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BREEDING ANIMALS AND PLANTS

BY

W. M. HAYS

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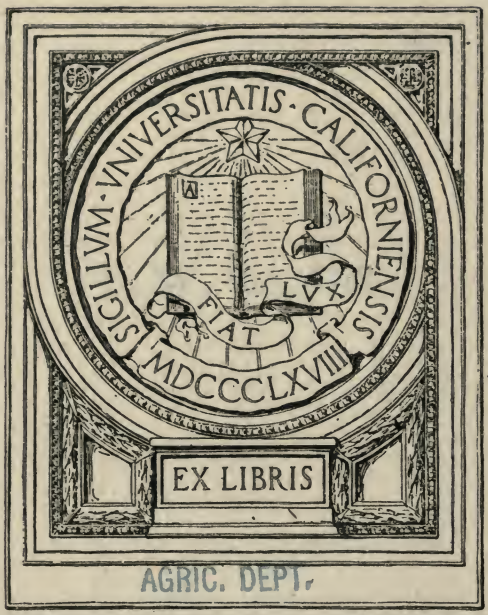
FARM STUDENTS' REVIEW



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E. W. MAJOR

BREEDING PLANTS AND ANIMALS

BY

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PUBLISHED BY

FARM STUDENTS' REVIEW

ST. ANTHONY PARK, MINN.

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INTRODUCTION.

The Farm Students' Review in publishing in book form these papers by Prof. Willet M. Hays, now Assistant Secretary of the United States Department of Agriculture, believes it is doing a public service, as well as undertaking a profitable enterprise for itself. These articles published in discontinuous parts covering two years in a weekly periodical, have not had a fair presentation even to the readers of the Breeders' Gazette. While they were not designed to be brought together in a book, but rather became a part of a rapidly developing subject currently discussed in the periodical mentioned, they give in an emphatic way many of the theories of the author. The body of knowledge he gathered—after commencing investigations in animal breeding, but using many plants for theoretical experiments, for demonstrating that the science of breeding can be developed, and for the addition to wealth of the State and Nation—is here better ex- than in any of his earlier publications. It is believed by the Farm Students' Review that breeders of animals, breeders of plants, scientists who are studying related problems, and students in agricultural schools will appreciate these papers in book form. The price has been placed low for a book of this size and character.

Address:

FARM STUDENTS' REVIEW,

St. Anthony Park, Minn.

365777

PREFACE BY THE AUTHOR.

The author of these papers, which were published in the Breeders' Gazette in 1902 and 1904, joins with the proprietor of that paper, Mr. Alvin Sanders, in giving to the Farm Students' Review the right to publish them in book form. They were not written with any thought of their republication. Some revision has been made to make clearer the text and to better adapt it to new conditions. The deferred plan of writing a contemplated text on "Breeding," covering the laws of heredity in plants, lower animals and man, and the practice of breeding, on account of present lack of time has caused a reluctant agreement to the publication of these articles. No other apology is made for the form of the articles than that they were written concurrent with publication for a periodical. Any profits which may come from publishing this book is all to accrue to the Farm Students' Review, the agricultural college paper of Minnesota, the author and the first publisher having relinquished all rights. It is hoped that the readers of these notes may realize that the purpose was to promote an interest and to arouse all to begin larger efforts to improve plants and animals, rather than to write a scientifically arranged text. And it is hoped that the enterprising college paper which has undertaken its republication may profit from its sale.

Sincerely,

W. M. HAYS.

UNIV. OF CALIFORNIA

CHAPTER I.

POSSIBILITIES IN PLANT AND ANIMAL BREEDING.

Five billion dollars' worth of plant and animal products are to be annually produced on American farms from seeds and germs which may be so improved and selected that the value of the product may be made at least five per cent. more valuable. Five per cent. of five billion is a quarter of one billion. In other words, if the American people can change the heredity of the average of their crops and domestic animals so as to increase the value of the product five per cent. the increased valuation will be $250,000,000 annually, or a billion dollars more every four years. Much increase is now actually going forward under present methods, but if by extensive effort under scientific methods of breeding an additional five per cent be realized the cost of such improvement could not be more than a very small part of the increased production. We have no just conception of the immense economic value of the occasional plant or animal which becomes the chief factor in an improved breed or variety, as Messenger's blood became the foundation of the breed of trotting horses.

No one will doubt but that five per cent. could be added to our agricultural income by better methods of farming and superior management of live stock. All agree that time spent on gaining a better knowledge of farm and stock management and a better

training in carrying out the daily routine of the business of the farm and the farm home would pay the American farmers. Our colleges of agriculture are slowly but surely converting the farmers of this country to the idea that it pays to send boys and girls who are through the rural primary schools to practical schools of agriculture for their secondary course in education. And nothing is more true than that the nation and the States can well afford to pay millions of dollars annually that our farmers may have a technical education in agriculture and country home-making and a better general training in citizenship. Money thus spent not only helps the farmer's sons and daughters who take advantage of schools of agriculture, but by increasing and cheapening the cost of farm products, and by bettering country life, all the people of the nation receive an ample return for the expenditure. The intricacies of financing, equipping, advertising and governing such institutions; of experimental research, of writing text books, and of developing laboratory facilities and teaching, on the part of teachers and other officials; and of study of text, of laboratory practice work, of examinations and of individual research on the part of students, are complex almost beyond measure. Yet the presence of these problems enables us to comprehend them and the American people seem nearly ready to establish an adequate system of agricultural education including elementary work in the consolidated rural schools, practical technology in agricultural high schools, in many cases reorganized into larger units as consolidated farm schools; and scientific technology in agricultural collegiate courses. The people have seen that this education is profitable and they propose to pay the price.

The improvement of animals and plants by breeding can likewise be proved and made to seem real. No one who will examine existing facts will doubt that five per cent. can be added to the value of our crops

and our animals by the application of science and business principles to the practical work of improving existing breeds and varieties and of forming new ones. And all who will investigate will agree that if such an achievement could be reached millions of expenditure if needed would be justified. Improvement made by breeding our crops and animals differs from improvements through education. It is not applied directly to the improvement of the individual man or woman. It is more nearly a cold business proposition, but indirectly it increases the means with which people can press civilization forward. If by spending one hundred thousand dollars in breeding plants and animals the nation can create annually millions of dollars more of wealth in corn and cattle, the added revenues would support many schools of agriculture. If by expending a hundred thousand dollars intelligently employed in studying the mere science of breeding animals and plants many millions annually of added value could be produced by those who breed animals and plants, money could thus be provided with which to educate all classes. If improvements in plants and animals can be made as cheaply as known facts show, there is hardly a form of expenditure from which the nation or State can secure such large proportionate returns as from well-directed efforts in plant and animal breeding.

A few simple results from extensive research in mechanics and electricity gave impulse to genius which resulted in the development of modern steam and electrical transportation. The goal in view in variety and breed improvement may not be so large as that represented by improved forms of transportation, but it approaches sufficiently near that any possible cost of needed research is in comparison a mere bagatelle. In mechanics the nation found in rights granted under patent laws a way of assuring remuneration for inventors of mechanical devices. Breeding is not more

difficult than invention, but plants and animals cannot well be patented, and securing remuneration for new creations in the plant and animal world is a much more difficult business proposition than securing profits from improvements in mechanics. Society, through the general government's patent law regulations, invests vast sums in new inventions, thus encouraging invention. Society, through aid to national and State experiment stations, and through assistance to co-operating agencies engaged in breeding plants and animals, and to schools where breeding is taught, can stimulate the production of improved and new varieties of plants and animals, which will make this country lead the world in improved seeds and breeding stock, as it now leads in transportation and mechanics.

The emphasis is shifting in breeding from some of the time-worn principles to others just as old, but more recently brought to the front. Broad business policies are gaining recognition where general theories held sway. Writers of the theory and science of breeding are giving way to men who make history by improving plants and animals. The current writer on breeding problems is seeking the philosophy which is actually producing the great breeds of animals and the new varieties of plants. The scientists are learning to respect the organizing qualities of the mind of Wallace, who put the breeding of trotting horses on a scientific basis. They are also learning to value the far-seeing abilities of Burbank in his matchless work in plant breeding. The practical breeders of plants and animals are coming to see the profound changes produced by breeders of fancy and pet animals and of ornamental plants. Scientists are ready to study more earnestly the philosophy of practical breeding, and practical men of affairs are ready to put into operation new theories found to be of practical utility.

No apology is made for gladly presenting my views and experiences in these subjects. After being long a breeder and a teacher of animal breeding a part of my

attention was turned to the breeding of plants, for the purpose of studying the general philosophy of breeding and also to attempt actually to produce valuable varieties of the important field crops. In fact the writer entered upon plant breeding quite as much to acquire a broad grasp of the theory of animal breeding as to learn to breed plants, and actually to improve the value per acre of Minnesota's field crops. In plants it was found possible to deal with large numbers necessary to use in experiments on the theory and methods of breeding. Wheat has served well among plants for studying some of the questions involved in methods of breeding and for getting a general view of the broad principles which govern in plant and animal improvement. Flax, corn, alfalfa and other crops have each taught lessons, and they promise many more. Some plans, more or less new, for promoting animal breeding have been long in mind, and will here be first set forth in a general way. It is the desire to emphasize the value of meritorious pedigreed blood; the importance of research in the science of breeding; the need of more attention to teaching animal and plant breeding; the necessity of using large numbers, both in selecting individuals and in testing breeding powers; the closer co-operative organization of all interested in breed and variety improvement; and the expenditure of sums of money more nearly adequate to meet the difficulties and to produce the larger values which are possible in improved plants and animals. None will get more of interest or instruction out of whatever "talking back" may be aroused by these articles, whether from the editorial chair or from the fraternity of breeders, than will the writer.

Below are formulated some general propositions which briefly summarize part of the theories and conditions under discussion:

1. Variation exists in every class, breed or variety of animals or plants, a few being far below the aver-

age, the majority being nearly at the average, and a few being far above the average.

2. Breeding is ordinarily done mainly by selecting the small per cent. which are above the average, and improvements come surely though slowly.

3. Among the small percentage of best individuals variation exists as to their prepotency or breeding power; some being poor, the many nearly average, and a few excelling; these latter being a very small percentage of the entire number in the class, breed or variety.

4. By choosing for parents those superior individuals having especially potent blood, the breed or variety is rapidly improved.

5. The great problem is how to eliminate the many, and having found the few proving prepotent in transmitting highly developed and effectively correlated intrinsic qualities, fully emphasize the value of their blood and thus cause them to be widely propagated and utilized.

6. Plans for breed improvement must contemplate: (a) the use of immense numbers from among which to select many superior in individuality, (b) the testing of the breeding power of each of those selected, and (c) the retention of the blood of the very best breeders for the improved breed or variety.

7. It is easy in breeding many kinds of plants to grow many individuals so that each plant has approximately the same conditions as each other plant, and the small percentage of the best plants may be selected for mother plants.

8. It is likewise easy similarly to plant a large "fraternity group" of the progeny of each mother plant, and by recording the value of the average plant of each group have comparisons of the breeding powers, the projected breeding efficiency of the respective mother plants, that the most potent blood lines may be retained as the improved variety.

9. It is difficult in animal breeding to grow many

individuals under conditions similar for each, and therefore more difficult to determine which individuals excel, and it is still more difficult so to compare the breeding power of each superior individual that the very best in this characteristic of prepotency, or projected breeding efficiency may be chosen as the basis of the improved breed.

10. Organized co-operation among animal breeders, preferably grouped near together as in a county, is of especial significance, that the individuality of many animals of the same breed may be fairly compared; also that the breeding power or prepotency of many of these superior individuals may be properly recorded and compared, and that the few very best breeders may be mated together and thus made the basis of the improved breed.

11. Pedigrees representing correlated qualities of intrinsic worth, showing the breed or variety to have high practical value, should be so faithfully and clearly constructed that the animals or plants they relate to may be so accredited for intrinsic merit as to have large commercial importance and be widely used.

12. Business methods must be used in increasing, in developing to superior form, and in finding profitable markets for improved blood of improved stocks of animals and plants, that they may be more widely used to supplant poorer forms now used in general production. In other words we need better pedigrees, and we need them better exploited, so that the blood they represent will be in better demand.

13. The people have here important interests at stake, and should recognize that, through the government of the nation, state or county, they could properly assist with money, laws and official co-operation in the development of better plants and animals.

14. Systems of comparing or judging animals must be better developed: (a) that fancy points and distinguishing marks shall have only a minor place; (b) that the qualities in which special economic values are

sought shall be kept prominent; (c) that fecundity, stamina, and disease resistance shall be increased rather than diminished; and (d) that all characteristics shall be so correlated in the individuals that the production of the breed or variety will be highly profitable.

15. Performance records, as of the trotting horse or dairy cow; tests of intrinsic values, as the percentage of sugar in sugar beets, or the toughness of gluten in wheat; as well as records of visible characteristics, as beauty in a horse, size and smoothness of a steer, or stiffness of straw in a variety of oats, are now being recorded in many lines once thought impossible. And these records are worked into pedigrees showing relative values of individuals and of strains of blood, thus giving emphasis to the best stocks of animals and plants and causing them to be widely used.

16. Many other lines of importance, of intrinsic qualities, and of visible qualities of quasi-value, or those useful merely as distinguishing marks by which to identify blood lines of known value which cannot be recorded by the methods now known, could be shown in performance pedigrees, if methods were devised for the respective purposes.

17. Money could be expended with as much profit in determining the percentage of lean meat in families of hogs, as in determining the speed in trotting horses; and in testing the hardiness and longevity of clover plants as in determining the percentage of sugar in sugar beets. Methods need not be more complicated in many untried lines than in lines where performance records are now with great profit already being recorded.

18. More comprehensive methods of selection would have avoided a lessening of fecundity in some families of improved swine, and a decreasing of milk-giving qualities in some families of beef and general purpose cattle; and with more attention to general values the too exclusive policy of breeding the fast trotters for the short race would not have so greatly jeopardized

the blood of the "rock-bottomed" Morgan horses, which came near extinction.

19. More comprehensive plans are needed for improving all existing breeds and varieties, and especially for so marshaling records of intrinsic qualities in pedigrees that the best varieties and breeds will be in more active and universal demand to be used for upgrading our common herds and flocks, that scrub stock may be well nigh abolished.

