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# Hybrid Seed Corn

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IT IS NOW 41 YEARS SINCE I BEGAN the studies of variation in maize as affected by inbreeding, which led me to propose the procedure in corn production that is now generally known as "hybrid corn." My own name for the method was "a pure-line method of corn breeding," and my paper published under this title was read before the American Breeders Association in Columbia, Missouri, slightly more than 37 years ago. I grew my last experimental crop of corn in 1916, 30 years ago.

These facts illustrate well a frequent historical phenomenon, namely, the long interval which may elapse between the making of a fundamental discovery and the general understanding of its importance and full realization of its benefits.

The most notable example of this phenomenon is seen in the discovery and rediscovery of the Mendelian principles of heredity. The chief difference between the history of Mendelism and that of hybrid corn is that within the interval of 35 years between discovery and rediscovery Gregor Mendel died, mindful of the importance of the discoveries he had made, but wholly unaware that 16 years after his death he would receive the recognition that was his due. I have the comfortable distinction of having outlived the interval between discovery and rediscovery, and I now have the satisfaction of knowing that the results of my work will continue to benefit mankind for all time.

In thus expressing my happiness in the thought that my work has been of permanent value, I want you to know that I am fully mindful of the fact that I am only one of many who have made crucial contributions to the benefits that hybrid corn is now giving and will give more and more abundantly with the passing of the years. This award belongs, in reality, to the whole field of workers who have, each in his own way, helped to bring the hybrid corn program with truly amazing speed so far on its way to full fruition.

In all humility I admit that, regardless of any merit my own work may have to my contemporaries, there would be no hybrid corn now had there been no one else with vision, courage, enterprise, and persistence to carry on from where I left off in 1916. I like especially to think of Edward Murray East, Henry A. Wallace, Donald F. Jones, F. D. Richey, Merle T. Jenkins, W. Ralph Singleton, and many other workers at the Agricultural Experiment Stations, as well as at least a dozen great commercial companies which are now producing the major part of the many millions of bushels of hybridized seed-corn required by American farmers each year.

Some seven years ago at the annual dinner of the American Society of Naturalists held in New York City, I sat between Dr. Ivey F. Lewis, of the University of Virginia, who was then president of the Society, and Dr. William J. Robbins, the newly-appointed director of the New York Botanical Garden.

*The John Scott Medal Fund* derives from a gift of John Scott, chemist, St. Patrick's Square, Edinburgh, Scotland, to the city of Philadelphia in 1816. The original amount of the bequest was $4,000, and by 1917 the principal sum had grown to $100,000, whereupon court action was taken to increase the amount of annual awards from the original stipulated value of $20. Almost 500 awards have been made in the 130 years that the fund has been in existence. Between 1920 and 1945 ninety-five awards have been made under the sponsorship of the advisory committee which is at present composed of: Arthur H. Compton, Edwin G. Conklin, Harry L. Frevert, J. F. Metten, Thomas A. Shallow, Harlow Shapley, J. E. Shrader, Philip C. Staples, Harold C. Urey, S. M. Swaab (secretary), and Ernest T. Trigg (chairman).

In 1945 there were several recipients, among whom Dr. George H. Shull, the originator of hybrid corn, was one.

Dr. Robbins opened conversation by asking me why I stopped working with corn, and my answer was that I had completed my part of the program. I had discovered the basic principles, had formulated them in 12 succinct statements, had invented a method of procedure, and had pointed out the important advantages the proposed program offered to agricultural practice—the assurance of greater yields and greater uniformity, sharper specialization to fit different regions, different climates, different soils, and the production of strains having to a superlative degree any desired chemical content or any other desired qualities. I had recognized for the first time in the history of science, I believe, the reciprocal relation between the deterioration due to inbreeding and the increased vigor due to crossing as the two aspects of a single phenomenon.

In an invitation lecture delivered at Göttingen, Germany, in July 1914, I had urged practical breeders of both plants and animals to make conscious use of hybrid vigor as a theretofore unrecognized source of economic gains. In that lecture I had proposed the word "heterosis" for the stimulating effect of the union of unlike germ cells—a word which has now been widely accepted in genetical textbooks. I had specifically urged the Agricultural Experiment Stations in the corn belt states to work out the problems necessary for the utilization of these principles and methods in practical corn production, pointing out that such problems of practical application lay outside the field of my own responsibility as staff member of the Station for Experimental Evolution, a laboratory established by the Carnegie Institution of Washington for research in basic biological science.

The solution of these practical problems came from two important and unanticipated innovations: Dr. Donald F. Jones, of the Connecticut Agricultural Experiment Station, proposed the double cross, and Henry A. Wallace formed the Pioneer Hi-Bred Corn Company to produce and sell to the farmers the hybridized seed corn. Both of these steps were absolutely essential to the success which has come to hybrid corn.

