part in this new program of professional training and research.

Our biological engineering program, which went into full gear this past summer under the direction of its new head, Dr. Francis Schmitt, has received an additional grant of $70,000 from the Rockefeller Foundation for the establishment of a sub-microscope center for studying the application and improvement of the electron microscope, particularly in the biological field.

Recent years have brought increased emphasis at the institute on industrial or applied mathematics and the more extensive application of mathematical techniques to special problems. One example of this is our center of analysis, which provides a wide range of machines for the analysis of technical problems. The new differential analyzer, the major unit in this center and one of the great scientific instruments of modern times, is now nearing completion. In still another direction, a laboratory has been established for the application of mathematical statistics to industrial problems, particularly to quality control. The department of mathematics and the department of economics and social science have joined forces in this program, and they are assisted by a group of cooperating companies which by their support are aiding fundamental research in this field while at the same time receiving assistance from our specialists in the solution of specific problems. As the role of the applied mathematician becomes more defined and recognized we plan the establishment of a more formal program of instruction in the field.—*From the annual report of Dr. Karl T. Compton, president of the Massachusetts Institute of Technology.*

SCIENTIFIC BOOKS

FRANKLIN'S EXPERIMENTS

Benjamin Franklin's Experiments. Edited with a critical and historical introduction, by I. BERNARD COHEN. Cambridge, Massachusetts: Harvard University Press, 1941.

THIS book contains those writings of Benjamin Franklin which present his theories and observations in what was in his time the new and almost unexplored field of electricity. Franklin's attention was directed to the subject by a Dr. Spence or Spencer whom he met in Boston in 1746. By a happy coincidence the Library Company of Philadelphia, of which he was an active member, received about this time from its London correspondent, Mr. Peter Collinson, F.R.S., the present of a glass tube, with some directions for its use in making electrical experiments. Franklin had lately arranged his affairs so that he was no longer engaged in active business, and he was free to throw himself with ardor into the study of this new and fascinating subject. Apparently he was unacquainted with its literature and knew little of what had been done in Europe. He must have been informed of the performance of the Leyden jar, but in practically all his work he relied on his own observations and made his own theories. He gave them to the world in the form of letters, most of which were sent to Mr. Collinson, and were read by him to the Royal Society and published in its Transactions. They were afterwards collected and published in several successive editions, from the fifth of which the text of this edition is taken. These letters were widely read both in English and in French, German and Italian translations, and gave Franklin a reputation as a thinker which served him well when he entered public life.

It would be idle to attempt to decide on the question of Franklin's priority for his discoveries. So many men were working and playing with the electric spark and the Leyden jar, and the communication of their results was so uncertain and often so long delayed, that it is probable that many of the important facts were discovered again and again. We can be sure, though, that Franklin's work was independent and original. His most important achievements were the discovery of the way in which electricity streams from or to a point; the discovery of the way to charge an insulated conductor by induction; the recognition from this experiment that electricity is not produced by the act of friction but is merely altered in distribution; the satisfactory analysis of the charging of the Leyden jar; and the demonstration that lightning is an electric discharge. In describing these results he uses the hypothesis that there exists in all bodies an electric fluid, ordinarily in a normal or passive condition, and that the act of charging a body gives to it a surplus of this fluid, which is taken from other bodies. The one body has a positive charge, the other bodies a negative charge. He is puzzled by the fact that two negatively charged bodies repel each other, but seems to be willing to accept the fact without explanation. This one fluid theory, as it was called, in distinction from DuFay's two fluid theory, which had been announced a few years earlier, and which Franklin does not seem to have known, was for a while the prevalent theory and has left its mark in the nomenclature of the subject.

In a valuable Introduction of 160 pages—the text of Franklin's papers, with some supplementary matters, takes up about 275 pages more—the editor indicates his belief, based on some expressions of Franklin in private letters, that he was essentially a scientist

and that he always regretted that he had been drawn away by public business from more congenial pursuits. This may be true, but it is hard to believe that he would have chosen to spend his life manipulating glass tubes and Leyden jars in preference to managing men. There is given a very accurate and interesting account of the state of the science of electricity before Franklin, and a complete survey of Franklin's own work in the subject.

Then follows the text of those parts of Franklin's writings which have been selected by the editor to exhibit Franklin's discoveries in electricity, and a few letters on other subjects which show his scientific methods. An appendix contains some account of the work of Franklin's collaborators, particularly that of his friend and follower, Ebenezer Kinnersley: also an amusing anonymous letter addressed to Franklin in 1777, "in which his pretensions to the title of NATURAL PHILOSOPHER are considered." The critic chiefly objects that Franklin does not employ the methods of Sir Isaac Newton.