20. We need new breeds and new varieties, if by new combinations of lines of blood now available we can repeat the experiences of the makers of our present stocks and thus have better breeds and better varieties.

21. By hybridization the breeder creates greater variations, destroys the uniformity of his herd or variety, and usually decreases its immediate value, but if large numbers of the hybrid are propagated, he has a wider range of variation from among which to secure extraordinary individuals with remarkable prepotency or which may be made so by breeding more or less within close relationships.

22. Hybridization of plants or animals is very easily accomplished, and is not expensive, but the labor and time involved in selecting the best from among very many make it the work of the philanthropist, or of the permanently established seed house or breeding firm, or of the state, whose life is continuous and is therefore directly interested in future generations.

23. The public at large is so vitally interested in the discovery of those germs, whether of useful plant varieties or of animal breeds, which are powerful in their ability to transmit qualities of great intrinsic value, that it can afford to aid the successful individual breeder, the co-operative association, and the corporate seed breeding establishment or firm, in creating them by hybridization and in eliminating the many undesirable ones to secure the few best.

24. Since private agencies are too slow in pre-empting the virgin soil in these long-time business proposi-

tions, the people are properly bidding their public agents in the national and state experiment stations to lay out the land, work up the methods of experimentation, and possibly permanently hold a part of the fields of variety and breed improvement.

25. Varieties and breeds of some species, as of corn and dairy cattle, can best be bred by individual farmers; others by co-operative associations, as swine; others by large establishments; and others, as walnut or pine trees, and even wheat and timothy, by experiment stations. These public institutions, with the aid of scientific laboratories in universities, can best develop the science of breeding. The profits in the sale of new things will encourage the development of systematic business methods, which in turn will produce the means for the necessary experimenting.

26. Single valuable germs, or valuable combinations of germs which "nick," to use the stockman's term, are found or produced by hybridizing and the work borders on the creative. The fact that here, as in the diamond mine, the real gems are found only after thousands or hundreds of thousands of parts of base soil are handled, only makes them seem the more precious. These germs are wonderful, living, reproducing beings, a part of the world of life, related to the very essence of man. No business is all sordid, but here the compensation in interesting living forms, in scientific development, and in a close insight into living nature is peculiarly varied, rich, lasting and satisfying.

Plant breeding has been immensely benefited by animal breeding, but at present plant breeding is more than paying back in new theories and new business methods. Animal breeders should get into the same attitude in which plant breeders find themselves, and recognize that important and helpful changes in methods may occur, if indeed they are not now imminent.

CHAPTER II.

BREEDING WHEAT, CORN AND OTHER CROPS.

The possibilities for making valuable improvements in domestic animals and plants offer opportunities for the profitable employment of energies and capital at every point. In many cases private enterprise properly assumes the work and secures the rewards. In other cases co-operative associations can best meet the conditions for making improvements and securing that proportion of the new values which will pay those who do the work. Rewards are needed to induce breeders to continue actively pressing forward the improvements needed by the practical growers who use the new breeds and varieties. In yet other instances large and powerful corporations for breeding and merchandizing can best effect the improvements needed by the mass of the people and secure that share of the rewards which will support their business. In not a few lines the work may best be accomplished by those servants of the public who are employed by State experiment stations, by the national government and by other institutions of a public or semi-public nature.

In many lines of field crop production the field is entirely unoccupied, so far as known to the writer. No one in this country has placed on the market a single newly-bred variety of timothy, brome grass, red clover, alsike clover, white clover, alfalfa, Kentucky blue grass, orchard grass, millet, soy beans, Kaffir corn, flax, broom corn, nor of many other field and horticultural crops, while the breeding of forest crops has hardly been mentioned in any country. In only a few lines of field crops has a substantial start been made.

The most wonderful scientific work in any one line has been accomplished in the breeding of sugar beets,

which through the expenditure of hundreds of thousands of dollars, has created millions of added wealth. The per cent of sugar in the juice of the common beet has been increased from six to fifteen per cent, or 150 per cent increase of sugar, and the solids other than sugar have been materially decreased, making the purification of the sugar less expensive. This breeding has rendered it possible for growers of sugar beets to make profits, for factories to conduct a paying business, and for the people of the world to enjoy sugar at a less price. The growers of sugar beet seeds in Europe have their work of breeding highly developed, but even in sugar beets American plant breeders have an opportunity for profitable employment. We need varieties adapted to numerous local conditions and the seeds can best be bred under conditions similar to those where the crops of sugar beets are to be grown. European varieties, long bred for a climate with less sunshine, a moister atmosphere, cooler nights, and with cooler soils with moisture nearer the surface, are hardly adapted to our sunnier climate. What is wanted is tonnage of sugar per acre and to get this we must have larger yields of sugar beets than we now have from European seeds. Our warm dry climate will usually give quality; we must work more for size of roots. Unlike Europe we can easier secure richness of juice than size and yield. Factories have been so perfected that high percentage of sugar and low percentage of solids not sugar are not so essential as formerly. For the farmer to secure more profit per acre he must increase the yield of sugar per acre. Taking the best sugar-yielding varieties now obtainable from Europe as his foundation stock the scientific sugar beet seed grower in this country needs to work for yields mainly through somewhat increasing the size of the roots, keeping up, however, and even increasing that of England. Only part of this difference is attributable to the fact that England has a wheat climate and America a corn climate. Part is due to the fact that for centuries Europe

has been improving varieties by adapting them to conditions there. These varieties do not succeed so well here, yet we have continued growing them too long. The breeding of wheat in Europe has not reached that perfection found in the breeding of sugar beets, but it has been effective. Hallet's square head wheat bred by Major Hallet, of England, was the parent of a class of wheat which has been very widely used throughout the northern portion of the wheat belt of Europe and has been worth many millions of dollars to farmers and consumers of flour. Dr. Rimpau, of Germany; Vilmorin, of France, and others have originated new wheats which have been widely used because they have increased the value of the products per acre. Still others, as Fr. Strubbe, of Schlanstad, Province of Saxony, Germany, are effectively carrying such varieties as Hallet's square head wheat on to further perfection. More bold, the Garton Brothers, of Newton le Willows, England, are striking out into the dangerous, yet most fruitful field, of radical hybridization, and are creating new varieties, if not, indeed, new species of wheat. If they have the element of long endurance, their reward promises to be great. Still others there are who merely dream of breeding the richness in sugar and freedom from impurities of the juice. Hybridization in the formation of entirely new varieties is also an agency which should be utilized by experiment stations and others situated where it is practicable to wait many years for results which may be of especial value. Thus it will be seen that even in this, the most exploited line of breeding, there are opportunities for Americans in plant breeding. This view was assented to by European sugar beet breeders with whom the writer conversed at several German centers of sugar beet seed growing.

The breeding of potatoes has been carried forward so extensively that the original potato has been changed to yield vastly more tubers of much improved quality. Yet the improvements which continue to go forward with the decades, show that the limit of perfection is

yet in the future, if, indeed, there is such a thing as a limit to the changes which may be produced in living form through selection and hybridization. Special varieties are needed in many localities peculiar in soil and climate. Varieties are needed which can be produced in the North and are better adapted to sending South for seed, as is now done with some varieties. Kinds with more starch are needed for the manufacturers of starch and starch products.

The yield of wheat in America is ridiculously low, only half wheat. But results are different with the director of the plant breeding experiment station of Svalof, Sweden. Here a semi-public experiment station produces new varieties of wheat and also other crops, thoroughly tests the many kinds, and distributes thru a co-operative organization those few which are proven to be markedly superior to the kinds commonly grown.

On this continent, Carmen, in New York; Blount, in Colorado; Saunders, in Canada; Haynes, in North Dakota; Hays, in Minnesota, and others have each given to the public one or more new varieties of improved wheats. Others, as Shepperd, in North Dakota; Carlton, of Washington, D. C.; Atkinson, in Iowa; Chilcott and Sundaers, in South Dakota; and Bull, of Illinois, are now taking up the work of making improved varieties of wheat especially suited to their respective states. Blue stem varieties or classes of spring wheat which hold full sway in the middle Northwest; Turkey Red winter wheat, which leads all others in area in the Great Plain States; the wheats of the Poulouse region of the Atlantic States, and the special wheats of each minor locality, are nearly all imported from Europe. And now the macaroni wheats of Southeastern Europe are coming into prominence in that semi-arid zone where the agricultural districts and ranch plain join. Each and everyone of these winter and spring bread wheats, also the macaroni wheats, can doubtless be improved by selection so as to yield ten or even twenty per cent more value per acre. At least,

this has been done in several instances at the Minnesota Experiment Station with the spring bread wheat.

By extensive hybridization followed by selection, no doubt varieties can be made which will far better fit into the conditions of each and every wheat growing section, and even extend the wheat area into sections where wheat does not now succeed. It were better if many sections now growing wheat on the same land continuously would grow a less acreage, and if other sections now growing but little would grow more of the world's leading wheat crop in rotation with other crops. Wheat has proved to be one of the easiest plants to work with in making improvements and results are far-reaching.

In Minnesota a new variety of Fife wheat, Minn. No. 163, and a new variety of Blue Stem wheat, Minn. No. 169, have been placed among the farmers to displace the parents of these two varieties. Ample proof is in hand that each of these wheats will yield an average of 1½ bushels more per acre than its parent. Estimates place the acreage planted to these two wheats in Minnesota in 1902 at about 60,000 acres. All the cost of plant breeding at the Minnesota Station, including all variety testing of all species, and all the studies in animal breeding in the past dozen years will have been paid for by this increase, estimated as worth $1 per acre. If these varieties of wheat could be increased only four fold annually for four more years there would be sufficient wheat to sow the entire crop of Minnesota and much to spare for other states. One dollar added to the value of each acre of wheat in Minnesota makes a total of over $5,000,000 annually. Even if those wheats are so increased as to plant one-fifth of the field of the state, which is to be hoped, as business methods are being used to distribute them, the increased value of the crop will be a million dollars annually.*

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* Note—This has already practically resulted, August, 1905.

The experiment station has one or two thousand other newly-selected hybrid wheats in its nursery field test plats, some of which it is hoped will prove worthy of supplanting those disseminated. This station's opportunity to add two to five bushels per acre, six to fifteen million dollars per annum, to the crop of wheat in Minnesota, is by no means singular to Minnesota, because other states have crops of which the average yield is ridiculously small. It may require 25, 50, or even 100 years to increase the crop of wheat five bushels per acre by breeding, regardless of any additional increase which may come from better methods of managing the farms and fields. In any event, the effort will pay. A wheat germ which can be the parent of a variety which will yield a bushel more of wheat is worth millions. The yield alone is not the only point for improvement, even in the wheat. The hard wheats can be made still harder and the soft wheats can be so improved that they will rival the hard wheats in the toughness of their gluten, in the color of their bread, and in the nutriment they contain. It is quite as much of an undertaking to hunt for such germs in places where they are so much needed as to hunt for diamonds in the greatest diamond mines.

Corn is the king concentrate for animal rations, in that it yields more money per acre when fed to live stock over a larger area than any other crop. Dr. Hopkins, Prof. Shamel, Prof. Holden, and others in Illinois and Iowa, are showing what may be done in improving corn. They are emphasizing the fact that farmers in their field selection have bred mainly for yield and that now an additional opportunity offers in improving corn in America's great corn belt lies in increasing the nitrogen and fat percentages, and the yield of these compounds per acre. No doubt the Illinois Corn Breeders' Association, headed by the State Experiment Station, will have the credit in ten years of having increased the value of the corn crop of that great state five or ten per cent. In Minnesota, the experiment station took

up the pioneer problem of pushing the north line of the dent corn zone further to the North and Northwest. Minnesota No. 13 corn, bred by the Experiment Station, has been one of the potent factors in pushing dent corn grown for ears fifty miles north in a decade. The modern corn binder and corn husker have also had a great influence on this movement. This same variety of corn has figured prominently in the introduction of corn into the northern counties as a hay crop. A bushel or more of seed of this short-stalked variety of dent corn planted in drills three and one-half feet apart, with seeds one to two inches apart in the rows, produces several tons of fine hay in regions where clover does not succeed. Flint varieties, which thrive better in the northern climate with cooler soil, are being bred by Minnesota's two northern sub-stations and by the North Dakota Experiment Station on the Minnesota line. Minnesota alone needs numerous varieties of corn bred for its varying conditions of soil and climate.

Since corn hybridizes by the pollen being carried by the wind forty or more rods, an experiment station or a farmer cannot well breed more than one or two kinds. There is here opportunity for many corn breeders. None of our other crops seems so readily adaptable by breeding to local conditions. While a variety of wheat may dominate in several states, a variety of corn is more likely to be adapted to a group of counties. Breeding corn by scientific methods will pay private individuals; therefore it will be rapidly developed. Manufacturers of corn starch and its products will provide a market for corn especially bred for their purposes. While feeders can afford to pay more for corn containing more protein, manufacturers can afford to pay for the higher percentage of oil and starch. Since a bushel of seed will plant seven or eight acres of hill corn, the farmer can well afford to pay the breeders two or even three dollars per bushel for seed

having superior heredity and so dried and stored that its vitality is unimpaired.

One more example will suffice for opportunities in breeding field crops. Alfalfa is a wonderful crop in dry regions where the temperature does not reach too low a point. But in the northern tier of states the common alfalfa of the West sometimes fails to endure the winters. The National Department of Agriculture has imported from Turkestan several new forms of alfalfa. One of these found by Prof. Hansen in Northern Turkestan promises to be very hardy, though no considerable quantity of that variety is yet available for seed. It is worthy of note in passing that some seed being distributed as Turkestan alfalfa will probably not prove hardy as some of the original varieties secured from warm cotton-growing portions of Turkestan have not proven hardy. Hardy forms of alfalfa have been accidentally discovered growing in the Northwest and are to be disseminated. This crop can be especially bred to yield even more for the different irrigated district, for the unirrigated districts of the Southwest and for the cold districts of the North. In Minnesota, for example, we have great need of such a crop to grow hay and with which to enrich our soils for grain, and which will compel as well as enable us to raise more live stock, that we may let alfalfa and other "crops go to market on foot and leave the fertility on the land."