## The Meaning of "Hybrid Corn"

I would like to explain now as briefly as I can just what we mean by hybrid corn, for in this expression we are using the word "hybrid" in a very special sense. Nearly everyone I meet these days has heard of hybrid corn, but it is infrequently that I find one who knows just what it is that makes it "hybrid corn." Earlier biologists and laymen generally used the word "hybrid" to mean the offspring from the mating of two parents belonging to different species, as, for example, in the universally known case of the mule produced by mating a mare to a jackass. In modern genetics the meaning of the word "hybrid" has been extended to all cases in which the parents differ in one or more hereditary traits. The result is that hybrids which were in the old sense relatively rare occurrences have come to be in the new genetical sense of almost universal occurrence in cross-breeding organisms. Only under systems of self-fertilization of hermaphroditic plants and animals do we find hybrids rare or nonexistent.

Although corn is a hermaphroditic plant, it self-fertilizes naturally only occasionally. The tassel at the top of the stem consists of the male flowers, which shed their pollen only when they are shaken by the wind. This pollen is so light that the slightest breeze will carry it away from the plant on which it is formed, thus making it mechanically difficult for the silks, or female flowers located about midway of the stem, to receive the plant's own pollen. This ensures that practically every plant in a field of corn as ordinarily grown is a hybrid in the modern genetical sense. This was the first basic fact that I discovered about corn, and it provided the subject matter for my first corn paper, "The composition of a field of maize," which I read before the American Breeders Association in Washington, D. C., in January 1908, and which was published later the same year in the yearbook of the Association. Keeping in mind this demonstration that practically every corn plant is a hybrid—what can we mean by the term "hybrid" corn that will differentiate it from the natural hybrids in the ordinary field? The distinctive feature of "hybrid corn," as the term is now generally used, lies in the fact that the *promiscuous* hybridization of the ordinary field of corn is replaced by *completely controlled* hybridization in the production of the hybridized seed corn from which the modern so-called "hybrid corn" is grown.

## Economic Importance of Hybridizing

The manner in which this control is established is very simple. Self-fertilization of the individuals in a hybrid progeny results, in the course of a few generations, in analyzing that hybrid into a group of pure lines which together may possess all of the hereditary elements present in the hybrid with which the self-fertilizations were initiated. If this original hybrid was very complex, each individual pure line derived from it may be unique in possessing a combination of hereditary elements different from that which characterizes each other pure line of the same derivation. When this stage of "purity" has been established by repeated self-fertilizations, we have in hand the elements for the production of various kinds of hybrid corn. Each kind of hybrid corn is produced

by the definite combination of two, three, or four of these pure lines. Each given combination results in a hybrid which may then be compared with the hybrids produced by other definite combinations, and it is found by this comparison that some of these hybrids are superior in yield and/or desired qualities. When such a superior hybrid has been found, it can be maintained and perpetuated year after year in only one way, namely, by keeping the appropriate pure-bred strains (pure lines) carefully self-fertilized every year and by repeating the same combination of pure lines every year. These tedious and relatively expensive processes must be carried out with meticulous care and are too complicated to be handled by the ordinary farmer. For this reason the successful fruition of the hybrid corn program had to await the establishment of a new industry, that of the commercial corn hybridizers, led by the pioneering work of Henry A. Wallace in the establishment of his Pioneer Hi-Bred Corn Company. When the farmer wants to duplicate the splendid results he has had one year with hybrid corn, his only recourse is to return to the same hybridizer from whom he secured his seed the previous year and obtain again the same hybrid combination. He must pay twice as much for his seed corn than he was accustomed to pay for the best selected seed corn before hybrids became available, but this expensive seed corn adds only about $.50 to $.75 per acre to the former cost, and from the investment of this added $.50 to $.75 he increases his yield from that acre by about 25 per cent.

The hybrid seed industry has grown by leaps and bounds. Wallace's company now grosses more than $1,000,000 annually, and several still larger companies are approaching, if they have not already passed, a $10,000,000 annual turnover.

