SCIENCE

VOL. 88 — FRIDAY, NOVEMBER 18, 1938 — No. 2290

SCIENCE: A Weekly Journal devoted to the Advancement of Science, edited by J. MCKEEN CATTELL and published every Friday by

THE SCIENCE PRESS

New York City: Grand Central Terminal
Lancaster, Pa. — Garrison, N. Y.

Annual Subscription, $6.00 — Single Copies, 15 Cts.

SCIENCE is the official organ of the American Association for the Advancement of Science. Information regarding membership in the Association may be secured from the office of the permanent secretary in the Smithsonian Institution Building, Washington, D. C.

FIFTY YEARS OF AMERICAN MATHEMATICS[1]

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IT is indeed a great honor to participate in this semi-centennial celebration of the founding of the New York Mathematical Society in 1888, which became in 1894 the American Mathematical Society. As one of the speakers I have set myself the challenging task of tracing our mathematical development under the auspices of the society during the years which have passed. Obviously in such a *coup d'oeil* only the principal factors involved can be alluded to, and the point of view adopted must necessarily be more or less personal.

At the very outset it is well to recall the general mathematical background of our country at the time when the society came into existence. In colonial days scientific and mathematical knowledge had a certain definite standing, largely for its practical value but in part also for its own sake. George Washington was a scientifically minded gentleman farmer for much of his life, and in his youth was a skilled surveyor, familiar with trigonometry; Benjamin Franklin discovered experimentally the electrical nature of the lightning discharge, theorized concerning electricity as a fluid, and had enough mathematical interest to devise ingenious magic squares; Thomas Jefferson regarded geometry and trigonometry as "most valuable to every man," algebra and logarithms as "often of value," while he classed "conic sections, curves of the higher orders, perhaps even spherical trigonometry, algebraic operations beyond the 2d dimension, and fluxions" as a "delicious luxury"; in his later years Jefferson spent much of his time in mathematical reading, and was ever a true friend of mathematics. The interest in science and mathematics continued to be genteel and amateurish among American scholars and devotees until towards the middle of the last cen-

[1] Opening portion of an address delivered at the semi-centennial celebration of the American Mathematical Society, New York City, September, 1938.

tury, with few notable exceptions. The best mathematicians of those days looked appreciatively toward Europe without much thought of high emulation.

Then came a gradual change in the temper of the times, which led to the formation of our society. Characteristic of this change were the outstanding figures of Benjamin Peirce, of Josiah Willard Gibbs and of George William Hill. Peirce died in 1880, Gibbs in 1903 and Hill in 1913, having been fourth president of the society in the years 1894 to 1896. But it was the contagious enthusiasm of a group of young Americans, returning from mathematical studies in Europe, which proved the immediate cause of the formation of our society; and in this so important enterprise Thomas Scott Fiske, seventh president of the society, and Frank Nelson Cole, long its devoted secretary, took leading parts. The year 1888 of our beginning as a professional body devoted to the interests of research marks with precision our coming to a fitting mathematical position among the nations of the earth.

Of the three figures mentioned it was Benjamin Peirce who was by far the most influential in America as a scientific personage. I remember a talk about Peirce with his last pupil, the late Dr. Leonard Waldo, mathematical meteorologist. Waldo said that the first sight of Peirce seated behind his desk at home rendered him quite speechless. Ex-President A. Lawrence Lowell, of Harvard University, fell under Peirce's mathematical spell while an undergraduate and wrote a few years ago: "Looking back over the space of fifty years since I entered Harvard College, Benjamin Peirce still impresses me as the most massive intellect with which I have ever come into close contact, and as being the most profoundly inspiring teacher that I ever had. His personal appearance, his powerful frame and his majestic head seemed in harmony with his brain."