The opportunities for breeding other crops will be mentioned in future pages in connection with detailed methods of breeding the respective crops.

CHAPTER III.

PEDIGREED ANIMALS AND PLANTS.

Readers of these pages do not need to be told of the wonderful opportunities for profitable business in improving and growing pedigreed animals to be sold for breeders. The many advertising pages of the Agricultural press speak louder than words that our breeders are producing wonderful stock, and that America has become the greatest market in the world for pedigreed animals. Our stock shows and public sales illustrate that live stock is of paramount interest in things agricultural. We have no stronger, more vigorous, nor more brainy class of men than those who make live stock breeding and live stock growing their chief specialty. The enormous sales of live stock and live stock products illustrate the interest our country has in domesticated animals.

Breeding animals as practiced is mainly an art, though scientific methods are creeping in. The art as now developed is too much subject to fashion. Standards are not so determined as to consider or include all correlated qualities needed to give general values and the fashions change, resulting in the loss of part of that force of heredity which comes from long breeding in one line. Mere fancy points and distinguishing marks are too often bred into the surface, while intrinsic qualities are not bred to uniformity. Artistic methods dealing with the outward appearance should not be made less important, but scientific methods dealing with the intrinsic qualities should be largely developed. A prominent poultry judge, in the writer's presence at a national show in Chicago, placed all the weight of his score card on the wattles, feathers, leg scales and other mere "clothes" of the rooster of a meat breed and gave

no attention whatever to the thickness of meat on the breast and legs. He illustrated how judging by fancy points can be carried to a ridiculous extreme. Trotting horse breeders, on the other hand, have held so closely to trotting records that they have too often overlooked comeliness, one of the most important characteristics of the road horse. What is needed is breeding in a formal way for the combination of intrinsic qualities, artistic qualities and distinguishing points which will yield the greatest value. The breeder must have a broad, scientific plan and besides he must have a broad mental attitude as an artist in breeding.

The opportunities in animal breeding lie in comprehensive breeding and in recording performance records which will greatly re-inforce pedigrees, as we ordinarily understand the term pedigree. The performance basis of our pedigrees is now on too narrow a plan in many instances. In case of some families of special egg-producing chickens the only records claimed to have a semblance of performance records are prizes given cocks and hens by some judge who simply judged their outward appearances and gave them a high record because their "clothes" were of the same type as that mentioned in a standard of excellence. Catch a trotting horse breeder choosing a stallion for his mares because some judge had given him a blue ribbon on account of his neck and back being built right and because he was of a pretty color! Yet too many of our beef, swine and sheep pedigrees have in them too little which indicates the performing ability of the animals besides the judgment of judges at shows. This point would not be mentioned here if there were no remedy. The writer recognizes fully the great value these prizes have as a means of dispelling the indifference of farmers to the value of really meritorious breeding stock. There is not so much need of new breeds of animals, as the term breeds is commonly used. But there is need of improvement within the existing breeds and if im-

provement can better be secured by making new ones then new breeds are needed.

The breeding of swine will illustrate this point. There is needed a breed which has the prolificacy of the Tamworths, the earliness of maturity of the Berkshires, the comeliness and general desirability of the Poland-Chinas, the ability to make more weight out of a hundred pounds of feed than any existing breed, having more lean meat than any of the so-called bacon breeds and with a goodly degree of immunity from hog cholera, rheumatism and other hog diseases. The writer and Prof. Andrew Boss have presumed to plan for the development of a hog along these lines. If within fifteen years of effort a good degree of excellence could be reached in the combination of the qualities mentioned, and records were preserved proving and amply illustrating the facts of such excellence, the pedigrees would assist in selling breeding stock at long prices. While many difficulties present themselves at the outset in such an undertaking some have been in part solved and no doubt more may be. Experiments in animal breeding are so expensive that scientists have not yet seriously undertaken to solve many problems of a practical nature which are of immense importance. Half the battle will be won by securing the best available foundation stocks, just as "a steer well bought is half fed." It would seem wise to use some Tamworth blood and possibly some Yorkshire, at least the families of these breeds should be rigidly tested. Families of Poland-China, Berkshire or of the other hogs long bred in the corn and clover belt may also be found to score up well under the score card outlined in the foregoing and could be chosen for all or part of the foundation blood. It may be that the mule-footed hogs with vigor transmitted from their wild Ozark ancestors may have one or more characteristics, as disease resistance, which can be brought into use. When the field is thoroughly reviewed and the chosen family lines extensively tested then it is time to say whether to make the improvements

all within that breed which is now nearest the desired type by mere breed improvement or to make the effort by hybridizing two or more kinds. It may be that efforts along two or more parallel lines should be made. The expense is too large and the goal is too great to stop short of the best way. While crossing breeds is generally thought poor policy in upgrading or in growing stock for market the experimenter must not be too fearful of new things.

The first point to investigate is that relating to disease resistance. In plant breeding rapid strides are being made to secure wheat that better resists rust, cotton that resists cotton blight and grapes which resist phyloxera. It is well known that some individual hogs resist cholera entirely and that others have only light attacks. Can we not find individuals whose progeny will be nearly immune? Who has records along this line? Do the litters from certain sows show greater ability to resist cholera than litters from other sows? The writer would like to correspond now or in the future with persons who have evidence that some families of hogs are more nearly immune from cholera or rheumatism than others. This is a matter worthy of wide inquiry and investigation. This might be a most fruitful line of research for the Bureau of Animal Industry at Washington in its highly important experiments with swine diseases. A small fraction of the money now lost from hog cholera if spent in breeding cholera-proof hogs might possibly greatly lessen the disease.

The second point for investigation is concerning the proportion of lean meat or the thickness of the muscular covering over the bones and the quality of the meat. This seems even a bolder proposition than determining the power of disease resistance. It is hardly less important. Lean meat is what justifies high prices, and pedigree records showing that a breed or family of hogs had a high percentage of lean meat would give a basis for high prices for breeding animals. If the breed were

of such form or color that buyers of fat hogs could distinguish them in the stock yards they would sell for a better price. Certainly consumers buying at the block would gladly pay for more lean meat throughout. The writer has observed carcasses of hogs which have over 50 per cent more lean meat than other carcasses of the same size and reared and fed under the same conditions. There are wide variations of lean meat even in the individuals of the brood of one sow. There is a marked difference in the proportion of lean meat in one breed as compared with another. No doubt prepotent in producing a large percentage of lean meat and others in which the progeny average less in this desirable characteristic. Actual measurements in the thickness of lean meat could not be generally carried out in practical breeding of pedigreed hogs by the ordinary small breeder, nor should that be necessary. But the State or co-operative organization or large corporations might record such measurements; or the State or county might aid the co-operative organizations and foundation stock be thus made available for the common breeder.

It is not probable that suggestions here made can be worked out without modification. But to place the suggestions under specific and practical conditions let us assume that twenty farmers in Carver County, Minn., are organized into a co-operative hog breeders' association. Let this association deliberately plan to take the lead in the production of a strain of Yorkshire hogs which shall be more cholera-resistant, especially high in percentage of lean meat, excelling in the number of pigs successfully reared per litter, superior in the amount of growth per hundred pounds of standard food eaten, comely, uniform in appearance and prepotent when used in crossing and upgrading and otherwise valuable and desirable. Let the association determine upon a type of hog that shall be the ideal toward which all shall work. Let each of the twenty breeders secure by private means or through chosen

officers of the association five or more sows and a boar of the better strains of Yorkshire hogs and be guided by rules similar to the following:

All members shall adopt about the same date for farrowing and breed each bunch of sows. All males are to be kept until their progeny are matured, that those proving most prepotent of the twenty males may be available for use another year. All members shall use similar care and similar rations and otherwise treat the sows and the young broods alike. There will be unavoidable differences in treatment since one man will have more skim-milk for his pigs, more pasturage for his shotes and will feed and care for his herd more regularly and carefully than another. But reasonably uniform conditions should prevail and an effort should be made to induce all members to give equally good care to their pigs, that all may come to the test at about the same weight and from similar previous feeding and care. It is safe to assume that the litters will average six pigs. When four months old any very poor pigs are to be discarded from further test and the best appearing male and the two best females are to be reserved by the breeder and given that good care which will develop them for breeders. From the remaining number of each brood each breeder is to place at the disposal of the association two or three average animals. These are to be cared for and fed by some one chosen for that purpose by the association. All these test animals are to be fed alike and together for two weeks. During their sixth and seventh months the selected pigs from each group are to be fed separately for six or eight weeks. A ration uniform in character and adapted to ad libitum feeding is to be fed throughout and weights of food eaten and of gains made are to be recorded. When the feeding experiment is finished all

are to be slaughtered and the percentage of lean meat and of fat to bones, and of lean meat, fat and bones to live weight, etc., are to be determined and recorded. Some observations already made along this latter line lead to the belief that by sketching the areas of fat, lean and bones on the cut surfaces of certain carefully made commercial cuts; or by making photographs, a practically accurate record can be secured of the percentages of lean meat, fat and bones. The measurements of areas of parts in the cross-sections of meat are easily made by means of an instrument called a planimeter, which measures areas no matter what may be their form. Experiments have been planned to construct a conversion table for reducing measurements made as above to a percentage basis, that they may be more easily utilized in pedigrees. A careful record shall be made of the number of pigs each sow farrows and of the number she rears, and of important facts concerning the death of any young. Her milking ability shall be determined where practicable, also her disposition in the care of her brood. All facts concerning each pig shall be recorded by the breeder, old, color or other markings and any peculiarities which are especially noteworthy.

The average records made in the feeding trials of the shotes comprising the progeny of each dam and of each sire shall constitute the breeding measure or record of that parent. These records can be designated by the term, "centgener records," a term recently adapted to a similar use in plant breeding. Centgener is made up of the words centum, a hundred, and genera, generation, or, practically, many of one generation. Here it may mean the average of one generation, or one year's get of a sow, or a boar, grown under similar conditions.

Discussion of this proposition and especially of families which might be worthy of investigation as possibly useful in connection with such an experiment would

be appreciated by the present writer. Future articles will discuss in a somewhat similar manner the breeding of other animals for special and general purposes and the breeding of leading crops. The writer desires to suggest to others that they may better outline methods of attacking problems rather than undertake to outline in detail plans for breeders to follow. The rapidly evolving subject causes many of these plans to be revolutionized every few years.

CHAPTER IV.

THE SHAKESPEARES OF PLANTS AND ANIMALS.

In taking up the general propositions enunciated under paragraphs numbered 1 to 26 in early pages, there is no assumption that these are more than a basis for informal discussion. Practical examples and suggested plans for comprehensive reorganization of the breeding business will serve as a basis for the discussions. The facts relating to heredity and the achievement of breeders of both plants and animals will be used to show that the current literature and the books on breeding have not been sufficiently optimistic. We need to read between the lines in Darwin's books to gain the full inspiration they leave for breed and variety improvement. The theories of Francis Galton, the researches of Hugo de Vries, and the actual achievements of Luther Burbank all lead to more faith that wealth may be increased with greater raidity by breeding than is at present being accomplished.

Francis Galton, of England, and other naturalists with a taste for mathematical processes have instituted studies of living organisms in which measurements and statistics are the prominent features. A new periodical called "Biometrica" (measuring living things) has recently been launched in London to give publicity to the results of these experimental researches. That paper is to the work of these scientists what *The Gazette* is to practical breeders, and each should more fully realize the point of view of the other. In fact, has not the time come when practical and scientific men interested in the science of breeding should formally and effectively join hands in pushing forward a knowledge of the laws of heredity, both in its relation to the evolu-

tion of natural species and to the artificial evolution of higher types of economic plants and animals?

Books, monographs and bulletins reciting the results of experiments in those laws of life in which the breeder is interested are also beginning to appear. To illustrate this class of literature, and to show that such experiments, theoretical studies and measurements have value in the study of living things as well as in working out the science of astronomy or mechanics, the following example is given: Quetelet found that the law of error applies to living organisms as well as to other phenomena. To illustrate this he used the heights of soldiers, all natives of the one country and district. If arranged in a row from the shortest to the tallest and a line be drawn over their heads these several things are observed: (a) The center man in the line represents the average in height. (b) For nearly the entire length the line is almost straight, but descends slightly. (c) At the lower end the line curves rapidly downward. (d) At the upper end the line curves rapidly upward.

Yield of milk in dairy cows, speed in trotting horses, strength in draft horses, the thickness of lean meat on the breast of Asiatic fowls, men's capacity for music and all other special and general characteristics seem subject to representation by the same curved line. That is, in the stable variety or species the many do not vary greatly from the average, but there are a few which are weak and a few which are strong in each quality. Thus in case of wheat plants grown in hills 4x4 inches apart, one plant in a hill, there are a few plants in a hundred which are tall and a few which are short; some are heavy yielders, others light yielders, and so on. This expression of the law of variation does not apply to visible qualities alone, but to all qualities. Most important of all, it applies to variation itself. Most species, varieties, families and individuals of ani-

mals and plants have "blood" which is average in its stability, or in the stockman's term in its "prepotency." A term coming into use in plant breeding where some species are hermaphroditic and self-fertilized, where the word prepotent does not quite fit the case, is centgener power, or the ability to produce generations of strong and valuable progeny. The word centgener, made up of the root words centum, hundred, and genera, generation, is applied to the large group, a hundred, more or less of one generation, usually from a single mother plant, but may be used in animal breeding where the measurements may be based on the average value of only a few, or many, progeny. Projected efficiency is also a recent expression which may most forcefully express the idea of breeding power in many statements, and is also a useful addition to the language of the breeder.

The future is interested in selecting from among the many individuals those few at the very top of the curve which combine in their inherited makeup the ability surely to reproduce the many superior qualities which must be correlated to give excellence, whether for specific or general utility. Thus because of its value as a parent plant, Peter Gideon's original tree of the Wealthy apple was worth millions. Because of its centgener power the mother plant from which "Minn. No. 163" wheat sprung is adding 10 per cent to the yields of Minnesota wheat fields as rapidly as the farmers can substitute it for the wheats in common use. The germ in the one kernel from which that variety sprung in 1892 contained the prepotency which is now spread over 60,000 acres, and in five years more, or fifteen years after the parent seed germinated, its progeny could be made to cover the wheat area of the group of hard spring wheat States, increasing the value of the crop many millions of dollars.

