were made at a time when the demand for accuracy was not as great as it is today. New methods of producing spectra have revealed the possibility of making significant additions to spectroscopic literature. Complete and reliable information about different spectra is needed not only for spectroscopists whether in physics or astrophysics, but also for workers in many allied fields like physical chemistry and various branches of technology and industry for whom spectroscopy is an important tool of research. When hundreds of thousands of lines are involved the necessary measurements and all the subsequent calculations constitute a tedious and time-consuming task. That few are willing to undertake such drudgery is a great handicap to future work in the field and impedes the work of others who are not directly interested in spectroscopy but need the data for other purposes. Hence it is that any attempt to lighten the burden of data compilation must be welcomed.

Hitherto Georgetown University had employed the conventional techniques of wavelength measurement which are still in use in most spectroscopic laboratories. The plate is viewed through a microscope and the microscope is moved till the center of a line coincides with the crosshair of the eyepiece. The position of the microscope is read on the headscale and pitchscale and the value is written down on paper. Apart from the time required for these operations considerable strain is involved in the adjustment of the eye to different distances and different degrees of illumination. An analog digital converter (Telecordex) is now being used for automatic recording of comparator settings. The observer can keep his eye fixed on the microscope eyepiece and positions will be typed out as fast as settings on the lines can be made. The telecordex is a dual indicating and recording device which stores electric pulses. Magnetic reading heads are attached to the horizontal and vertical screws of the comparator and electric pulses are generated each time the microscope travels a thousandth of a millimeter. The number of pulses which represents the position of the microscope is available for reading any time the *readout* button is pressed. An automatic typewriter prints the information on a continuous roll of paper.

The positions of the lines being known the next step in the conventional method is to determine the plate factor from the positions of two known lines and to calculate the approximate values of the wavelengths for all the measured positions according to a linear dispersion formula. This is done with a desk calculator. A calibration curve for the plate is drawn using known wavelengths. The wavelengths of the unknown lines are obtained by adding the residual corrections which often are very large. Greater accuracy and considerable saving of time can be obtained by using the electronic computer (Electrodata) model E 102, which has recently been installed at the Georgetown Observatory. All the known wavelengths and their positions are supplied to the computer. The computer has been programmed to calculate the constants of an equation of the second degree or higher, by the method of least squares and thus to determine a curve which best fits all the given values. It types out the position of the line, the known value of wavelength and the value recalculated from the constants of the least square solution, one below the other. The same constants are then used by the computer to calculate the wavelengths of the previously unknown lines. The printing of the results is almost as rapid as the punching in of the known wavelengths and the measured positions, and the values are more accurate than can be obtained from a calibration graph.

The conventional method of determining wavenumbers from wavelengths is by using the well-known Kayser's wavenumber tables. This involves a tedious extrapolation for the second and third decimal places of the Angstom unit. More recently accurate dispersion formulae have been proposed, e.g., the Edlèn dispersion formula for converting wavelength in air to wavelength in vacuum. The wavenumber is then obtained by computing the reciprocal with a desk calculator. With the E 102 computer it is possible to obtain wavenumbers just as easily as wavelengths since the computer can be programmed for formulae however involved they be. The computer takes the wavelengths from its memory locations where 220 wavelengths can be stored at one time, and prints out the wavenumbers according to the given dispersion formula.

A computer with the speed, accuracy and all-purpose adaptability of the E 102 can facilitate each successive step in the processing of observational data. Computation time has been reduced to about a tenth of what it used to be previously when connventional methods alone were available and a considerably greater degree of accuracy can be obtained.

THE THEORY OF SPONTANEOUS GENERATION

Parts I,* and II.

FRANCIS X. QUINN, S.J.