Benjamin Peirce's papers on "Linear Associative Algebra," announced at the first meeting of the American Association for the Advancement of Science in 1864, give him a just claim to be considered an eminent mathematician. His researches in this field were made at a time when English and American mathematicians looked upon the great invention of quaternions by W. R. Hamilton as a supreme achievement, destined to be of incalculable importance for mathematics and physics. Peirce saw more deeply into the essence of quaternions than his contemporaries, and so was able to take a higher, more abstract point of view, which was algebraic rather than geometric. However, he was much more than an algebraist, for he was well informed about some of the most significant mathematical developments of his day. His volumes, "Curves, Functions, and Forces," testify to a real interest in the function-theoretic work of Cauchy, albeit somewhat superficial in character. His large book, "Analytical Mechanics," showed that he had read and mastered the works of Hamilton, Jacobi and others in the extensive field of dynamics. In addition, he was skilled in the theory and methods of computation useful for dynamical astronomy, and spent a considerable amount of time during later years in a somewhat unhappy attempt to show that Leverrier and Adams had no adequate basis for the calculations leading to the celebrated discovery of the planet Neptune; one naturally calls to mind the calculations by the eminent astronomer, the late Percival Lowell (brother of A. Lawrence Lowell), which brought about the discovery of the small planet Pluto in 1930, since these calculations have also been occasionally criticized for similar reasons.

Despite Peirce's remarkable ability to inspire especially capable and advanced students, he was not regarded as a good teacher for the rank and file; a characteristic feature of his lectures was a reaching toward seemingly endless vistas of abstract generalizations.

Josiah Willard Gibbs was a man of modest and not especially impressive personality, who did far more to advance physics and chemistry through his work on statistical mechanics and the equilibria of chemical systems than Peirce ever did for pure mathematics. Gibbs's title to be considered a mathematician rests mainly upon his largely notational contributions to vector analysis, a subject also closely related to Hamilton's quaternions. The late Maxime Bôcher, who with William Fogg Osgood really succeeded Peirce at Harvard, later attached the name of "Gibbs's phenomenon" to a fundamental fact about Fourier's series which was observed by Gibbs; this is related to the peculiar behavior of the successive curves of approximation $y = s_n(x)$ to a discontinuous function near the point of discontinuity. As has happened from time to time here and elsewhere, the fundamental contribution of Gibbs's physical work was first recognized by admirers in other countries, in particular by James Clerk Maxwell, so that it was only somewhat tardily, by reflected light as it were, that Gibbs came to be properly appreciated in the United States.

George William Hill was a scientific figure of altogether unconventional type who spent more than three decades of his life as an assistant in the Nautical Almanac office in Washington and then went back to the place of his birth, West Nyack, N. Y., to continue his researches.[2] Hill, like Gibbs, never married. His life was devoted to what were essentially mathematical studies of the solutions of the three-body problem use-

[2] Professor R. C. Archibald has informed me that Hill lived in Washington only for ten years.

ful to the lunar theory and in making specific astronomical computations. His work on periodic motions was the worthy forerunner and inspiration of the splendid theoretical advances of Henri Poincaré in celestial mechanics, who thus owed much to Hill's achievements. The free introduction of infinite determinants by Hill in his celebrated papers on the restricted problem of three bodies was especially noteworthy, although it is only recently that this interesting analytic instrument has been perfected.

Of these men, Hill would be claimed for themselves by the theoretical astronomers, along with Nathaniel Bowditch, translator and commentator of Laplace's "Mécanique Céleste," and Simon Newcomb, great perfecter of lunar and planetary theory; while Gibbs would be justly taken by physicists and chemists for their own. Thus there remains to the mathematicians of America only Benjamin Peirce for their undisputed possession. He appears as a kind of father of pure mathematics in our country. In his deep appreciation of the elegant and abstract we may recognize a continuing characteristic of American mathematics. In his concern with its many applications there resides a virtue which we are finding it more difficult to realize, because of the trend towards professional specialization. Without doubt, however, there is a spiritual necessity upon us to-day to regain a similar breadth of outlook.