The projected efficiency of Messenger, the father of the American trotting horse, was wonderful. Truly, there is power and value in certain germs, and effective

methods of securing such germs and of bringing their progeny into general use are of vast importance. We need to breed for intrinsic qualities; to record the large values of authentic pedigrees, and so to exploit the values of the best breeding stocks that the people will use them.

Francis Galton says statistics show that only one man in about 5,000 rises to marked prominence. Man is a very complicated individual and the successful man must have correlated to this nature very many qualities so combined as to give him pronounced abilities. Galton also emphasized the fact brought out by Wallace that Messenger became the father of the American trotter, though many other Thoroughbred horses were in competition with him in the early efforts of the breeders to produce trotters by using running stallions on American common and grade mares. Messenger evidently had that strange power of prepotency which resulted in his blood giving the form, the fiber, the wind, the docility under training and the instincts to contest and win the trotting race. He was one sire in thousands whose blood flowed powerfully toward the trotting gait through generations of his progeny. To analyze his power to transmit against the blood of dams or to "nick" with their blood is a process as yet not fully worked out. We must accept the wonderful fact, hoping that it may some day be better understood. But we can use many important facts which we cannot understand. Seeds germinate and why should not new breeds germinate? Messenger was the first seed of the breed known as the American trotter.

I understand that Prof. de Vries has deduced evidence that in nature species are not always developed by gradual evolution, but that there is a strong element of revolution, an occasional marked mutation from the species, variety or breed. No one familiar with the work of Darwin, Mendel, de Vries and their fellow workers on the theory of heredity can believe in the old theory of the immutability of species. Occasionally,

according to de Vries' theory, there is an occasional Messenger among wild plants or among wild animals, which dominates or is prepotent over all its fellows with which it crosses and there is thus found a marked variation, sometimes a new species, so peculiarly fitted to survive that it supplants the parent form, or simply lives beside it. And certainly this revolutionary phenomenon is often observed in our cultivated plants. If nature produces a peculiar and pretty chrysanthemum some man is sure to save seeds from it. If it is prepotent in its peculiarity or if it produces part of its progeny of a peculiarly valuable type the gardener or greenhouse man propagates the best, and possibly with a single bound—and that based on an accidental variation—he distances his competitors in the flower trade of a city and a new variety is born.

Some of the great Short-horn and Hereford sires have had a remarkable influence on the breed. Suppose, as has been done in case of some new varieties of wheat, an entire sub-breed could have been made up of the blood of these best cattle. A new Short-horn breed made up of the blood of those twenty individuals of the breed having the greatest power to produce valuable cattle would be worth far more to the world than is that splendid breed in its present form. How can we eliminate the blood of the many less valuable individuals and secure in suitable combination the blood of the few very best breeders in the whole breed and multiply this blood to supply the entire country is the great question. If the proof of the values of these best animals was put into authentic figures, serving as performance pedigrees, would their progeny not bring fabulous prices. In this connection a remark made by Prof. Curtiss recently, while showing me his experiment with breeding blue-gray cattle, is worthy of repetition. He said: "Sotham is a remarkable breeder. While it is recognized that the success of every noted breeder of cattle has been based on the remarkable breeding ability of one bull secured for his herd, Sotham has had two

remarkable bulls." We are all looking for a Messenger or a Lord Wilton. As Prof. Hansen, of South Dakota, the foremost breeder of hardy fruits, says: "We are all looking for Shakespeares among plants and animals."

Luther Burbank writes no manuals on breeding plants. With his own hands he writes his manuals on achievements in new creations. This man is doing more to inspire breeders of plants and animals than any dozen writers. His is a working philosophy. It seems to him mainly art. He works with the plants and secures marvelous results. Some of his methods and theories he has not interpreted in writing, nor orally. He knows more than he tells. The plants have taught him how to treat them. He has dealt with the plants rather than interpreted in language the philosophy of breeding. His simple statement that the breeder must deal with immense numbers is the most important factor in his philosophy and in his work. He has learned by experience that the breeder must find that rare plant in thousands, or in hundreds of thousands, which combines the desired breeding elements. This theory leads him to grow immense numbers of plants and save only the few. It leads him to creep about on his hands and knees among wild flowers, hunting for that rare plant in many thousands which varies in the desired direction. It induces him to search long for many of these rare plants that he may grow progeny from each and discard the blood of all but the very few which prove prepotent, or to have high projected efficiency in the desired characteristics. It is not sufficient that a plant be found with some desired variation in its individual character. The power to reproduce that character in a more

or less constant form is the all-important quality. We need not merely the correlation of qualities making a desired individual, but the power to reproduce such correlated qualities in the young. It is not strange that only one in thousands or in tens of thousands carries that exceedingly complex combination of characteristics which makes up the strains of blood desired for a given definite, yet often trying and important field of plant or animal production.

CHAPTER V.

SELECTION OF FOUNDATION STOCKS.

In the case of wheat, mentioned in previous pages, the height of the plants is only one of the qualities in which there is variation. There are also a few plants which yield heavily and a few which yield but little grain. Likewise, there is occasionally a plant with stiffer straw, one a little more rust resistant, one with more or tougher gluten. But to find a plant in which are correlated to a maximum degree all these desired qualities thousands must be examined. And to find one that has such a desirable combination of good qualities and also the far more complex and important quality of breeding power or projected efficiency in transmitting the combination, it would seem natural that many of those with the desired individuality must be tried as breeders.

The problem is very complex if we take the case of plants which are open pollinated, as corn; or of animals, which also are reproduced only by the sexual union of the two individuals. Here the strong individuality of the prepotent plant or animal must be able with its combination of desirable qualities to override the qualities of the other sex with which it is bred, or it must so "nick" with the qualities of the other member of the cross as to make a new combination of value. This feature of the complexity of the problem is here dwelt upon to lead men to see that not by easy or short methods are important breed or variety improvements to be made. Large numbers must be tested, measured, recorded and averages made and the blood of only the very few utilized in breed or variety formation, or in material and radical variety or breed improvement. This general proposition is borne out by the fact that

most of the new varieties of cultivated plants have been accidentally discovered rather than the results of efforts of the plant breeder. Those who have worked systematically have usually confined their observations to hundreds, or at most to thousands, in their flower beds or green-house benches, or in their vegetable gardens. Producers generally, on the other hand, annually have under review hundreds and thousands and millions of plants in gardens, orchards and fields. Here the curious or the trained eye catches the occasional plant which widely departs from type. The new form may prove so valuable that it is propagated, its progeny selected to type, if need be, and eventually developed into a commercial sort. But the trouble is that the world is not receiving enough of these accidental sports. People are not alert enough to discern all such plants, and too few are expert in so propagating and selecting such new stocks as to make of them the most useful varieties. Besides, chance discoveries are too often lost by inefficient means of testing or by distributing them under a plan which will fail to induce people to use them in preference to inferior forms. What nature, and chance, and ordinary men, and common methods are now accomplishing in a slow way is unsatisfactory. Enterprise system, capital, extensive co-operation and large patronage must be brought to operate and accomplish in an adequate, modern, scientific way the rapid and profound improvement of our crops and animals. If one-fourth as much enterprise, thought, energy and money as is now devoted to mechanical invention could be diverted into study, experimentation and effort in scientific plant and animal breeding, our country would be as famous for its crops and animals as it now is for its bridges, buildings, machine shops and implements.

Breeding should be made more scientific. Breeders of animals who have spent a lifetime in building up fine herds or flocks will, no doubt, feel that these articles will not especially aid in solving their problems. Possibly some may feel that I have made the

problem look even more difficult from the standpoint of the practical man than it has heretofore appeared. But the breeding fraternity as a whole wants the facts. The broad historical fact stands out clearly that if we simply breed for generations from the best appearing individuals, we make sure progress, but it comes at too slow a pace, and the final result is not as large an improvement as we should like. We must not only pick out the superior individuals, but the blood of those which have proved in their young to have the very highest breeding must be sought with far more system and persistency and made to more rapidly crowd out the commoner blood of the breed. The scrub should be more universally replaced by pure, strong blood; and performance pedigrees built up on tests of intrinsic values must be more generally employed to accomplish that result.

In some species of plants many variations are found by those who deal with them in practical production, as in case of geraniums and chrysanthemums where the gardener views and handles each individual plant. In other cases, as in wheat, the stems or culms from the separate seeds are so interwoven in the field that the individual plant cannot be separately observed. In species like wheat, timothy and oats, methods must be devised under which each seed may be separately planted, that the individual plant may be studied. In case of animals, likewise, methods of comparison must be devised so that each animal can be separately observed and a record made of its qualities. Thus the qualities of the parent, the qualities of its progeny and the average quality of fraternity groups of progeny may be recorded so as to compare not only the individuality but the breeding power of the respective parents.

CHAPTER VI.

WHEAT BREEDING.

Wheat breeding is one line which has been taken up in earnest and a discussion based on present developments along this line will here serve useful purposes. It will show that there is wide scope for skilful art and for scientific research in developing the technical part of breeding. Here also may be illustrated the fact that through plant and animal breeding much wealth can be added to the country. Wheat is one of the best species with which to conduct statistical experiments on the theory of breeding and in studies concerning heredity. It has numerous characteristics which are capable of measurement; e. g., weight of grain from a single plant, average weight of kernels, quality of grain, height of plants and days required to mature; and its seeds may be preserved for several years that original stocks may be compared with improved forms. And in hybridizing its distinctive characteristics, as bearded or awnless, hairy or smooth chaff, color of chaff, and color of berry, serve to identify strains of blood. The fact that new varieties of wheat which yield even 10 per cent. additional value per acre may be rapidly multiplied so as to make that increase apply to farms, counties and states, makes the problem of practical wheat breeding one not only of scientific interest, but of vast commercial importance.

A discussion of wheat breeding as carried on at the Minnesota Experiment Station will serve to illustrate how efforts are being made to meet some problems. Here (a) the varieties proving best upon test are secured for foundation stocks; (b) large numbers of individuals are compared; (c) superior plants are selected; (d) the breeding powers of many of these

superior plants are tested; (e) the blood of those proving strongest is saved, and (f) by the aid of records of large yield and good quality, as shown in milling and baking tests, the best blood is accredited, and (g) business methods are used to induce farmers generally to grow the improved varieties in place of the common kinds. Numerous experiments on the theory of breeding are also being carried on, some of which will be mentioned in succeeding articles.

The experiment station or the large seed firms in starting to breed wheat may properly collect and try many varieties in order to secure the best foundation stocks. The farmer cannot usually afford elaborate field and milling tests to begin with and he should confine his attention almost exclusively to the improvement of those few varieties which are successfully grown commercially in the region he wishes to supply with seed wheat. Experiment stations and seed firms also can best secure varieties which they may first improve by taking up simple and quick methods of improving the standard wheats already grown by the farmers. Longer and more thorough processes of selection, also hybridization, followed by selection, should also be begun early, but the results of these will later come into available quantities for distribution. It is worthy of note in this connection that each state has only a very few varieties of wheat grown in commercial quantities and the same is true of oats, barley and rye. This makes it easy to select the few varieties to be used in improvements by breeding. Moreover it is easier beginning to sell an improved variety of a kind of known character and quality than new and untried forms. It is of especial importance to experiment stations that the new varieties they first multiply for distribution be kinds not too strange, differing for instance, only in yield, that they may at once become popular with the farmers, grain merchants and millers. It is an advantage to distribute new varieties in the order of their value. Improved varieties make a market for varieties still

more improved. It would be quite impracticable to sell a new variety after selling others superior to it. It has been found quite practicable at the Minnesota Experiment Station to have a progressive series of varieties of wheat coming on for sale to the growers of pure bred seeds who are taking up the work of multiplying for sale the new pure bred field crops originated by the experiment stations, as pure bred stockmen grow for sale animals as improved by a Cruikshank or other breeder. These men pay a good price to the station for new things and having once made a nice profit from raising one of our new varieties and selling it to their neighbors for seed they are the station's best customers when it invites them to co-operate in distributing another new variety which promises to be of still greater value.

As there appears an advantage in taking up first the simpler methods of breeding wheat, plans of originating by selection will precede the discussion of hybridizing and selection combined; and in each of these two general plans the simpler methods will be followed by those more complex. While these suggestions may be open to the criticism that they are given from the point of view of an experiment station worker, the effort will be to have them apply to farmers and to large seed growing firms as well.

Improve Wheat by Selecting Large Spikes.—The experiences of Maj. Hallet of England, Dr. Rimpau of Germany, Zavitz of Ontario, Shepperd of North Dakota, Haynes of North Dakota, Soule of Tennessee, Wellman of Minnesota, the present writer and a number of others demonstrate that the selection of the best spikes, or heads, from a field of wheat will work some improvement of yield. The farmer who has a superior variety of wheat and wishes to sell seed should at least select the best heads from the field each year in quantity to multiply in one or two years so as to grow his entire crop from this selected stock, pursuing some such plan as follows: The first year a man who raises annually

twenty acres of wheat should go through his field and pick out a sufficient number of the best spikes to make, when shelled out, a half bushel of wheat. The second year this seed should be carefully graded so as to secure the heaviest large kernels and sown as a stock seed plot on the best part of the wheat field. This crop should be saved for seeding the entire field the third year so that improved seed may be grown for sale the fourth spring. This should be sold under a number as Jones' Fife No. 3, assuming that Jones has already on his farm two wheats, Jones' No. 1 (Fife) and Jones' No. 2 (Blue Stem) introduced from other farms or perchance from a seed firm or from an experiment station.

It has been found a good rule to give to every stock of grain which has been improved a new number or in some other way to distinguish it so that farmers will keep track of that identical blood. This is especially important if the yield is known to be good and in case the seed is lost the same stock, subvariety or variety, as the case may be, can be again secured from the originator or from some one else who has kept it pure and true to name. The crops grown for seed should be planted on fields free from those weeds the seeds of which cannot be completely cleaned out of the seed wheat; the seed wheat should follow a crop which leaves the soil well prepared for that grain. The seed grower needs to be a live-stock grower so as to keep his lands fertile and so that his fields may be under a system of rotation which will keep the land free from weeds and in heart for crops of plump, strong, fine-looking seeds. Not wheat farmers, but stockmen, are the best men to grow seeds. Live-stock on the farm and crops fed out to live-stock are necessary for growing grain for market on part of the fields of a farm; and for growing seeds to sell for planting; stock and manure-making crops are doubly necessary.