The book is beautifully printed at the Harvard University Press, and reflects great credit on its editor and publisher.

W. F. MAGIE

PRINCETON, N. J.

SPECIAL ARTICLES

THE EXTRACTION OF BIOTIN FROM TISSUES

THE interest in biotin and the biotin content of tissues has been great in recent months, partly because of the possible relationship of this substance to malignancy.[1,2,3]

The first determinations of the biotin content of various tissues and materials were made simply by studying the content of the hot water extracts.[4] Subsequently the freeing of relatively large amounts of additional biotin by the autolysis, for example, of liver tissue was observed.[5,6]

In an earlier publication[7] and in a recent bulletin[8] from this laboratory the biotin content of tissue autolysates was investigated, supplemented in the latter case by a few separate determinations on acid hydrolyzed specimens. The treatment used in these latter determinations is now recognized to be inadequate.

The purpose of this report is to bring together and to extend some of the observations made in this laboratory with regard to the question of different natural combinations in which biotin appears to exist.

Six methods of extraction were first investigated on eight tissues. The methods of extraction were (1) cold water (15 minutes), (2) hot water (100° C. 15 minutes), (3) autolysis (24 hours at 37° C. under benzene), (4) acid hydrolysis (6N H_2SO_4, autoclaved 1 hour at 15 lbs. pressure), (5) enzymatic digestion (1 per cent. "clarase" plus 1 per cent. "caroid," figured on the basis of the moist tissue, for 24 hours at 37° under benzene), and (6) enzymatic digestion for 48 hours, otherwise identical to (5). The tissues extracted were egg yolk, dialyzed egg yolk, dialyzed egg white saturated with biotin (avidin-biotin complex), rat liver, rat muscle, rat brain, *Pseudomonas fluorescens* cells, and *Clostridium butylicum* cells. After extraction the solids were removed by filtration through a thin mat of kieselguhr and the biotin content of the extracts determined by the method of Snell, *et al.*[5] The results are shown in Table I.

TABLE I

BIOTIN YIELDS BY DIFFERENT TREATMENTS (γ/GM. DRY WT.)

	Cold water	Hot water	Autolysis	Acid hydrolysis	24 hr. enzyme	48 hr. enzyme
Clostridium butylicum	.00048	.00098	.0046	.52	.62	.69
Pseudomonas fluorescens	.041	.068	.130	2.70	.77	1.19
Egg yolk	.018	.081	.088*	.41	.32*	.33*
Egg yolk, dialyzed	.029	.41	.27*	.50	.36*	.48*
Egg white-biotin, dialyzed	.16	4.90	.21†	8.10	.17†	.17†
Rat liver	.028	.056	.53	2.30	2.00	3.10
Rat brain	.0033	.0077	.0058	.27	.14	.22
Rat muscle	.0050	.0098	.0036	.11	.061	.098

* Heat sterilization was used in these and other cases not indicated.

† No heat sterilization was used in these cases.

It will be noted that acid hydrolysis under the conditions employed freed the maximum amount of biotin except in two cases in which enzymatic treatment yielded up to 35 per cent. more. Longer digestion with acid increases the yield (see Table II). If we consider the largest amount freed as the total amount present, the proportion freed by autolysis varies from 0.7 per cent. in the case of *Clostridium butylicum* up to 18 per cent. for rat liver. It is interesting that the *clostridium,* which is unable to synthesize

[1] P. M. West and W. H. Woglom, SCIENCE, 93: 525, 1941.

[2] W. L. Laurence, SCIENCE, 94: 88, 1941.

[3] V. du Vigneaud, Symposium on Vitamins, Chicago, September, 1941.

[4] F. Kögl and W. van Hasselt, *Zeits. physiol. chem.*, 243: 189, 1936.

[5] E. E. Snell, R. E. Eakin and R. J. Williams, *Jour. Amer. Chem. Soc.*, 62: 175, 1940.

[6] György and coworkers found "vitamin H" freed by autolysis of yeast but not of liver. *J. Biol. Chem.*, 131: 733 and 745, 1939.

[7] R. E. Eakin, W. A. McKinley and R. J. Williams, SCIENCE, 92: 224, 1940.

[8] The University of Texas Publication, No. 4137, 1941.