Any account, however brief, of American mathematics before 1888 must chronicle an event of the preceding decade which was of extraordinary importance not only to mathematics, but to the whole field of scholarly endeavor, namely, the foundation of the Johns Hopkins University at Baltimore in 1876. Although the Graduate Schools of Yale University (1847) and of Harvard University (1872) were in existence, nevertheless, as has been said by Dr. Abraham Flexner in his book, "Universities: American, English, German," the Johns Hopkins University was the first American institution "consciously devoted to the pursuit of knowledge, the solution of problems, the critical appreciation of achievement, and the training of men at a really high level." Thus there was called to the new mathematical department at Baltimore the great English algebraist, James Joseph Sylvester, who remained there until 1884. Under the direction of the department there began in 1878 the *American Journal of Mathematics,* our first journal given over to mathematical research, and now completing its sixtieth year of high achievement. Ever since, there has continued to be at Baltimore, despite material limitations, an important center of mathematical activity, of which the staunch and kindly remembered British geometer, Frank Morley, was the titular leader from 1900 to 1928.

In all previous mathematical history perhaps no mathematical development in any country has been so extensive and rapid as that which ensued here upon the founding of the society. All the great nations of Europe had produced illustrious mathematicians of whom they had the right to be extremely proud. The French and German mathematical traditions were particularly well established and of incomparable brilliancy, represented at that moment by Henri Poincaré, the young David Hilbert and a number of other figures of very high rank. Italy and the Scandinavian countries were also flourishing vigorously. Yet up to that time there had scarcely arisen any occasion for European mathematicians to note the work of their American colleagues. A solitary exception was the early recognition of Hill's lunar theory by Poincaré, while the algebraic advances of Peirce failed to receive the attention which they deserved.

But now able young mathematicians, fresh from studies abroad, began to carry on vigorous and independent research at home, and their contagious enthusiasm soon aroused a deep interest in the younger men around them. Almost over night, as it were, the great University of Chicago sprang into existence in 1892, with a mathematical department made up of Eliakim Hastings Moore, Oskar Bolza and Heinrich Maschke from Germany, and others. Of these men, only Bolza is living to-day. They formed a notable and inspiring group which will ever be remembered in our mathematical annals. At about the same time Osgood and Bôcher, inspired by their German sojourn and in particular by the great Felix Klein of Göttingen, bent their every effort to strengthen the tradition at Harvard. Under the genial leadership of Moore at Chicago, who had studied with Gibbs at Yale University and for a year in Berlin, there was emphasized the abstract and algebraic side of mathematics, although Moore was remarkably catholic in his outlook. At Harvard attention was turned towards the vast field of analysis. The center in Cambridge was much strengthened by the transference of the Massachusetts Institute of Technology from Boston across the Charles River in 1916. Its mathematical group and that at Harvard University have been in close and mutually stimulating association since that date.

A few years later, under the wise and benevolent guidance of Dean Henry Burchard Fine, who had been strongly influenced by his studies under Leopold Kronecker, promising young men were called to the mathematical staff at Princeton, in particular L. P. Eisenhart, Oswald Veblen and J. H. M. Wedderburn. From that day forth there has always been an important mathematical group at Princeton. There came a notable further impetus with the founding there in 1930 of the Institute for Advanced Study, with Abraham Flexner as director. At the outset the new institute devoted its attention to the fields of mathematics and theoretical physics, calling at first Albert Einstein, Veblen and Hermann Weyl to ideal research posts. Up to the present time the mathematical staff of the institute has worked side by side with the staff of the university in Fine Memorial Hall. The others at the institute have in general already obtained their doctor's degree and come to enjoy a period of uninterrupted study and research under favorable conditions. The institute is fortunately able not only to augment its staff through distinguished temporary appointments, but also to give partial financial support to many of those who come to study.