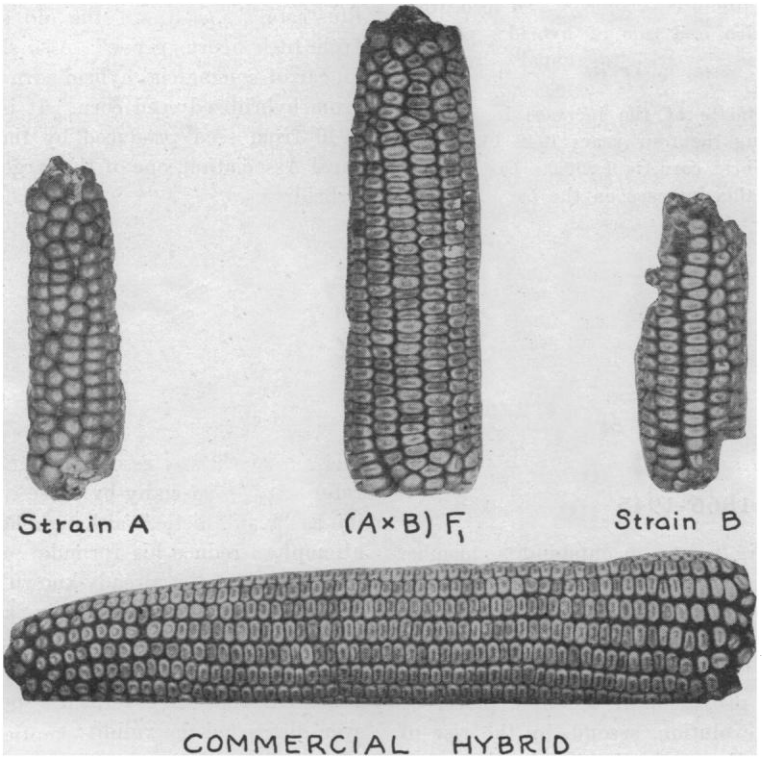


FIG. 1

### MONEY VALUE OF HYBRIDIZING

The increase of 25 per cent on a crop amounting to $3,000,000,000 annually so far transcends our powers of comprehension that I prefer to make no statement of my own on the magnitude of the contribution which has resulted from the use of the new methods, lest I seem to be exaggerating. Instead, let me quote a recent authoritative statement made by Dr. Louis J. Stadler, of the University of Missouri, testifying before a subcommittee of the Committee on Military Affairs, of the U. S. Senate on the subject of Science Legislation. Dr. Stadler said in part:

We know from the crop estimates of the United States

Department of Agriculture what fraction of the corn planted in each county was planted from hybrid seed, and we know from numerous and widely distributed field experiments the comparative performance of different strains of corn when grown side by side under identical conditions. In these experiments adapted hybrids consistently outyield the varieties of corn formerly grown, with an average margin of over 25 per cent.

This is an increase in yield which costs nothing except the added cost of producing the special type of seed and the added cost of harvesting a larger crop. In practice the seed is commonly produced by specialized seed growers, and the production and sale of hybrid seed corn has now become an industry with an annual turnover of about $75,000,000.

A conservative estimate of the increase in national corn production during the four years 1942–45, due to the partial use of hybrid corn, is 1,800,000,000 bushels. The money value of this increase on the basis of farm price per bushel is more than $2,000,000,000.

It is, therefore, no exaggeration to say, speaking in terms of the over-all national economy, that the dividend on our research investment in hybrid corn, during the war years alone, was enough to pay the money cost of the development of the atomic bomb.

Fig. 1 shows three ears of corn from my experimental crop of 1912, one ear each from my purebred strains, designated in my papers as Strains A and B and the hybrid produced by crossing A with B. These illustrate the truth of the old saying: "Great oaks from little acorns grow." Also shown in the figure is an ear of commercial hybrid corn of recent production from hybridized seed corn. It is a hybrid grown in 1940 from seed produced by the De Kalb Agricultural Association, one of the largest of the commercial hybridizers.

# *Obituary*

## Thomas Hunt Morgan

### 1866-1945

Thomas Hunt Morgan was an outstanding member of what may be called the heroic generation of American biologists—those whose work raised American biology to a position second to none among the countries of the world. This was the generation which, under the stimulus provided, in the first place, by Darwin's theory of evolution, second, by the rise of cell study in Central Europe, and third, by the sensational results of the experimental method of approach to problems of generation and development, set afoot that great series of researches in these related fields which made all general biology a really exact science, and which gave hope that ultimately the gap between it and the sciences dealing with inanimate matter could be bridged. With respect to both its versatility and the far-reaching nature of the conclusions convincingly established by a continuation of the lines of attack opened by his pioneer experiments, Morgan's work stands pre-eminent among the accomplishments of his generation.

Morgan's nature was iconoclastic: he took no stock in the pseudophilosophical mumbo jumbo rampant among many biologists even in the era immediately following Darwin, and would not let himself be overawed by the air of mystery surrounding such subjects as regeneration, embryology, heredity, and evolution. His approach was essentially of the type sometimes referred to (especially by those out of sympathy with it) as "mechanistic," although he did not commonly attempt to reduce his formulations all the way down to the level of the already-known physics and chemistry. As an ardent believer in, and practicer of, experiment, and again experiment, in whatever field, he belonged to that group which at the same time so abhorred what they termed "speculation" that they even distrusted the validity of the most essential lines of reasoning of Darwin himself, and he was a leader in that wave of skepticism whose participants "doubted the doubt till they doubted it out." Perhaps biological progress might have been even more rapid if the wheat had not been thrown away with the chaff, yet the end result of the skepticism, since it was combined with experiment and exact observation, was to lead some of this generation, and most of the next, to a vindication of the Darwinian essentials after all, and to an effective implementation of the Darwinian theory which joined it up with a scientific view of living matter in general. It is unusual to find a man who, like Morgan, is willing so to go back on his early preconceptions when the empirical facts demand it.

Starting out along morphological lines, Morgan, following Roux and Driesch, early went over to the experimental attack on problems of development, and his work helped to establish rational interpretations of such phenomena as the polarization of the frog's