VIII. EMPEDOCLES

To resume our narrative we move down to Acragas of Sicily, the home of Empedocles (450 B.C.). He conceived life to have risen out of the earth—first plants, then animals. As the latter, first came limbs in separate cases. Later limbs were attracted to bodies; sometimes the coupling missed and misformed creatures arose. Shapeless lumps were belched forth through the subterranean fires gradually to take form in the air. Men, who have a warm temperament came from a southern climate; women, the more cold-blooded sex, were created in a northerly climate.[20]

> Observe the sun, bright to see and hot everywhere, and all the immortal things drenched with its heat and brilliant light; and observe the rain, dark and chill over everything, and from the earth issue forth things based on the soil and solid.[21]

Here Empedocles cryptically gives all the requirements for spontaneous generation: heat, moisture, and the result is life. Later he sounds as if he were compounding a prescription to bring forth life:

> The earth, having been finally moored in the harbors of love, joined with these in equal proportion: Hephastus, with moisture, all-shining (ether), either a little more (of earth) or a little less to their more. And from these come blood and the forms of flesh.[22]

IX. LEUCIPPUS AND DEMOCRITUS

From our Sicilian interlude we now return to the Greek mainland and witness a revolutionized abiogenetic theory. The founder of the revolution was Leucippus (430 B.C.), the teacher of Democritus. According to Leucippus life is produced by many wet atoms of differing shapes. These atoms separate from the infinite mass and come together in a great empty space. Like atoms attract each other and interlock; finally we have the outer skin, globe-shaped, enclosing the joined atoms. The whirling motion of the atoms causes a drying of the mass and the squeezing out of water. None of this happens at random but rather all happens out of reason and necessity.[23]

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*Continuation of part I from THIS BULLETIN, 34, 49-53 (1956). References for the first two instalments are appended. Mr. Quinn, S.J. is now stationed at Georgetown Preparatory School, Garrett Park, Md.

Democritus (420 B.C.) held the same views as his teacher. Discussions on atomism and materialism always seem to redound to him.[24]

Democritus seems to have had a real interest in the origin of life and great respect for views developed since the time of the Ionian school. To his deep interest he added considerable insight and boldness of speculation. He held the fundamental tenets outlined in discussing Leucippus and yet in his abiogenetic theory it is hard to find anything especially atomic. There is nothing in his recorded views which is inconsistent with atomism. The most interesting statement on the origin of life is that life originally sprung from water and mud.[25] Life came from the earth and the moist element was its efficient cause. Later Lucretius will elaborate on this idea of the wombs of life rooted in the ground.

The biological work of Democritus is vast and generally shows an accommodation of his theories to the main principles of atomism.[26]

X. The Sophists

It is well known how the Sophists changed the intellectual atmosphere of Greece by pushing aside the considerations of the start of life and replacing them with emphasis on the art of life. Xenophon, in his *Memorabilia,* tells us that Socrates did not discuss the nature of the universe and the origin of life, but regarded such problems as sheer folly. The rise of sophism momentarily clouded the theory of abiogenesis.

XI. Hippocratus

Our next step is to analyze the abiogenetic theories of the late fifth century and chiefly the Hippocratic *corpus.* The brief hibernation of the developing abiogenetic theory is still not over. One can find references to the Ionians and early founding fathers, but there seem to be few new contributions. This will frequently be the case: where one can find no new view, the old views of Empedocles and Alcmaeon of Croton can be traced down to Galen.

The scientific method of Hippocratus (420 B.C.) added the important element to moisture and soil, namely, the seed. Some would refer to this as the abiogenetic theory. He does give great stress to the importance of good soil, filled with vital juices. As soon as he adds the seed, however, it is hard to see how the theory would be spontaneous. Like Empedocles, Hippocratus talks about life and the four vital juices of life: blood, phlegm, yellow and black bile. The existence of life was somehow dependent on the proper commingling of these four representative elements. If they were not properly proportional, disorder in life would result. The only reason Hippocratus is incorporated into our history is because he passed on the earlier traditions.