By great good fortune I have been intimately associated with the centers at Chicago, Harvard and Princeton. I feel deeply indebted to them all. Indeed, there are not many American mathematicians who have not been profoundly influenced by one or another of these three groups. It was in the spring of 1902 that I made a first journey across the city of Chicago to the university, and found my way into the excellent mathematical library in Ryerson Physical Laboratory; before that time I had only been in contact with the mathematical books of the John Crerar Library and the small mathematical collection at Lewis Institute. I remember the thrill which the sight of the well-filled shelves gave me. Soon I met Professor Moore, of whom I had already heard, and found him then and always extraordinarily inspiring, suggestive and kind. During my first (junior) year at the university I profited much from my contact with Bolza also. At his suggestion I read the work of Gauss on the cyclotomic equation and the equally celebrated paper of Abel on the impossibility of solving the general quintic by radicals. Bolza's lectures were marvels of clarity and finish. But it was Moore above all who seemed to me to have the true fire of genius within him.

The year following I went to Harvard, with Moore's approval, for two years of study. There I learned more analysis, particularly from Osgood and Bôcher. I found Bocher's lectures the equal of Bolza's in lucidity and superior in placing important points in high relief. It was only later, however, that I came to realize how much I owed to Bôcher for his suggestions, for his remarkable critical insight and for his unfailing interest in the often crude mathematical ideas which I presented.

On my return to Chicago in the fall of 1905, I profited greatly by two further years of work with Moore, both in his seminar on analysis and outside the classroom. Moore was a deep admirer of Hilbert and was then following closely the rapid developments at Göttingen, attendant upon Fredholm's fundamental work in linear integral equations of 1900. It happened that I saw Moore's program of General Analysis taking shape day by day, as he came to appreciate the full abstract significance of the papers of Hilbert and the beautiful dissertation of Erhard Schmidt.

In 1907 I started teaching at the University of Wisconsin, and in my two years there I especially valued my scientific and personal relationship with my senior colleague, Edward Burr Van Vleck, whose distinguished son is now at Harvard as a member of the departments of physics and mathematics.

It was in the fall of 1909 that I became a member of the staff at Princeton. The presence of Veblen, nearly of my own age, with large ideas for American mathematics in general and for the Princeton Department in particular, meant much to me during my three years there. Veblen was then completing his important "Projective Geometry," volume 1, written in collaboration with J. W. Young, whom many will remember kindly. It was my privilege to read the book in page proof and to learn of Veblen's geometric program and ideas directly from him in our frequent walks and talks together.

I have recounted these personal circumstances only because I know that in their essence they are not very dissimilar to those of many American mathematicians.

In selecting Chicago, Cambridge and Princeton for especial reference I have realized fully that American mathematics reaches overwhelmingly beyond what is to be found in any three or even in any ten centers. And yet I think it is a comforting thought for American mathematicians everywhere to know that there are centers like these where scholarly conditions have been uniformly good and where high ideals have been steadily maintained. Such places, by their influence and example, support and stimulate mathematical scholarship and achievement throughout the whole of our country.

Concerning the other mathematical centers suffice it to say that there are now about thirty institutions where the advanced student of mathematics may go with advantage to study for the doctorate, while only fifty years ago he was forced to go to Europe to secure adequate training! Among the privately endowed institutions may be mentioned Brown, Bryn Mawr, California Institute of Technology, Chicago, Cincinnati, Columbia, Cornell, Duke, Harvard, Institute for Advanced Study, Johns Hopkins, Leland Stanford, Massachusetts Institute of Technology, Notre Dame, Princeton, Rice Institute and Yale; and among our state universities, California (at Berkeley and at Los Angeles), Illinois, Iowa, Michigan, Minnesota, Ohio State, Pennsylvania, Texas, Virginia and Wisconsin; and in Canada, the University of Toronto. The number of such centers should increase still further. All that is required in many cases is that mathematicians in a position of influence take the proper steps. As instances in point, I would cite what was done by Fine at Princeton and by Harris Hancock at Cincinnati.

The extraordinary contrast between 1888 and 1938 is equally manifested by the fact that fifty years ago there was a mere handful of competent mathematicians in the country, whereas there is now a body of over two thousand American members of our society. Among these, between one and two hundred have gone far beyond a doctoral dissertation to make important additions to mathematical knowledge, and some forty or fifty are highly creative with established international reputations. Later on I shall have occasion to refer to a number of these mathematicians and their specific contributions.