The fields of seed grown for sale should be harvested at once when fully ripe and the grain should be

most carefully shocked, stored in stacks or barns, threshed and stored in bins in such a manner that the seeds will be thoroughly dry and kept dry, so that their full power to germinate and produce fine vigorous heavy yielding plants may not be diminished. Farmers can well afford to pay for fresh improved potent blood in seed grain which has been so preserved that every kernel retains its full power of producing yield and quality. At best our seeds are subjected to many vicissitudes after they are planted and any injury from being wet in shock or bin makes them less able to germinate under unfavorable conditions. And many kernels which are able barely to germinate are so injured in vitality, or the store of food in the kernel is so reduced in amount or in quality, that the young plant is greatly handicapped. The breed or variety of superior power and value when given the best conditions as care of seed, good soil, proper cultivation and excellent climate, will produce the maximum yield.

Future Years.—Each succeeding year a sufficient number of the best spikes to supply a half bushel of seed may be selected from the field in which stock seed is being grown or from the general field wherein seed for the market is being produced or this work may be inaugurated only once every two or three years. This seed should be used to plant each year a stock seed plat to produce seed for the field in which the next year's seed wheat is to be grown for sale. Experimentation is needed to determine whether the selection of the best heads may be permanently used in improving a variety of wheat. It will probably conduce to the production of only one or a few culms and heads per plant, reducing the number of stools which spring from a single seed, or decrease the plant's stooling power. There is little doubt that the selection of the largest upper ears of corn has reduced the dent varieties of corn and also some of the flint varieties from several-eared to one-eared kinds.

It is quite probable that some of the more complex

plans roughly outlined will better serve permanently to make new varieties, and even to improve old ones, though this simple yet effective plan can best be employed by many farmers who wish to improve for sale a variety which they believe is better than their neighbors can secure elsewhere. Too much must not be presumed from breeding under this plan, especially if the yields of the resulting varieties are not really tested by adequate field trials. Where an experiment station follows this or any other method of breeding the resulting varieties, where practicable, should be tested near the parent variety or other standard varieties which they are designed to replace. Milling, baking and other laboratory tests where radical changes are made by breeding should also be made. These final tests give figures of performing ability which may be used as a powerful aid in selling the new variety. On the other hand they may show that the new variety is not as valuable as the old, in which case it should not be distributed. I realize that this contemplates a high standard of excellence in wheat breeding and in seed wheat growing, but I believe the American experiment stations can and will lead in removing the seed business from free seed packages on the part of the Government and from selling by means of overdone word and pencil pictures on the part of seed dealers. Statistical methods in breeding and in selling are revolutionizing both plant and animal breeding.

Selecting the best heads of wheat wherever carefully tried has given an increase in the crop. Though that increase is on the average small it would seem quite legitimate where tests of yield can not be made to sell seed thus grown from common varieties known to excel even before the product of the new variety has been grown sufficiently long to be tested. The present always seems even more important than the future and the improvements easily made, though they be very modest, should be made at once available for the farmers to use. The more pronounced improvements which

can be made by longer, more expensive and more complicated methods possible on a state experiment farm can be paid for from the profits of this first work. The results of hybridizing are sometimes misleading, while varieties produced by selection from standard sorts are nearly always reliable. If carefully grown, stored, cleaned and sold, seeds selected as indicated from standard varieties give the grower, whether a farmer or seed firm or an experiment station, the confidence of the farmers.

These varieties sold in nice form serve to use in learning how to advertise, sell, pack, ship and to follow the resulting benefits from the distribution. The yields secured by purchasers of new varieties may also serve as a source of information of yields and quality which may be used as testimonials to encourage others to look to the breeder for superior seeds. Even the seed breeding scientist at the state experiment station will find many perplexing questions in the work of placing his new varieties before the public. He may not want especial financial returns for the station, but he does want the value of his varieties fully recognized and he is not doing his duty to his institution unless he secures for it just recognition of any improvement made whether of scientific or of economic value. But the important point is that the facts as to average yield of value per acre of new kinds be so collected, tabulated and advertised that the conservatism of farmers will be overcome and that they will be induced to adopt the better varieties and widely use them. It may be that the new variety produced by the practical farmer is best sold through seed firms, but even then the breeder needs experience and knowledge of how best to deal with them and advertise his varieties so that the dealer may bring the improved seeds into general use to the profit of breeder, dealer and grower.

CHAPTER VII.

METHODS OF PLANTING NURSERY WHEAT.

The method of breeding wheat outlined in previous pages may result in an average increase of 5 to 10 per cent. over large areas while occasionally no increase results. But to secure more radical increase more effective plans may be pursued, requiring more of method, detail and time. In the plan already outlined the improvement is secured by choosing the best heads. These may be from seeds which, on account of producing only one or two culms, could develop one strong head. It is probable that selecting too large heads for a long series of years might reduce the stooling habit. This might result in reduced yields, especially in years when climatic and soil conditions are unfavorable to stooling, which condition frequently occurs in case of spring wheat. On the other hand a variety so bred as to produce only two or three large culms, instead of dissipating its energies on a number of small culms with no heads, might require more seed to the acre and have the advantage, providing more seed were used per acre, thus depending on more primary culms and fewer seeds. Besides, more pounds of seed per acre give more food to the plantlets, making them more independent of the soil food during the earliest stages of growth. An experiment now under way may later on indicate the solution to this point. These thoughts illustrate that we need to better know the theory of breeding, and more experimenting on the theory of breeding is needed. Actual knowledge of these seemingly minor matters often is of great importance in practical breeding.

But try as we may to select superior heads in the field and superior berries in the bin, we come around

finally to the individual wheat plant as the unit. Just as in animals, so in plants we must record and compare the breeding powers of the individuals. The group of several culms from the single parent seed, each bearing a spike of wheat, constitute the plant. The spike or ear of wheat, generally called head, is no more the plant unit than is one of the several ears on a branching stalk of popcorn. In breeding plants we deal with blood lines just as we do in breeding animals. Since in the thickly-sown wheat field at harvest time we cannot discern the culms arising from one seed which are interwoven with the culms from another seed, wheat must be grown in hills, one seed in a hill, that one plant may be compared with another. It has been found by both formal and extensive practical experimentation that 4x4 inches is a suitable distance to grow spring wheat, and 5x5 inches winter wheat, where the individual plants are to be compared. Wheats thus planted in plots and the entire plants compared are bred on a far different basis than wheat bred by selecting out the best heads in the field or by selecting out the best kernels by means of the fanning mill. Those methods are worth while and should be carefully followed in general farm practice and by all wheat seed growers and particularly in case of new varieties which have had the abnormal quality of high yielding made still more abnormal either by selection or by hybridizing aided by selection. But nursery breeding as described in future pages is very much more important as a method for wheat improvement.

In 1893 Henry Vilmorin, the great Paris seedsman and plant scientist, said that "wheat flowers are nearly always self-pollinated, not one in ten thousand being fertilized by pollen from another plant." Formal experimentation shows that his statement is substantially true. This fact makes wheat breeding a very unique problem, although many other plants are also commonly self-fertilized. Talk about inbreeding, here is the most incestuous of inbreeding! Self-breeding is the almost

universal rule, the stigma or female organ receiving the pollen or male element from the anthers of the same floret. Wheat thrives under this closest of close breeding and when crosses are made, in many if not in most cases the average of the progeny is poorer than the average of the parents. Darwin might well say that wheat often seems to abhor crossing. His dictum that plants and animals abhor self or very close breeding might more broadly cover the facts if stated in some such form as follows: Plants and animals abhor radical changes in their accustomed habits as to the closeness or wideness of their relationships of parentage. Thus in corn, where comparatively few of the flowers receive pollen from the same plant, self-fertilization and presumably breeding between close relationships greatly reduce the productiveness of the plants, while close fertilized species are not injured even by self fertilization. Because wheat is close-fertilized it is peculiarly adapted to use in illustrating some problems in breeding and is proving a useful living organism in developing statistical methods in breeding and in studying some problems in heredity.

To study individual plants of many species of plants and to use them in large numbers in pedigreed breeding and to carry on statistical studies with plants a method of planting and a system of records have been devised. The seeds of wheat and other small grains are planted in beds 5x42 feet in area. In case of wheat the hills are 4x4 inches apart and one seed in a place, or two or three seeds are planted and then thinned to one plant in a hill. In case the viability of the seeds has been impaired planting two or three seeds insures a full stand, but great care is necessary to thin to one plant in a hill, as hills with two plants would wrongfully be chosen as the best in the plot. During the past eleven years approximately a million plants of the various field crops have thus been grown individually in hills, and from necessity a system of planting and records has been evolved. The 250,000 plants now in the field crop

breeding nurseries at the Minnesota Experiment Station could not be managed as one of the several lines of work there in progress were not a system used and trained men employed in carrying out the details. Methods of planting have been evolved which greatly expedite the work and in many cases place the seeds in the soil under the most favorable conditions. Wheat and other small grains are planted 4 or 5 inches apart each way, timothy, soy beans and white beans a foot apart each way, and alfalfa and red clover two feet apart each way, while field peas, bromus, and white clover are planted three feet apart. Distances and depths to plant are only tentatively determined and those found best in Minnesota would not prove best in all localities. The depth to plant the seeds must be regulated very much by the conditions of the soil and climate. In most cases the figures may be taken as averages, planting shallower for early spring with cold soil and wet weather conditions and deeper for late spring with drouthy open-soil conditions. The planting of wheat is done in carefully-prepared beds, preferably on land which was bare followed with frequent cultivation the previous year to reduce to a minimum the insect enemies and to furnish a fine seed bed easily made mellow and uniform in texture. The stocks of wheat are planted in beds, both to admit of clear demarkation of plots in note-taking and to provide slightly depressed paths to prevent rains from washing across the plots and to serve as paths for workmen who must do much hand work in planting, cultivating, note-taking and harvesting.

Since wheat roots spread widely it has been found necessary to discard the outer two rows of the bed, or plat, in some theoretical experiments. In many cases it has been found convenient to place between the different stocks of wheat two rows of variety differing in general appearance, so that these rows may be cut out before harvest, that the plats may be thus set apart by these narrow alleys so as to make note taking easier, each plat standing out by itself. All these are called

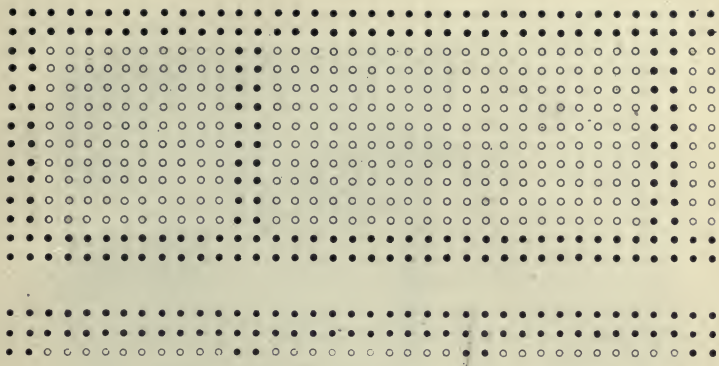

Fig. 1. Method of placing plants in hills.

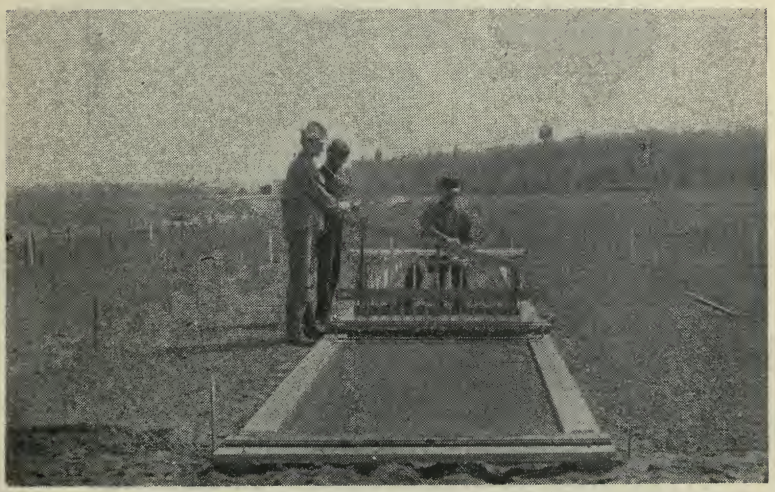

Fig. No. 2. Nursery planting machine without tent. The man sitting drops a seed in each of the 14 cups and dumps them in 14 tubes. The man at the lever throws the machine forward four inches at a time, thus planting the seeds in squares 4 x 4 inches.