XII. Diogenes of Apollonia

Quick mention is deserving to Diogenes of Apollonia who lived in this latter half of the fifth century. His longest surviving work was *On Natural Science*. He receives the credit for accentuating the pneumatic tendencies of Anaximenes. He added that, "Plants are generated on land when water putrefies and takes on an admixture of air."[27]

XIII. Plato

More sophisticated than his master, Plato saw that any philosophy with a claim to generality must include a theory on the origin of life. Plato held that the universe was uncreated chaos in the beginning. The ordering of this chaos was not chance spontaneous evolution but the result of the activities of a supernatural being, by the realizing of an intellectual design. For the most part, Plato limits himself to a discussion on the origin of the elements. He seems to be poking fun at the theory of spontaneous generation when he says that parts of beings are created and joined through necessity. The degeneration of man leads to his soul transmigrating into women, beasts and birds. In the *Phaedo* Plato tells us that Socrates investigated the early theories of spontaneous generation and found them unsatisfactory as an explanation of the origin of life.[28]

As we read Plato's ideas we see a great contrast between his manner of thinking and that of his predecessors. Plato's knowledge proceeds from heaven downward. The knowledge of the early abiogeneticists begins with homely things on the face of the earth and sometimes soars slowly heavenward. Plato's whole idea of science should have been the wind to extinguish the last spark of the abiogenetic theory.

XIV. Aristotle

We now approach a new age, the age of Aristotle, which is essentially different in many respects from the preceding one, in spite of its proximity.

According to Aristotle every lower stage of development is potentially in relation to a higher stage which represents its full realization. Thus we get a whole series of stages beginning with the formless matter or exclusive potentiality, followed by inanimate nature in which matter is stronger than form, and finally animate nature in which the form governs the matter. There is a higher form of existence than earth-life. Outside the outermost celestial sphere is the world of form free from all matter, the highest intelligent existence. God is the fundamental origin of motion and life. Aristotle's vision of a constant evolution from lower to higher forms of being is a very fertile one in the biological sphere.

Aristotle's theory of spontaneous generation is much more clarified and restricted than that of his predecessors. He constantly differentiates between plants and animals which reproduce themselves by sexual means, by asexual means and those produced by spontaneous generation. The latter occurs in a number of lower animals which are produced out of putrefying substances; among these certain insects receive special mention: fleas, mosquitoes, and day-flies. Other insects, such as grasshoppers, wasps, and flies, have sexual reproduction. Abiogenesis is explained by the fact that the whole of nature is full of life-spirit. This life-spirit under certain circumstances gives form to the inanimate matter and so gives rise to new beings. Here, under Aristotle, we clarify the point that spontaneous generation, or effect without a proportionate cause, means the appearance of living things without the mediation of parents. It does not always mean the origin of life from non-life, but sometimes the origin of life outside the ordinary laws of generation.

To our minds, the idea of life from non-life appears excessively improbable and certainly not proven. The chief argument in favor of abiogenesis rests on the difficulty of always proving the existence of germs. To the ancients the sudden appearance of life where there had been no previous parent was sufficient proof.

At this point we insert the salient quotations of the biologist of Stagira on abiogenesis:

> So with animals, some spring from the parent, while others grow spontaneously and not from kindred stock. Spontaneous generation can come from putrefying earth or vegetable matter, as some insects, while others are spontaneously generated in the inside of animals out of the secretions of their several organs.[29]
>
> Other insects are not derived from living parentage but are generated spontaneously: some out of dew falling on leaves, ordinarily in spring time, but not seldom in winter when there has been a stretch of fair weather and southerly winds; others grow in decaying mud or dung; others in timber, green or dry, some in the hair of animals, some in animal flesh and some in excrements.[30]

Some species of the grey mullet grow spontaneously from mud and sand.[31]

> As a general rule, testaceans grow by spontaneous generation in mud, differing from one another according to the differences of the material.[32]

The hermit crab grows spontaneously out of soil and slime and finds its way into untenanted shells.[33]