For the moment, however, I should like to direct attention to two interesting and important special groups. The first is made up of mathematicians who have shown the rare quality of leadership, of which Moore was an outstanding instance. Among the earlier of these I would mention the late eccentric geometer, George Bruce Halsted, who attracted to mathematics two notable figures, L. E. Dickson and R. L. Moore, both of whom in their turn have been able to exert a large personal influence. I would also mention with high esteem James Pierpont, who for many years was a source of inspiration at Yale. Among the other and younger men, besides Dickson, R. L. Moore and Veblen, the names of G. A. Bliss, G. C. Evans, Solomon Lefschetz, Marston Morse, J. F. Ritt, M. H. Stone and Norbert Wiener come to mind as having shown the same quality to an exceptional degree.

The second special group to which I wish to refer is made up of mathematicians who have come here from Europe in the last twenty years, largely on account of various adverse conditions. This influx has recently been large, and we have gained very much by it. Nearly all the newcomers have been men of high ability, and some of them would have been justly reckoned as among the greatest mathematicians of Europe. A partial list of such men is indeed impressive: Emil Artin, Solomon Bochner, Richard Courant, T. H. Gronwall, Einar Hille, E. R. van Kampen, Hans Lewy, Karl Menger, John von Neumann, Oystein Ore, H. A. Rademacher, Tibor Radó, J. A. Shohat, D. J. Struik, Otto Szász, Gabor Szegö, J. D. Tamarkin, J. V. Uspensky, Hermann Weyl, A. N. Whitehead, Aurel Wintner, Oscar Zariski.

With this eminent group among us, there inevitably arises a sense of increased duty toward our own promising younger American mathematicians. In fact, most of the newcomers hold research positions, sometimes with modest stipend, but nevertheless with ample opportunity for their own investigations, and not burdened with the usual heavy round of teaching duties. In this way the number of similar positions available for young American mathematicians is certain to be lessened, with the attendant probability that some of them will be forced to become "hewers of wood and drawers of water." I believe we have reached a point of saturation, where we must definitely avoid this danger.

It should be added, however, that the very situation just alluded to has accentuated a factor which has been working to the advantage of our general mathematical situation. Far-seeing university and college presidents, desirous of improving the intellectual status of the institutions which they serve, conclude that a highly practical thing to do is to strengthen their mathematical staffs. For, in doing so, no extraordinary laboratory or library expenses are incurred; furthermore, the subject of mathematics is in a state of continual creative growth, ever more important to engineer, scientist and philosopher alike; and excellent mathematicians from here and abroad are within financial reach.

Having thus glanced at our mathematical firmament which shines so brightly to-day, let us turn to survey briefly the general situation in our country which has made it possible. In the year 1888 there were probably about two hundred thousand students in our high schools and preparatory schools; to-day there are between five and six millions. This enormous increase is a consequence of the unquestioning belief in higher education which pervades our country. At the same time our colleges, universities and advanced technical schools have increased correspondingly in numbers and resources. There are to-day nearly a thousand such institutions scattered throughout our land, serving well over a million students, with a total physical plant staggering the imagination and representing billions of dollars of endowment. Probably the majority of these institutions struggle along under financial as well as educational difficulties, although rendering distinct service. But when all is said and done, there remain some two hundred and fifty of them which meet the exacting requirements of approval by the Association of American Universities.

As far as the mathematical side of this vast American enterprise of higher education is concerned, its magnitude is probably best appreciated by means of a different approach. The American Mathematical Society has a membership of over two thousand persons, the great majority of whom hold positions in our institutions of learning. Our highly esteemed sister organization, the Mathematical Association of America, devoted primarily to the interests of collegiate mathematics, has nearly twenty-five hundred members.

The conclusion then is plain. There must be between two and three thousand mathematical teaching positions in our higher institutions, with an average salary which must certainly lie between two to three thousand dollars. We see in this way that there is probably a sum of about six millions of dollars which goes each year to the support of higher mathematics!