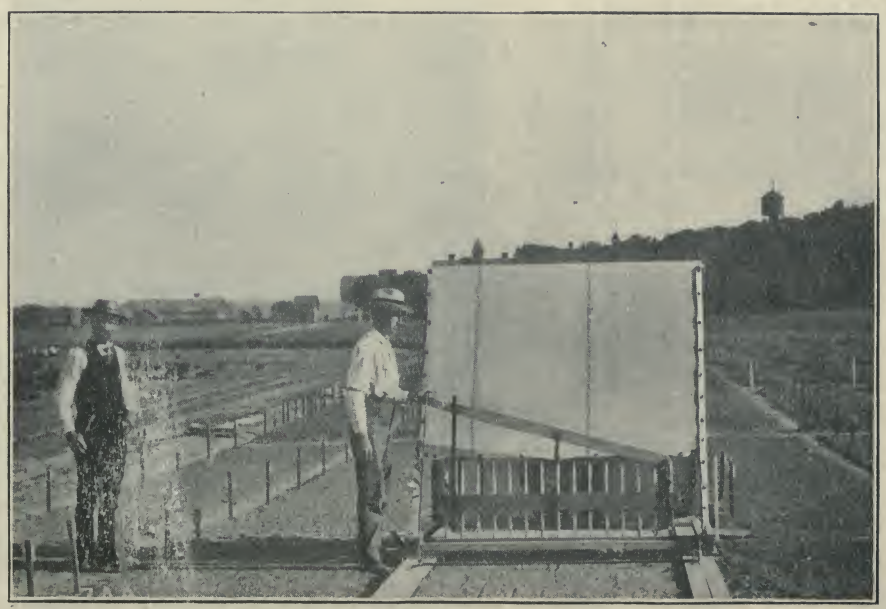

Fig. 3. Nursery planting machine with tent to protect from wind.

border plants and are cut off with a hand sickle and sheep shears and discarded before taking the harvesting notes. As many of the plots consist of a hundred plants of one generation the removal of the side and cross border rows causes the little plots forty inches square or the longer plots to stand out distinctly to be judged and notes made of each plot as a definite unit, often a fraternity group from a single mother plant. Fig. 1 illustrates the method of placing plants in hills and grouping them in beds. Originally these plots were planted by hand in cross marks made in the soil, a plan still used in case of plants which must be planted a foot or more apart. A mechanical method of planting has been in course of evolution for some years and has been so far perfected that it saves half the immense labor of planting. With the machine illustrated in Fig. 2 the seeds are planted very regularly in the squares at a uniform depth and so rapidly that with one or more machines large plant-breeding nurseries may be put in early in the spring. In. Fig. 3 the machine is shown covered with a tent put on simply to prevent the wind from scattering the seeds. This makes it possible to plant the wheat, oats, barley, flax and other species which are planted in close hills during windy days. The still days are then available for the early planting of timothy, clover, alfalfa and other small seeds which are planted far apart and by hand. Thus all seeds for early planting in the season are gotten into the soil when the conditions are most favorable. Here at the North the spring opens late, but suddenly and the transition to summer conditions of heat and often drouth covers a very short period, making early planting of small grains, grasses and some clovers very desirable.

At either side of the plot, 5x42 feet in area is a track forty-five feet long made up of 1x8 boards, the two tracks being bolted at either end to cross pieces to hold them in place. These cross pieces give sixty-two inches between the tracks, allowing room for fifteen rows four inches apart of grain to be planted at once,

or five rows a foot apart may be planted. By discarding the outer two rows on either side there are eleven rows left. By leaving off one row in planting, the little plots may be blocked out ten hills square, 100 plants in each. But as some hills are usually blank, necessitating counting the actual number of plants harvested in the centgener trials, there is no special advantage in having the plots exactly ten planks wide. Boards like sled runners resting on the track carry the machine. A system of levers enables an operator to place grapples in holes four inches apart in the track and carry the machine forward four inches for each new row. Through a strong cross piece connecting the two runners are fifteen holes through which pass tubes, serving as drill holes extending a few inches into the soil, the depth being regulated by the thickness of the runners. These tubes extend upward nearly two feet. Above them is a cross frame bearing fifteen pint cups. A man sits on a comfortable seat and drops one seed, in some cases two or three, into each cup, then tips the cross frame and drops seeds into all the fifteen hills at the same instant.

The operator of the levers throws the machine forward four inches, and the rows are thus rapidly and accurately planted. The operator and the dropper thus are able to plant the seeds at uniform distances apart each way.

To make the depth uniform a board straight-edge is used to dress down the soil between the two tracks, leaving it two inches below the top of the track at all points. Wheat is usually planted two inches deep and as it falls through these tubes it always lies on moist soil at the bottom of the furrow. It is observed that seeds planted with this machine germinate much nearer at the same time than do those put in carefully with the hand dibble. The soil needs some attention after planting. Heavy rains often require going through the narrow rows with small two-inch tined hoes to break up the crust. Usually one cultivation is

necessary and care must be used in pulling out of the hills every weed, as a weed will make the conditions poor for the plant beside which it grows, thus destroying the primary basis of the comparison of the individual plants.

When nearly ripe the border plants are all removed by means of a grass sickle or sheep shears from around and between the plots, the grain being tied in bundles and shocked up at one side of the field. Notes are now taken according to the purpose of each experiment. In some cases it is desired simply to secure a large number of superior plants. In other cases a smaller number of the very best plants are wanted for mothers of centgener plots. In the comparison of the progeny of mother plants the best heads are wanted for the best plants and the number of plants harvested and their yield of grain are desired. In yet other cases theoretical studies of breeding require that statistics be gathered of numerous measureable qualities of each individual plant. The plants may be pulled up by the roots or may be harvested, or may be cut off with sheep shears or grass hook, as the purposes of the experiment require.

This article is already too prolix with details and the system of numbering, the detailed herd-book method in use, would seem a little cumbersome to insert here. Each variety secured by the station is given a number with the name of the state prefixed, as Minnesota No. 169 wheat and Minnesota No. 13 corn. Each plot in the nursery is alloted one or more hundreds in a system of numbering which allows a number for each individual plant. Each new plot begins to number with the even hundred and one, thus 101, 1101 and 1201, even though the previous plot did not fill out the full hundred last previous numbers. By discarding the two figures at the right the remaining figures at the left have come to be used as the centgeners 1, 11, 12, while the entire number stands for the first plant of the respective centgener plots. It should be observed that should

a plot have any number as 100, 1043, 1235, 83, or any other number, the centgener number of the plot following is secured by adding the number in the plot and counting the last hundred as if it were an even hundred.

Thus a plant in plat 83 might have the number 8374; or a plant in plat 1235 might have the number 123532, etc. A stake at the beginning of each plot bears the centgener number which is the pedigree number of that stock. In the nursery year book this year's centgener number in one column and last year's in an adjoining column connect each stock historically with its ancestor as completely as the Short-horn Herd Book shows the historical part of parentage of the "red, white and roans."

CHAPTER VIII.

VARIOUS METHODS OF BREEDING WHEAT.

A second method of breeding wheat, more effective than the method adapted to the conditions of the farmer given on previous pages, may be outlined as follows: Plant of a standard variety of wheat 5000 seeds in hills as mentioned in previous paragraphs. When ripe remove all but 500 of the plants which appear to be the best yielders. Harvest the spikes of each of these separately and place them in a packet. Weigh the spikes from each plant and discard all but 200 of the best plants. Shell these, weigh and grade the seeds and discard all but the best 50 plants. Mix the seeds of these 50 plants together rapidly—multiply into a variety and distribute the fifth to the seventh year. Wheat thus bred will have a more interesting pedigree than that bred by the first method. It will serve to offer for sale as a variety a stock of seeds of the original variety more improved than that first sold and should prove profitable to purchasers. Since it is based on the blood lines of 50 mother plants, chosen for high yield and superior quality of berry, its milling and bread-making properties will differ little from that of the standard parent variety used as foundation stock. The farmers and millers will accept improved forms thus originated with little fear of lack of quality in the flour or bread. It is worthy of note that in Canada millers have found fault with Prof. Zavits for having brought about the general use of one or two varieties of wheat which have lacked so much in quality that the output of the mills was unfavorably affected. To compete with the best flour the mills must have wheat with gluten of good color and especially tough and strong in the dough. Prof. Zavits evidently paid too strict attention to yield and

appearance of berry and had no adequate facilities for making milling and baking tests. Prof. Zavits did not carry his breeding farther than finding throughout the world those varieties which would yield the best, and breeding them by a plan similar to the first plan mentioned in previous pages. It is not probable that this method of selecting within the variety materially changed the quality of the grain, although he made a material though modest increase in yield. The lack of milling quality, no doubt, was in the varieties as originally introduced from outside the Province rather than produced by his methods of selection.

In England in like manner the scientists are seeking to correct a similar fault in the winter wheats. They write that the wheat breeders have injured the quality of the wheat, and they are seeking the blood of American winter varieties which are of especially strong milling quality to hybridize with their large yielding wheats. Wheat breeders in breeding for yield alone have made a similar mistake to that made by breeders of Short-horn cattle, who bred for beef and neglected the dairy qualities. It is far easier to breed for a single quality than for two or more, but it is a anarrower business proposition. The wheat breeder wants the greatest value per acre; and to get that he must combine good yield with good quality. The Short-horn breeder also wants the greatest profits per animal or per herd. and to secure that good beefing quality and good milk-giving powers combined are best. In neither case can we have the greatest excellence in either one quality, but we can have the greatest general value for the general farmer in the variety or family in which the two qualities are combined. Since the quality of flour is greatly jeopardized by some of the methods of breeding wheat which are mentioned below these questions are as vital to the wheat breeder as is the dual-purpose problem to the breeder of cattle. Both problems will lend themselves to scientific methods where statistical facts take the place of vaporizing theory. But this

will be referred to further under the heading of cattle breeding in future articles.

A third method of breeding wheat carries the recognition of the individual plant still further. Here an actual and successful experiment will serve to illustrate both the method and its results. Ten years ago last spring the writer planted several thousand wheat plants, one plant in a hill. In those days the hills were placed 12 inches apart instead of 4 inches, as now. The seeds of those plants which appeared to yield heaviest were harvested in separate packets. These were carefully weighed and graded and 31 of the heaviest with superior quality of berry were chosen as mother plants. The next spring 300 seeds were planted from each mother plant, again 12 inches apart each way. The third spring a quart or so of wheat from each of the 31 sticks was planted and one-half bushel of each was secured. The fourth year larger plats were grown in comparison with the several parent wheats which had been used as foundation stocks. This was repeated the fifth and sixth years, when eight of the 31 new varieties showed average yields here at University Farm superior to the old varieties. Four of these were of especial promise and two, Minnesota No. 163, a new fife variety, and Minnesota No. 169, a new blue stem variety, were chosen to distribute. In the meantime these varieties had been tested under agreement not to distribute by the three sub-stations in Minneota and by the North Dakota, South Dakota and Iowa Stations. By 1899 Minnesota No. 163 had been so increased in quantity that 200 bushels were sold to Minnesota farmers; in 1900, 100 bushels were sold and in 1901 again 200 bushels were sold, in all cases to farmers selected by the State Expeiment Station. In 1899 carefully gathered statistics from growers showed that this wheat yielded over two bushels more than its parent variety and about one bushel more than blue stem wheat. It should be said that fife and blue stem are almost exclusively grown in the State, the latter predominating in the

Southern part and gradually supplanting the fife in the Northern half of the State.

Estimates show that there are about 60,000 acres of Minnesota No. 163 wheat now growing (1902) in Minnesota. This new variety producing wheat worth a dollar per acre more than the varieties it is supplanting will add enough wealth to repay all the money the station has ever spent in introducing and improving crops. If this wheat could be increased five fold for three or four years more it would cover the State and the increased yield would be worth several millions of dollars annually. That result is not to be hoped for, but it promises to increase rapidly and cover a large portion of the wheat acreage of the State. But the station has other and still better varieties coming on and it is our ambition to increase the State's yield five instead of one and one-half bushels per acre by breeding; and also a similar amount by so improving the farm management that the fields planted to wheat will be better prepared for that crop. This seems practicable both by choosing the kind of crop preceding the wheat and by better methods of tillage and manur ing. Minnesota's average wheat yield is 13½ bushels per acre, while England's is about 30. It is the aim to bring Minnesota's yield up 10 bushels, or to 23½ bushels per acre. Too high? Should it not more nearly approach that of England even if she has longer seasons, cooler, cloudier summers, and mild winters, permitting the use of winter wheats?*

It would be manifestly unsafe to distribute varieties originated under this third plan from single mother plants without first testing their ability to yield larger crops of grain of superior quality. The new varieties are run annually in plots of one-tenth or one-twentieth of an acre for three years. Since wheat is close fertilized these can be planted only two feet apart as shown in the picture of a man harvesting plats of wheat.

The bundles from each plat are carefully shocked separately and as soon as they are sufficiently dry they

Fig. 5. Weighing bundles on way from plat to threshing machine.

are drawn to the barn and threshed. The station had a machine especially constructed for threshing small plats. It is simply a small-sized threshing machine so reconstructed inside that no ledges or other places will allow grain to lodge. Each variety thus runs out clean before the next variety is started through the machine. So as to doubly insure that the varieties do not become mixed, most of the grain from each plat is placed in a large bag and a half bushel of that which runs through near the last, while the machine is yet "running full," is saved out in a small bag to use in planting the test plat the next year.

During one of the early years of these field trials milling and baking tests are made. Very satisfactory tests are made of the amount and the quality of the gluten with only a quart of wheat run through a test roller mill. And wheats which are thus shown to be poor in quality, unless their yield be so high as to more than compensate, are discarded at the end of the three annual field trials. The remaining wheats which have shown superiority are now distributed to other stations for trial under agreement that the originator shall have the say as to when they shall be distributed. This precaution protects the station and enables it to later secure the co-operation of farmers who will aid in distributing new things if they have an even chance with others, to sell at the same time as other introducers, that they may make profits from extra care, advertising, etc. This plan of securing farmers to co-operate with the Minnesota station promises to result in the two new wheats already distributed rapidly displacing the two parent varieties. In case of Minnesota No. 169, the second new wheat distributed, nearly 1600 bushels were sold last spring (1902) to nearly 400 farmers, four bushels to each at $1.50 per bushel. These co-operators were chosen by the station because of their being recommended by other farmers, or by local grain dealers, as men adapted to seed grain growing, and

through personal correspondence were induced to join the station in introducing this new variety. These men are well distributed throughout the counties of the State.

CHAPTER IX.

PROJECTED BREEDING EFFICIENCY

Previous paragraphs have dealt with superior wheat seeds, spikes which excel, and individual plants which yield more value in grain than do their fellows. But there is another and far more important measure of the value of plants to be chosen as parents of varieties. Some plants and animals are large, strong, hardy and very prolific, but without the ability to transmit their prolificacy and other qualities which combine to make up all-'round values. Because the individuality of the plant or animal is visible, present before us, we are wont to give undue weight to the value in pedigrees of the show characteristics, or even to qualities of the largest intrinsic merit shown in the individual, and to undervalue the more subtle, yet far more valuable ability to project a high value into future generations. Breeding power, "projected efficiency;" of high general value, is what should be sought.

A man with twenty trotting-bred mares and with a choice between a 2:10 stallion with a large number of 2:30 colts and a 2:30 stallion with a large number of 2:10 colts would not waste a breath before choosing for the sire the horse which had sired the fast trotters. In wheat breeding we found after a few years that the columns in our tabular score card telling the yield of mother plants were no longer even scanned. When we compared the average yields of the progeny of a large number of mother plants we instinctively neglected the yields of the mother plants. We learned by extended experience that the progeny with the best individuality from each generation is not always the best breeded and is sometimes a relatively poor breeder. We learned that the true measure of the breeding value of the

parent plant as well as of the parent animal was to be found by measuring a large number of its progeny. Formerly we had been content to breed from the best individuals; now we have learned to use the blood of the best breeders and to devise methods all along the line to measure breeding powers in the terms of averages of large fraternity groups of progeny.