> Sponges grow spontaneously either attached to a rock or on sea-beaches and they get their nourishment in slime. A proof of this is that when they are first secured they are full of slime.[34]
>
> Eels are derived from the earth's guts—they grow spontaneously in mud and humid ground.[35]

There are other quotations which say much the same thing and for the sake of brevity we have omitted them. There are a few more, however, that should be noted in passing:

> Some insects come from putrefying matter, liquid or solid—various kinds of flies and fleas.[36]
>
> The same holds also in plants, some coming into being from seed and others, as it were, by the spontaneous action of Nature, arising either from decomposition of the earth or some parts in other plants. Some are produced by themselves separately upon trees (mistletoes).[37]
>
> In connection with the origin of men and quadrupeds, if ever they were earth-born, as some say, they came into being either by formation of a scolex or out of eggs.[38]

It seems to be Aristotle's opinion that each species would have a separate beginning by spontaneous generation and not be descended from a common ancestor. Why is it, he asks, that some animals come into being from sexual intercourse, while others from a compounding of certain elements? He then adds:

> (This compounding of certain elements is) a process resembling the original production of their species.[39]

There is always a great emphasis on the decomposition and corruption of living beings giving birth to new life.[40] In all of these quotations Aristotle is clear and definite. Scholars often consider his work done in the field of genetics as his greatest biological contribution.[41] As the sections around the above quotations are read, one is amazed at his great ability of speculation.

XV. Theophrastus

When Aristotle fled from Athens he entrusted his school to the hands of Theophrastus who had been his friend and follower ever since their student days under Plato. Theophrastus' treatises are to botany what Aristotle's works are to zoology.[42] Theophrastus seems to hold spontaneous generation and yet is bothered by it. He hints that perhaps seeds may be so small as to be invisible.

> Spontaneous generation takes place in smaller plants, especially annuals and herbaceous. Occasionally it occurs in larger plants whenever there is rainy weather or some peculiar condition of air or soil . . . but if the air supplies seeds as Anaxagorus says . . . more investigation must be made and the matter of spontaneous generation must be thoroughly inquired into.[43]

XVI. Epicurus

Our journey now leads us into the garden of Epicurus. The theories of Democritus had been overlooked during the last part of the fourth century. Plato never mentioned him, Aristotle referred to him often but only for the sake of adverse criticism. It was Epicurus who resurrected the atomic abiogenetic theory.

The most important of his writings was undoubtedly the treatise *On Nature*, which extended to no less than thirty-seven books. He modified the theories of Leucippus and Democritus and casts a great light on both of their theories.

When we were discussing Democritus we had the makings of a contradiction: all things come into being by atoms and yet abiogenesis through mud and water was also endorsed. Epicurus thinks of the nucleus of atoms as *seeds*. There are different shapes relative to the creation of some particular thing. We have here an abiogenetic theory maintaining that nothing is created out of the non-existent. To prove this he says that if life did come from the non-existent, everything would be created out of everything with no need of seeds. Later Lucretius[44] develops the same idea: that complexes of atoms fit together to become the germ of living things.[45] Epicurus also says that a new world is created "when seeds of the right kind have rushed in from a single world or interworld or from several." Here by seeds he means some part of an atom—perhaps nuclei.[46] It may be maintained then that the atomists pictured spontaneous generation taking form from mud and slime after the seed or germ atoms formed proper arrangements. The apparent earlier contradiction is resolved. It was Epicurus' fame to have passed on the torch of atomistic abiogenesis from Democritus to Lucretius.

XVII. Lucretius

The Romans did not add a great deal to science. This contribution lay elsewhere, in the field of organization. Among the Romans the Stoic philosophy of the Greeks had far reaching effects, chiefly because it presented many of the traditional beliefs inherited from the Etruscans.