Since the great war salaries have been increased and the teaching burden has been reduced, at least in the better institutions. I remember talking some twenty years ago with the late J. C. Fields, of Toronto, about the status of professors throughout the world; it will be recalled that Fields did more than any one else to bring about the important International Mathematical Congress held at Toronto in 1924. He told me that, after making a special study of the facts, he had come to the conclusion that the American professor was the worst treated of all! At that time there was much in his contention, even though there were already in existence a number of American professorial chairs where the salary was good and the teaching duties not excessive. To-day there are many such positions. In this connection it may be well to mention the fact that Harvard University has been able to reduce the amount of teaching and tutorial routine of the regular mathematical staff to six hours a week, of which only three hours are devoted to more or less elementary mathematical instruction. Such a schedule gives to all concerned a notable opportunity to carry on mathematical research, and would be socially unjustifiable unless the highest standards of achievement were being maintained. Although such ideal conditions are impracticable at present except in a few fortunate institutions, it should be strongly emphasized that twelve hours of instruction a week (including at least one course of advanced grade) is about all that can be required if the best standards of scholarship are expected. Indeed, wherever possible, the hours of instruction should be reduced to not more than nine, and if there are heavy outside duties there should be a compensating diminution in teaching.

But the situation has very definitely a complementary aspect. On our part there is an unescapable, deep responsibility to the nation which, somewhat unwittingly perhaps, has afforded us such splendid support. It is our duty to take an active and thoughtful part in the elementary mathematical instruction of our colleges, universities and technical schools, as well as to participate in the higher phases. To these tasks we must bring a broad mathematical point of view and a fine enthusiasm. In so far as possible we must actively continue as competent scholars and research workers. Only by so doing can we play our proper part.

It is interesting to note that the other material accessories useful for our extensive mathematical edifice have also been provided. With our *Bulletin* and *Transactions,* with the *American Journal of Mathematics,* all under society auspices, and with the *Annals of Mathematics,* the *Duke Mathematical Journal,* the *Journal of Mathematics and Physics* and the *American Mathematical Monthly,* we possess excellent facilities for the publication of original articles in periodicals. Aside from the *Journal of Mathematics and Physics* there is as yet no journal directed towards applied mathematics. More extensive publication in book form is afforded by our Colloquium Publications, and a similar new series in contemplation by the Institute for Advanced Study. For the prompt publication of short articles there is available the Proceedings of the National Academy of Sciences. There are in addition certain facilities to be found in the annual publications of learned societies (such as the American Academy of Arts and Sciences) and of higher institutions of learning (such as the Rice Institute Pamphlets), etc. Thus far, however, the commercial publishing houses of the country have not contributed much towards the publication of important advanced mathematical texts. In this respect they suffer by comparison with progressive European publishers, who take pride in the publication of significant mathematical books. The University Presses of the country have partly made up for this lack.

In addition to our regular meetings, the Colloquium Lectures, the annual Gibbs Lecture and the Visiting Lectures of the society provide important means for direct scientific interchanges among mathematicians. The coming International Congress of Mathematicians to be held at Cambridge in September, 1940, will present still other opportunities of this kind. In fact, the facilities for mathematicians to meet intimately with their colleagues at sister institutions are increasing constantly. The importance of such facilities in speeding up mathematical progress has long been recognized in European mathematical centers.

Then there is always the arduous administrative work of the society, carried on unselfishly by its officers and especially by its present secretary, Dean R. G. D. Richardson, true successor of Frank Nelson Cole. The way in which this work has been carefully and devotedly done without any paid officer has helped to unite the society more than anything else.

All in all, then, our American mathematical situation is about as favorable as can be hoped for on this very troubled planet. Our one real danger perhaps concerns the general standard of achievement. It is not enough for those who go into the rank and file of our colleges to devote themselves to a useful academic routine; they have a duty to live up to their highest mathematical potentialities and to awaken a deep mathematical interest in their students. It is not enough for the exceptional man, whose early work has led to a professional recognition, to take thenceforth an easy-going attitude; such a man should continue with the devotion of a leader in a great cause. Furthermore, we ought all to provide our share of first-rate elementary teaching, by which we justify our privileged positions in immediate practical terms. If we do these things, mathematics in America will rise to still greater heights and there will appear among us mathematical figures comparable to the greatest in the past.