Since there is only one very strong breeder in thousands of a given race of plants, and Francis Galton showed that there is only one really brainy man in 5,000, it was necessary to devise experimental and statistical methods of measuring and recording the breeding values of wheat and other plants in the terms of the average of the progeny of the respective parents. We want the blood of that one wheat plant in 10,000 whose blood will add a bushel of wheat per acre to the wheat crop, or, perchance, that one wheat plant in 100,000 whose blood lines will add three dollars per acre to the value of the wheat fields of the State. And we want a method of ferreting out those blood lines. We also want the blood lines which will make a general-purpose breed of cattle—seemingly a simpler proposition with a scientific, statistical method than it was for our fathers to have made a trotting breed of horses from a running breed by using a very crude statistical method of breeding. Statistical methods of breeding will not make mere name pedigrees and pedigrees based on mere art go out of use, because we have use for all these methods. But statistical pedigrees need incarnation. We have truly been playing at pedigree-making in some lines where science and facts should have prevailed more and mere artistic judging less, and far greater progress should have been attained. Without breeding, many of our best varieties of wheat, oats and the like have gone backward and under breeding it may be that some of the families of certain breeds of hogs and cattle, if not of other species, have become of less average value than formerly.

CHAPTER X.

NURSERY CENTGENER BREEDING OF WHEAT.

The following method is now in use at the Minnesota Experiment Station for testing blood lines of superior mother plants of wheat and multiplying them into new varieties.

From a large plot or a field of wheat select a sufficient number of heads so as to have several thousand large fine berries. The second year plant in nursery plots 4x4 or 5x5 inches apart each way, one seed in a place, 10,000 hills. When nearly ripe with the aid of sheep shears or a grass hook remove all but 500 plants. Cut the heads or spikes off each of these plants, not including more than an inch of the straw below the spike, and put in a packet. Remove each bunch of the spikes from its packet and weigh. Discard the half or two-thirds that are poorest in weight, and shell the remainder. Again weigh to get the net weight of grain and inspect for quality. Compare the net weights and grades and throw away all but one hundred. The third year plant a little plat ten plants square, 4x4 inches, from each of the one hundred mother plants. At harvest time pick out the best ten heads from what appear to be the best ten plants in the plot for stock seed for a similar plot next year. As there will be some blanks count the number of plants harvested, then thresh, weigh and divide the weight by the number of plants harvested to get the yield per plant. Pass judgment upon the grade, putting all grades into percentages so that they may be averaged. With the grain from the ten selected heads plant the fourth year a similar plot and repeat the fifth year. Add together the yields per plant for the second, third and fourth years and divide by three. Similarly average the

grades for the three years. From the one hundred new varieties thus compared choose the five to ten which give the best yield and grade.

The sixth year one of two methods may be employed. The seed from the five or more plants may be mixed together and a new variety thus made of the combined blood of several mother plants; or a variety may be made from each of the five or more mother plants. In either case the new varieties thus made should be multiplied the seventh year to produce a sufficient quantity of seed to plant a test plat of one-twentieth or one-tenth of an acre field. We are in the habit of running these field test plats through three years of successful comparisons, thus testing them during the eighth, ninth and tenth years. As hail, chinch bugs and other troubles strike experiment plats as well as practical fields of wheat it sometimes requires four or five years to get over this part of the tests. Among these field plots of new wheats are always interspersed plots of our standard wheats with which to compare the new kinds. We at once become interested in any of the new kinds which show pronounced ability over the standard wheats in yield. We make milling and baking tests, and, if necessary, chemical laboratory tests. Any of these varieties which still give promise of increased yields per acre are then distributed to the co-operating stations and there tested. Any variety which here distinguishes itself as adapted to a group of States or to a district within a State is rapidly increased during the tenth, eleventh and twelfth years to a thousand bushels or more and sold to co-operators. By this method about twelve years are required from the time the start is made until the variety is sent out to the farmers. This seems a long time to the beginner, but once there are on hand more varieties of wheat than the experiment station or a large seed firm can distribute the matter of time when a new variety is ready for distribution does not become of so great moment. Some original varieties are going into the

nursery and resulting new varieties are coming out each year.

This method may seem complex and like going too much into minutia for anything practical, but when it is realized that a single kernel of wheat has in a number of instances been multiplied into a permanent commercial variety the relative breeding power of one mother plant as compared with another becomes a matter of great significance. Some mother plants are so weak in their ability to project their good qualities into their progeny that in a few generations the stocks run out. Other mother plants are average in their ability to produce yields in new varieties; still others have superior ability. One wheat plant in Minnesota has been so multiplied that its progeny is now covering about 60,000 acres of land. If that stock of wheat were increased ten-fold for a few years it would be of sufficient quantity to sow all the wheat in two or three States. If the progeny of one kernel of wheat can be so rapidly and widely multiplied there is wrapped up in the possibilities of that one kernel large values. It would seem that it is quite worth while for States and communities to expend reasonable sums of money in testing the breeding powers of individual plants and having found superior ones use renewed effort to bring about their general cultivation.

The pedigrees of these mother plants are kept with quite as much care as are the pedigrees of pure bred cattle or horses. A system of numbering has been devised so that each little plot has a number and, if desired, each little plant within the little plot is given a number. In the nursery year book the plot number of this year is beside the plot number of last year, thus enabling the foreman to trace the blood lines back through a series of years. The progeny of each mother plant is also given a nursery stock number which serves as a name so long as that stock is in the nursery. This is sometimes necessary as a nursery stock often remains in the nursery for a series of years and more than

one field variety might be taken from the same stock number. In other cases several stock numbers are collected into a common variety. This is allowable where all of the stocks are the same in appearance and in quality. When the varieties are taken from the nursery to the field they are given what we call State or Station numbers, e. g., Minnesota No. 163 wheat or North Dakota No. 105 corn. To these numbers soon become attached their yields in the field plot tests, their record in the mill and breeding laboratory, also their yields at outlying stations and, finally, varieties which are distributed to the farmers are compared on a large number of farms with the varieties in common use and average farm yields are secured. Average yields as compared with standard and other varieties all along the line thus become the statistical part of the pedigree of these new varieties. When it comes to selling a new variety statistical facts if materially favoring the new variety are a great help in inducing farmers to purchase it. Seed dealers have already begun to use our statistical wheat pedigrees. It is of interest in this connection to note that custom has regulated the price of seed wheat at only a few cents above the price of similar wheat which would grade the same for market purposes. This makes it impracticable for seed dealers to try to make profits from selling good looking seed wheat, that is wheat merely of good grade of the ordinary varieties. There is not sufficient margin to pay for advertising and other necessary expenses. Wheats with statistical pedigrees will overcome this trade difficulty and will enable seedsmen to introduce new kinds into communities which have long held to old and in many cases very unprofitable varieties.

A system of keeping records and pedigrees of wheat, corn, sugar beets, clover, pumpkins and other field crops has been devised which is proving very satisfactory. This system has been followed during the last dozen years and has been used for the past two

years with very little modification, having proved adapted to nearly all new conditions which are constantly coming up in the work of making varieties and in the theoretical work of studying problems of heredity and breeding in plants. Some of the methods used in these records are proving satisfactory in keeping the records of animal breeding also.

CHAPTER XI.

CROSS BREEDING AND HYBRIDIZING OF WHEAT.

In Chapter IX a statement was made of the methods used in measuring the breeding power or "projected efficiency" of single mother plants of wheat. It can readily be seen that the value of varieties of wheat, which it is possible to make from any original variety adopted as a foundation stock, is determined by the peculiar breeding power or value of the best plants within that foundation stock. As a stream cannot rise above its source, so varieties better than the blood of the best plants in the original variety cannot be made. The plan outlined has proved well-adapted for cheaply eliminating all but the best and thus securing the blood of the best plants. Methods have been found also of making extended field, laboratory and baking tests of these new varieties originated by selection. Business methods have also been devised for effectively placing quantities of these new varieties on the market under statistical pedigrees, which show their intrinsic values in a way that will induce farmers to use them, and seed growers to grow them in large quantities for sale, thus rapidly bringing about their wide and general use, supplanting kinds of less value.

The question now arises, are there not means of securing mother plants of still higher breeding value than those originally existing within a given variety of wheat? Cross-breeding and hybridizing have proved of greatest value in this connection. It seems a matter of convenience hereafter to use the term "hybridizing" in a more liberal sense than is the general custom, that one term may be used to cover the crossing of varieties as well as of species. In a future article, before taking up the subject of the breeding

Fig. 6. Parents and progeny of wheat hybrid.

Fig. 7. Field crop nursery at harvest time.

Fig. 8. Cross-fertilizing wheat.

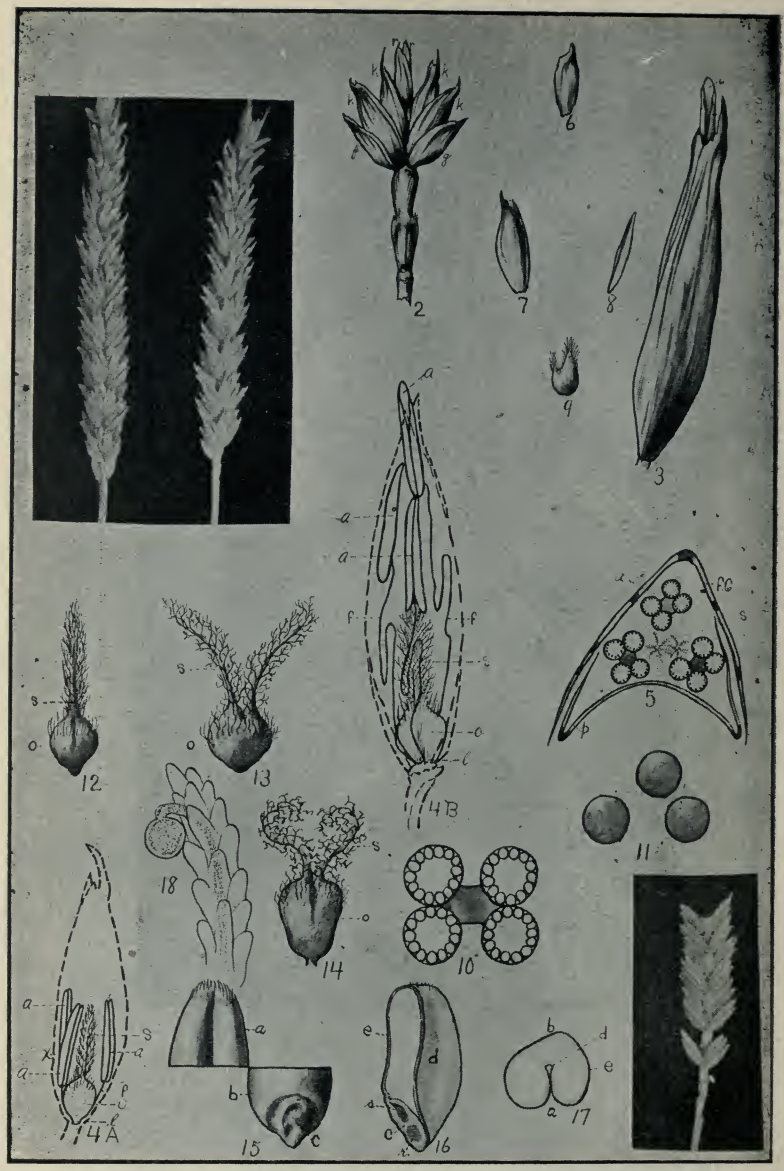

Fig. 9. Wheat spikes, flowers and seed.

of cattle and other species of animals, a discussion will be presented giving expression to some of the facts of variation by means of graphic illustrations, curved lines and other diagrams. For the present it will be sufficient to discuss the fact that greater variation is produced, and the methods of ferreting out plants which have the highest breeding power. The fact should be at all times kept in mind that increasing variation of hybridization does not always increase the average value of all the progeny. The practical business fact is that it does increase the value of those few which vary in the desired direction. By proper statistical methods of breeding we simply throw out all but the few best and base the new variety on these few. We deal not with the average of a given hybrid, but with the blood of the few best breeding individuals in the hybrid. That hybridization causes variation is shown by the photograph in Fig. 6. At the right in the upper row of heads is the blue stem plant used for the male parent, and at the left the fife wheat plant used as the female parent. The middle and lower rows represent types chosen from among the progeny, showing that great variation was produced Here are plants which resemble the female parent, others resembling the male parent, and other plants which resemble numerous other known varieties of wheat, still others of entirely new types, compounded out of the blood of the two parents.

Henry Vilmorin, the great plant breeder and seedsman of Paris, showed the writer varieties of wheat representing all of the sub-species of that grain which he claimed to have produced by crossing two common varieties of different sub-species. In some cases of superior mother plants among hybrids there is no essential variation in the botanical type, but in size of heads, yield of grain per plant, quality of grain and other individual characteristics, there may still be a difference of a practical nature. There is also a very great difference between the breeding power of these hybrid

plants. By hybridizing two varieties of wheat we secure in occasional plants of the new hybrid many of the good qualities of both the parents and in some quite new qualities are created and new value added to old qualities. By testing tens and even hundreds of thousands of the progeny of a given cross we are able to find an occasional plant which has breeding power superior to that found in the parent varieties. The amount of labor required in merely hybridizing is only a very small part of one per cent of the work of making new hybrids wheats. It consists in increasing the hybrids to a large quantity so as to get good vigorous parents to put in nursery trials, testing the mother parents in the nursery so as to eliminate all but those which actually yield best and produce the most value per acre. The milling, baking and laboratory tests are even more important in case of hybrids than in case of wheats produced mainly by selection from good varieties, because in hybrids the quality is often changed from the quality of the parent varieties. It is both wrong and dangerous for an experiment station to distribute a new variety of wheat until its milling and baking value have been definitely determined, and especially so of new hybrid varieties.