The opposing school of Epicurus found a notable exponent in Lucretius (c. 95-55 B.C.). Lucretius, like Epicurus, preserved the context of the early atomic-abiogenetic theory. Following the example of Empedocles, Lucretius clothed his thoughts in verse form.

> Rightly has the earth earned the name of mother since out of the earth all things are produced. And even now many animals spring forth from the earth, formed by the rains and the warm heat of the sun; wherefore we may wonder if more animals, larger in size reached their full growth when the earth and air were fresh.[47]

According to Lucretius, then, the best time for spontaneous generation was when the earth and air were new and fresh. This is interesting if we consider that some hold spontaneous generation only took place when life was first whirling its way into existence.

The main abiogenetic theories set down in our discussion of Democritus and Epicurus need not be reiterated here. Lucretius merely clarifies our ideas that the aggregate of atoms acquires vital properties or powers which mark it off from other nuclei and qualify it particularly for the further union which constitutes life.

The *corpus* of spontaneous generation is now closed. From time to time the theories will be passed along but no new additions will be made. The physician Galen and Pliny the Elder were well known chroniclers of the abiogenetic theory. With a quick glance we pass the Neo-Platonists and the Anatomists of Alexandria. They deserve credit for passing on the theories of the Ionians and Aristotle.

Notes

1 Strabo, *The Geography of Strabo*, trans., H. L. Jones (New York; G. P. Putnam's Sons, 1929), VI, pp. 205-209.

2 All the dates represent the height of individual's career.

3 Herodatus, Plato, Aristotle and Doxographers.

4 Herman Diels, *Die Fragmente der Vosokratiker* (Berlin: Wiedmannsche Verlagsbuchlandlung x, 1954), I, p. 80.

5 Kathleen Freeman, *Companion to Pre-Socratic Philosophers* (Oxford: Blackwell, 1949), p. 52.

6 L. A. Seneca, "Naturalium Quaestionum," *L. Annaei Senecae Opera*, ed. Fredrick Hasse (Leipzig: Teubner, 1893), III, 14, p. 221.

[7] S. Augustine, *The City of God*, trans. Marcus Dods (New York: Modern Library, 1950), p. 244.

[8] Diels, *op. cit.*, p. 88.

[9] *Ibid.*, p. 84.

[10] Lempriere, *A Classical Dictionary* (New York: E. P. Dutton & Co., 1949), p. 98.

[11] We should not go too far in making a comparison between Anaximander's theory of the origin of life and the evolution theory of our own day. An attempt has been made to prove him a predecessor to Darwin. (*Vid.*, George Sarton, *History of Science* (Cambridge: Harvard Press, 1952), p. 176.) This view indicates a complete misunderstanding of the matter, although an easily accountable one. Highly debatable theories have always sought for direct predecessors as far back as possible.

[12] Kathleen Freeman, *Ancilla to the Pre-Socratics* (London: Blackwell, 1948), p. 19.

[13] Diels, *op. cit.*, p. 136, n. 33.

[14] *Loc. cit.*, n. 29.

[15] *Loc. cit.*, n. 31.

[16] Arthur Stanley Pease, "Fossil Fishes Again," *Isis*, XXXIII (1942), 689-690.

[17] Pindar, *Odes to Pindar*, ed. John Sandys (New York: G. P. Putnam's Sons, 1919), p. 77.

[18] Arthur Hort, *Theophrastus' Enquiry into Planets* (London: Heinman, 1948), I, p. 162.

[19] Diels, *op. cit.*, p. 244, n. 15.

[20] *Vid.*, reference n. 10.

[21] Diels, *op. cit.*, p. 319, n. 21.

[22] *Ibid.*, p. 346, n. 98.

[23] *Ibid.*, II, p. 81, n. 32.

[24] Karl Marx wrote a thesis on the difference between Democritus and Epicurus in 1841. Since then countless discussions on atomism and materialism have been traced back to the *laughing philosopher*. (Hor., Ep. II, 1, 194; Juvenal, X, 33.)