OBITUARY

GUY N. COLLINS

GUY N. COLLINS, Principal Botanist in the Division of Cereal Crops and Diseases of the Bureau of Plant Industry in the U. S. Department of Agriculture, died on August 14, 1938, of endocarditis at his home at Lanham, Maryland. Mr. Collins was born at Mertensia, N. Y., on August 9, 1872. He attended Syracuse University, but terminated his college career as an undergraduate in 1895 to join a survey expedition to Liberia organized by Dr. O. F. Cook for the New York Colonization Society. While in Africa he indulged his interest and perfected his skill in photography with the result that all his travels and most of his work are photographically recorded. Pursuing this interest he later designed and patented the Naturalist's Camera, which made it possible for the first time expeditiously to photograph objects natural size in the field.

His plates of fresh specimens of fruits, flowers and sections of plants, reproduced full size, did much to stimulate this method of recording.

Following the vicissitudes of life in the tropical rain forests of the West Coast of Africa, in the days before the discovery of the relation of mosquitoes to malaria and yellow fever, he returned to the United States and spent a few months (in 1898) as a free lance botanical collector on the Florida Keys.

Shortly after the close of the Spanish-American War he joined the staff of the Office of Botanical Investigations in the U. S. Department of Agriculture as Assistant Botanist, and in company with Dr. O. F. Cook explored the newly acquired island of Puerto Rico. Their expedition resulted in the publication by the Smithsonian Institution of the still standard treatise entitled "Economic Plants of Porto Rico." At this time also Mr. Collins wrote "The Mango in Porto Rico," probably the handsomest bulletin ever issued by the Bureau of Plant Industry.

Returning from Puerto Rico he entered the Seed Laboratory of the Division of Botany and there devised much of the apparatus used for subdividing large lots of seeds into samples for germination and purity tests. He never lost interest in the statistical problems of seed testing and the means for determining the probable quality of a large lot of seed from the analysis of small subsamples. This interest was manifested many years later by the publication of a paper on "The Application of Statistical Methods to Seed Testing."

In 1901 he published the bulletin "Seeds of Commercial Salt Bushes." In this undertaking full use was made of his skill in photography, and the plates of seeds in that bulletin have never been equalled in excellence of detail.

Many expeditions to the American Tropics followed his trip to Puerto Rico, and from one of these came the introduction of the Guatemalan "hard-shelled" avocado, which has been utilized extensively in developing the commercial varieties of this fruit grown in Florida.

While on another of these expeditions to Southern Mexico, accompanied by C. B. Doyle, he collected at Acala the variety of cotton now grown extensively under that name in the Southwest. This variety is known for its superlative qualities and far exceeds in merit any other cotton of the Upland type.

On all these expeditions to the American Tropics Mr. Collins lived on and close to Indian corn, and it is not surprising that the diversity of this magnificent grass captured his fancy. Soon his own garden at Lanham was crowded with a collection of tropical maize, and he was not slow to recognize the usefulness of this plant in testing and extending Mendel's rediscovered laws of inheritance.

His first contribution to the literature of maize was printed in 1909, at which time he was Assistant Botanist in the Office of Bionomic Investigations of Tropical and Subtropical Plants in the Bureau of Plant Industry. From that time on, though his official title and administrative position went through many changes, his time was devoted to a study of inheritance in maize and to the application to that study of biometrical methods, without which, he was convinced, no adequate conclusions could be reached. The numerous papers on inheritance in maize, published chiefly by the U. S. Department of Agriculture, constitute a permanent record of his achievements in research.

Mr. Collins was among that early group of investigators whose work provided the foundation on which rests the present popular system of producing commercial corn crops from hybrid seed. However, his interest in the commercial utilization of hybrid seed was