[25] Diels, *op. cit.*, II, p. 123, n. 139.

[26] Many of Democritus' scientific ideas we know only through Aristotle's polemics against them, and it is not seldom that modern research has proved Democritus right. For instance, he considered that the spider's web is produced from inside its body while Aristotle maintained that it was cast off skin.

When judging atomism we must beware of two exaggerations. The one consists in equating the modern and ancient theories; the other in rejecting the ancient theory because of vagueness. There is an immense difference between the two: all the difference that exists between a philosophic conception that cannot be tested and a scientific hypothesis inviting a long series of experimental verifications. There is no doubt that Democritean atomism, revived by Epicurus and popularized by Lucretius, provided an intellectual stimulant for centuries.

[27] Hort, *op. cit.*, pp. 163-165.

[28] John Burnet, *Plato's Phaedo* (London: Oxford, 1937) 96b 1-3.

[29] Aristotle, *Historia Animalium*, 539a 23.

[30] Aristotle, 551a 1.

[31] Aristotle, 543b 18.

[32] Aristotle, 547b 18; 763a 26.

[33] Aristotle, 548a 15.

[34] Aristotle, 548b 6.

[35] Aristotle, 570a 15. The discovery of eel generation is recent. The eel is not a direct offspring but passes through a larval stage such as a tadpole to frog. Reproduction takes place at tremendous depths. Sicilian fishermen still call the larval eel *casentula*—looks like the doric *gas entera*—earth's guts.

[36] Aristotle, 721a 8; 723b 1; 732b 13.

[37] Aristotle, 715b 25.

[38] Aristotle, 762b 29—a reference of special interest to the evolutionist.

[39] Aristotle, 892a 24.

[40] Aristotle, 924a 6. I have sought a common denominator in all of Aristotle's references on abiogenesis— He seems to insist always on the spontaneous generation of *bloodless life*.

[41] Lewes, George H. *Aristotle* (London: Smith Elder Co., 1864), p. 375.

[42] In many respects the treaties of Theophrastus are the most complete and orderly of all the ancient biological works. They give an idea of the interest a working scientist could develop when inspired by a great teacher.

[43] Hort., *op. cit.*, I, 5.

[44] Lucretius, *De rerum natura*, trans. W. H. D. Rouse (London: Heinman, 1931), I, 159-214.

[45] (As in n. 44 above; there is no n. 44 in the text of the manuscript.)

[46] Bailey, Cyril, *The Greek Atomists and Epicurus* (London: Oxford, 1928), p. 343.

[47] Lucretius, *op. cit.*, p. 397.

Science and Apologetic Motivation is the title of an article by Father Robert O. Brennan of LeMoyne College appearing in the *Bulletin of the Albertus Magnus Guild*, 4 (5), pp. 7 & 8 (Dec. 1957). This issue of BAMG is replete with crisp news items of Catholic doings in science, no small proportion of which is *Jesuit*. Information on joining the *Guild* and getting its *Bulletin* may be had from its Exec. Secy-Treas., Fr. P. H. Yancey, S.J., Spring Hill College, Mobile, Ala. *Ed.*

News Items

Boston College. Ten graduate students have been awarded Research Assistantships on the sponsored research projects under the direction of the science departments.

This year's freshman class has started the new Honors Program. Forty-three freshmen were selected for this program on the basis of their high-school records, College Board scores and personal interviews. Fourteen are in Physics, ten in Biology, five in Chemistry, four in Mathematics.

Fr. James Skehan is collaborating with Prof. Billings of Harvard and Prof. Boucott of M.I.T. on a project to reopen the abandoned Worcester Coal Mine. They will attempt to find fossils that will definitely date the rock strata of the Worcester area.

Fr. Stanley J. Bezuszka of the department of mathematics did work for the Air Force on negative resistance diodes, according to a departmental report. From August 21-28, 1957 he gave a series of five lectures on Modern Mathematics at the Institute held by the Association of Teachers of Mathematics in New England, at Dartmouth College. On August 28, 1957 he addressed the 48th annual Teachers' Institute in Boston on the topic: Recent Trends in Modern Mathematics. Other addresses on this topic include: Sept. 7 to the Conference of Religious and Superintendents of Catholic Schools in New England; and on Sept. 9, at the Annual Meeting of Superintendents and Supervisors of the Catholic Schools in New England. For travels, summer teaching, vacations, projects and grants of the mathematics staff at Boston College, consult the *Ricci Mathematical Journal* for Dec. 1957 (Student publication of the Ricci Academy of Mathematics).

Canisius College. Fr. Clark lectured at Lehigh University, Bethlehem, Penna., on November 7th. His topic was *Is Modern Science Set on Mathematical Quicksands?*. This was Fr. Clark's fourth appearance on the Campus Cooperative Lecture Series.

Cranwell Preparatory School. The *Scientific Motion Pictures Seminar* of Cranwell has arranged a program of instructive science movies for the year. At the suggestion of the Film Reviewer of the

JESUIT SCIENCE BULLETIN showings have been arranged for *The Strange Case of the Cosmic Rays* and *Our Mister Sun*. (See pages 42 and 44 of the previous issue of the BULLETIN.)

Fordham University. Fr. Joseph Mulligan has been promoted to Chairman of the Physics Department and has been named assistant professor.

Fr. J. Joseph Lynch was re-elected president of the Jesuit Seismological Association at the Association's 32nd annual meeting.

Thirteen papers were delivered by members of the Fordham chemistry faculty and graduate students at the semi-annual meeting of the A.C.S. in New York. Those whose papers were read include Dr. Milan Bier, Dr. Michael Cefola, Dr. Douglas Hennessy, Dr. Emil Moricioni, Dr. Nord, Dr. William O'Connor, Dr. Walter Schubert, Dr. Norman Smith and Dr. I. Moyer Hunsberger.

Two important research grants have been announced by Fr. Ewing, director of research services. Dr. William O'Connor, chairman of the Chemistry Department, and Dr. Moricioni have received a three-year grant of $36,000 from the National Institutes of Health for their work in cancer research. Dr. Leopold Cerecedo, professor of biochemistry, who is investigating the systematic effects of cancerous tumors, received word from the National Cancer Institute that he will receive a grant of $14,000 to carry on this work in 1958. This is the Institute's seventh annual grant to him for this purpose.

Fr. Clarence Schubert, physical chemistry instructor at the college, has received a grant of $7,500 from the Petroleum Research Fund to continue his research on the *knock* in internal combustion engines. Two research assistants working on this project are Fr. Frederick Dillemuth and Mr. Duane Skidmore, S.J.

Five appointments have been announced in the School of Pharmacy. Dr. Louis Elowe has been appointed associate professor of pharmacy. Mr. Ira Sharenow will be lecturer of professional law. Mr. Frederick Wallenberger has been appointed instructor of chemistry. Mr. Joseph McSweeney has been appointed instructor of biology. Mr. Paul Buday, a candidate for the Ph.D., will be assistant professor of biological sciences.

Georgetown University. Georgetown is erecting three new major buildings on the campus this fall at the cost of $5.5 million. Already underway are the Gorman Research and Diagnostic Building and the Medical-Dental students' dormitory.

America for November 23, page 233 carried an article entitled *Is there a Doctor in your House?* by Fr. Thomas O'Donnell and Dr. Charles D. Shields of the Georgetown Medical School.

St. Joseph's College. The Physics Department was the recipient of a gift of $12,000. Part of this gift will be used to establish a fund for a medal to be awarded for the highest proficiency in physics. The award will be named after the donor, Mr. Daniel J. O'Conor.

For the twelfth consecutive year a course in paint technology is being offered. Forty-five students are taking the course.

In a release by the American Institute of Physics, giving statistics on enrollment and degrees granted to Physics Majors in 1956, St. Joseph's ranks fifth in number of B.S. degrees conferred throughout the country. Only eighteen institutions gave more than twenty of these degrees. The first five were: University of California 57, M.I.T. 46, Harvard 39, University of Califoria at Los Angeles 36, and St. Joseph's 32. At present there are 166 students majoring in physics. Of these 66 are freshmen.

Wheeling College. Fr. Duke received a Sigma Chi RESA research grant to construct a grating spectrograph and conduct research in chemical spectrography. This is the first research grant awarded to Wheeling College.

Fr. Duke attended the National Conference on Scientific Education held in Chicago under the auspices of the Engineers Joint Council.

Dr. Frederick Rossini, chairman of the Chemistry Department at Carnegie Institute of Technology, gave a lecture to the students on Petroleum Chemistry.

Fr. Heyden, director of the Georgetown Observatory, gave an illustrated lecture on satellites before a standing-room-only crowd.

Weston Seismological Observatory. Fr. Linehan has recently lectured to the Military Engineers at Tulsa, Oklahoma and several other groups. He appeared on the *Spotlight of Science*, Museum of Natural Science, Boston and on two telecasts. He delivered a paper at the Golden Anniversary Meeting of the New England Water Works Association on *The Geohydrology of New England.*

Weston College Science Colloquium. On Sunday, November 24th Dr. Vincent McBrien, associate professor of Mathematics at Holy Cross College, gave a lecture on *The Undergraduate Revolu-*

tion in Mathematics. The fortieth meeting of the *Colloquium*, held Sunday, Dec. 15, 1957, featured Fr. William D. Sullivan's lecture on the *Effect of Ultra-violet Radiation on the Growth and Division of a Single Cell.* Special reference was made to the effect of sulfhydryl compounds found during the specific stages of cell division.

Varia. The American Institute of Chemists lists 144 student medal awards for 1957. Twenty-one of these went to Catholic colleges, including ten to students of Jesuit colleges. Jesuit colleges whose students received these important awards were: Boston College, Canisius College, Fordham University, John Carroll University, Loyola University of Chicago, Loyola of Los Angeles, Loyola of New Orleans, St. Joseph's, Xavier University and the University of Santa Clara. *The Chemist*, 34 (1957) 460-2.

Forty-six full-time and part-time members of the faculty of Creighton University School of Medicine have authored 364 publications since 1950. Dr. William Kleitsch is the most prolific writer of the staff. He has had 53 articles. (*Creighton Alumnus*, Nov. 1957, p. 18.)

Fr. Joseph Peters, Chairman of the Biology Department at Xavier University, was recently elected a fellow in the Academy of Zoology, an international organization.

The Louisiana State Pharmaceutical Association has presented Loyola University College of Pharmacy with an $18,000 scholarship fund. In the last sixteen years, sixty-nine Loyola pharmacy students have been given scholarship assistance from a similar fund. (*American Journal of Pharmaceutical Education* 21 (1957), 463.)

Fr. Bernard Hubbard recently revisited Taku Harbor, Alaska, checking equipment for future projects.

The *Oregon Jesuit* carried an interesting article on *Jesuits and Science* by Fr. Arnold R. Beezer in its October issue; and in the December issue: *Work of Jesuit Scientist featured on Television*, by B. A. Fiekers, from a release, part of which appeared in this BULLETIN, page 37 of the Nov. 1957 issue. Editor, Fr. Erwin J. Toner, S.J., Box 4408, Portland, Ore., is happy to publish suitable material from our scientific apostolate from time to time. Ed.

Marquette University. Application for a 650 digital computer has been approved by International Business Machines Corp. Installation of the $200,000 machine is expected to be completed by August 1958 for the opening of the computing center in the college of engineering. (*Industrial Science and Engineering*, Nov. 1957).