Fig 8 shows students at work making hybrid wheats. The necessary manual dexterity can soon be acquired under instruction, or by studying the matter from pictures shown herein one could soon learn to cross-pollinate wheat.

In Fig 9 with the subjoined notes are shown many facts about the wheat flower. Any boy or girl who is interested can take the wheat flower apart at the time it is ready to blossom and verify the truth of all the diagrams shown in this figure.

The essential parts of the flower are the covering of chaff, the female portion of the flower shown at O and S, in 4 A^0 and 4 B^0; also at 12^0, 13^0 and 14^0 in Fig. 4.

At the flowering time the stigma spreads out from its appearance at 12^0 to that of 13^0, and soon after

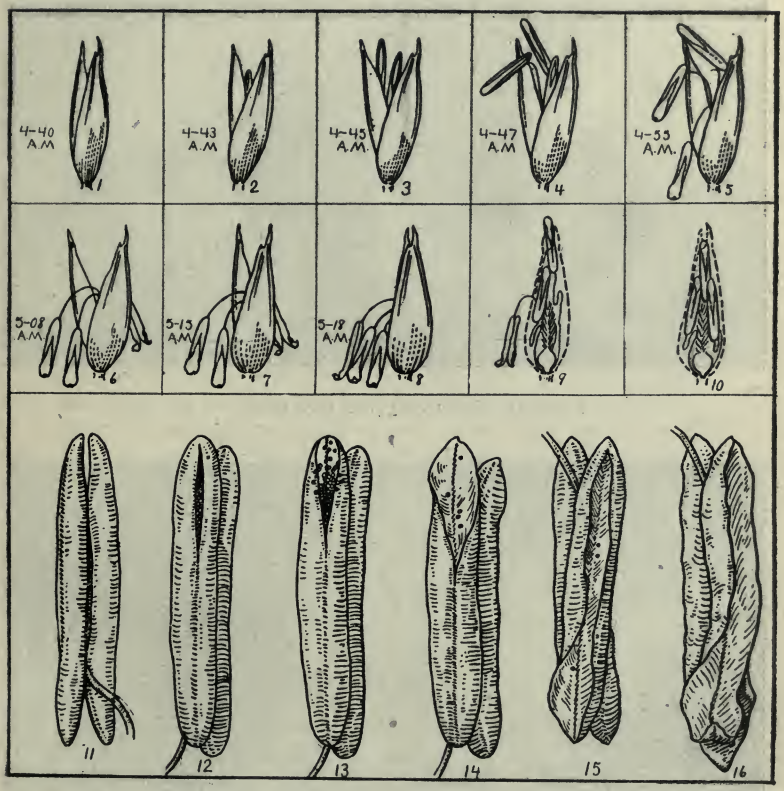

Fig. 10. Opening habit of the wheat flowers and anthers.

Fig. 11. Removing the florets.

Fig. 12. Extracting the anthers.

flowering the stigma is shriveled up as in 14°, but the ovary is enlarged and the growth of the grain is begun. At the time of flowering, the anthers, aaa-4 A°- also shown in cross section in 5°a and in 10°, are rapidly pushed up by their filaments, as shown in ff-4 B°. The opening of the flower is shown in Fig. 10. In this case the actual movements of a flower were observed and recorded from opening to closing. This opening can best be observed in our spring wheats by going out early in the morning and observing the flowers that are nearly ready to open, the anthers breaking open and depositing the little grains of pollen on the stigmas. These grains of pollen are shown in 11, Fig 9, lining the walls of the anther which is there shown in cross sections in 10, Fig. 4, as spherical bodies. In nearly all cases the pollen falls on the stigma of the wheat flower while the anthers are being pushed upward by the filaments and before the flower is fully open. In some cases the filaments succeed in pushing the anthers out so that they fall over and are not caught by the two portions of closing chaff, called flowering glume and palea. The breaking open of the anther sacks and the scattering of the pollen grains is illustrated in Fig. 10 at 11 to 16, inclusive. In some way not readily understood wheat florets nearly always self-fertilize themselves. Vilmorin and Rimpau have estimated that not more than one floret in 10,000 is cross-pollinated, and this is nearly a correct statement. It may be that owing to its being accustomed to self-pollination the floret's own pollen grows into the stigma more rapidly and more quickly unites with the ovule than pollen from another plant of the same variety, or than pollen from another variety.

The plan commonly followed in handling wheat spikes is to remove the smaller spikelets at the tip and also at the base of the spike. Then remove the smaller florets at the center and base of the spike, as shown in Fig. 11. The remaining are all emasculated by opening with small, sharp tweezers, as shown in Fig. 12, and pulling out the three anthers. This is done when the

floret is young and the anthers still greenish in color, though nearly ready to turn yellow, and as they ripen to break open and shed their pollen on the stigma. After emasculating the head of wheat it is covered with tissue paper, gently tied on, to prevent the introduction of foreign pollen. In 24 to 48 hours, when the stigma has become receptive, as shown by the opening of neighboring florets of the same age, the covering is removed and pollen from anthers taken from strong plants in the variety used as the male parent is dusted on. The crossed head of wheat is now covered and allowed to ripen. A careful operator can secure 50 per cent or more of seeds in the flowers handled. The rough treatment necessary injures many of the flowers so that no seeds set.

The seeds from a given hybridized spike may be planted the second year in hills, one seed in a hill, a foot apart each way. The seed from each of these spikes may be sown in drills or broadcast for two or three years until they have passed through their greatest variation. Strong heads may now be selected and the wheats from which to select good berries and the new hybrids may be entered in the field crop nursery in hills 4x4 inches, in plots of from 2,000 to 100,000 plants from each hybrid. The treatment of selection in the nursery, of taking the best to the field tests and there comparing them with the best standard wheats, may be carried out in a manner similar to that described in previous articles in regard to breeding wheat by selection alone. The hybridizing is done simply to increase the variation of an occasional plant toward a more valuable type. The word "type" as used here must not mean mere botanical appearance, neither must it mean yield alone. The word "type" in its broadest sense in breeding economic plants and animals means that combination of qualities which give the largest value, yield, disease resistance, hardiness, quality and economy of production, together with other intrin-

sic and artistic qualities which must all be combined, correlated, to make up general values.

Having thus given a method of breeding wheat somewhat in detail, very brief statements in future articles will suffice to give methods in use in the Minnesota Experiment Station in breeding other field crops. Interesting and apparently substantial progress is being made with the other cereals, including corn and flax, and with a number of grasses, clovers and other forage and root crops. The general features common to plant and animal breeding, and some of the lessons each can teach the other will become more apparent as the discussion of breeding horses, cattle, sheep, swine, poultry and pet stock proceeds. The value of selecting the best breeders from among immense numbers, the importance of statistical pedigrees as aids in improvement along economic lines, the necessity of correlating many qualities into varieties and breeds for general values, the danger while breeding for other important points, of neglecting to breed for disease resistance and strong fecundity, and the commercial value of tabulated statistics of intrinsic breeding values as an aid in securing long prices for breeding animals, are among the general subjects to be especially considered.

Some general suggestions will be made as to co-operative organizations in counties or groups of counties to press forward animal breeding which will be sufficiently novel, it is hoped, to stimulate discussion.

CHAPTER XII.

BREEDING ANIMALS

An editorial in the Breeders' Gazette of September 18, 1902, under the caption, "Thou Shalt Not," contained two sentences which ring with history-making importance. The Gazette urges a general effort to lift Short-horn breeding in the United States to a higher plane than the mere dealing in herd-book certificates. "Until we have a healthy public sentiment bearing upon Short-horn breeding; until we offer some reward for original work, we will continue to be consumers and not producers of Short-horn types."

This stand by the Gazette will serve as a landmark between the dealing in mere name or lineage pedigrees and adding performance records to our pedigrees; between breeding by mere outward appearances and breeding by statistical methods of performance, together with individual appearance; and between supinely following the lead of the old world and strenuously creating our own American families and breeds.

The editorial mentioned referred especially to Short-horns, but its broad philosophy applies with equal force to numerous other breeds of cattle, sheep, swine and horses, especially to those breeds designed for the production of meat. The fact that statistical methods have already been potent agencies in breeding faster race horses and better dairy cattle and in breeding many kinds of improved plants, is beginning to force itself upon the attention of the animal breeding fraternity. Even in chickens the statistical method is being used to bring out the inherited potency of animals with high average efficiency for producing a large number of eggs annually per hen; and how else than with trap nests and records can it well be done? At the

Maine Experiment Station Dr. Woods is developing hens with 200-egg capacity, and from the same breeds another family with an average of only 40 eggs annually—in part to demonstrate the fact that by systematic breeding radical changes may be effected. New methods of securing records of values can be devised in animal breeding just as it is being successfully done in plant breeding. New business methods may be a necessity, and the work of herd-book secretaries may need to be reorganized. As the old-time itinerant cobbler gave way to the modern shoe factory, so the pedigree herd-book of mere names may need to give place to a modernized plan of recording, tabulating and using measures of individuality, and also records of transmitting power as secured by averaging the measured individual qualities of a number of the progeny of each valuable parent. As manual dexterity in swinging the cradle has been superceded by skill at running the self-binding reaper, so skill in mere judging by the looks of animals may ere long in larger part be supplanted by training in ferreting out, through systems of tests of parents and progeny, those blood lines which have the highest general value. Shows could as well give prizes to teams of college students or to individual competitors for displaying and comparing the values of dairy bulls or trotting sires as for judging several classes of competing animals and writing their reasons for the placing of the animals.

Considerable time is required to reduce the breeding of any class of animals to a systematic or scientific basis. In both animal and plant breeding the goal is large, and the cost to the whole people can be only a fraction of the benefit they will eventually receive, providing the work is economically and effectively carried out and the possible results reached. The additions of 5 or 10 per cent to the net values of our domestic animals over present methods of breeding would add hundreds of millions to the national income.

These articles were started to arouse discussion

on the problem of how can we greatly develop America's system of breeding. The first ten articles, published a year ago, dealt mainly with plant breeding, in part because there more rapid developments are going on than in the science and practice of animal breeding. There was more room for development because until recently plant breeding lagged behind animal breeding in the general development. Plant breeders now, however, already have in some ways a deeper philosophy than animal breeders, though until recently the animal breeders were clearly in the lead. In plant breeding it is practicable to deal with immense numbers, to carry out cheaply theoretical experiments on heredity, and in case of some species to develop better business principles for practical breeding. No one who has familiarized himself with the breeding of both plants and animals doubts the application of most of the laws of breeding alike to the plant and the animal kingdoms. There is, in fact, more difference in the methods best to use between breeding corn and breeding wheat, or between breeding alfalfa and breeding plums than there is in a general way between breeding plants and breeding animals. Animal breeders need to have a medium for the exchange of ideas with plant breeders, and plant breeders need to keep in touch with the broad philosophy of the animal breeders. Animal breeders need to learn from the plant breeders the significance of measuring the parent in terms of the average progeny, centgener power or transmitting power; and the plant breeders need to keep in touch with the animal breeders, that they may properly appreciate the individuality of each plant.

And no doubt the recent awakening in the study of plant breeding will be followed by renewed activities in the study of animal improvement by more systematic methods. Scientific technique in the field, in the barn and in the laboratory is no doubt to be rapidly developed far beyond our present knowledge, and no doubt the recent awakening in the study of plant breeding will be

followed by renewed activities in the study of animal improvement by more systematic methods. Artificial evolution is the term under which many scientific and practical men will merge their common efforts in accumulating knowledge, acquiring wealth and developing a better heritage of improved blood lines for future generations. A most fruitful source of new ideas and new principles is to be found in the work of the animal and plant scientists of our public institutions. Some of these, having turned their attention to studying the laws of heredity and the relation these laws bear to scientific breeding, are getting results of importance. Mendel's Law, for example, of which more will be said later, may mark a turning point in the study of heredity and breeding by scientific or statistical methods. A new periodical called "Biometrica" (measures of living things) has been started recently in London, to publish the findings of the group of scientists who are working along this line.

A word has been recently employed by Prof. Davenport of the University of Illinois to designate the general subject of breeding living things—plants as well as animals. The word is "thremmatology," and technically means, as I remember Dean Davenport's statement, the nursing of young things; or, as defined by Webster, "the science which treats of breeding in its widest sense; artificial evolution." If this word could be generally adopted to cover in a broad way the science and art of plant and animal improvement it might be advantageously employed. Though a long term, it would prove convenient as expressing definitely and in a broad way the whole idea of breeding.

A Plant and Animal Breeders' Association is being formed and will hold its first general meeting in St. Louis, December 29 and 30. This movement was started in November, 1900, under the auspices of the American Association of Agricultural Colleges and Experiment Stations. The International Conference of Plant Breeders, held in New York City in October,

1902, endorsed the plan of organization to include both animal and plant breeders. This society will provide a place for the exchange of views on the principles of breeding. It will be such a general organization that the practical man will be there to give his point of view, and the scientific man will there find an appreciative audience ready to put into use any really practical discoveries he may work out. It will be of especial value also in promoting experimental research in breeding and in inducing deeper study and more thorough preparation for their business on the part of breeders, herd-book managers and teachers of breeding.

The suggestions in the next few articles will have running through them a general plan, i. e., that of co-operation among breeders, breeders' associations, counties, states and the general government in bringing about a more rapid evolution of our animal types. The writer has long had these plans in mind, but wished before publicly advocating them that he might make or see practical demonstrations in co-operation in animal breeding as well as in plant breeding. The results from organizing co-operation in plant breeding in Minnnesota and surrounding states serve as a partial basis for discussing what now appears the somewhat more difficult but no less important co-operation in animal breeding.

CHAPTER XIII.

BREEDING EXPERIMENTS AT THE MINNESOTA STATION

Before taking up the problems in animal breeding, a summary of the more prominent lines of breeding field crops under way in 1903 at the Minnesota Experiment Station may be of interest. Most of this work is devoted to variety formation and variety improvement, though numerous theoretical experiments are also conducted. In each case mentioned the hills contained only a single plant, that each individual plant might be studied and compared with its fellows under similar conditions, and that the values of parent plants might be learned in the terms of the average values of their progeny.

Of alfalfa, 18,000 plants in hills two feet apart each way were planted in 1901, 1902 and 1903. Most of these are of the hardy American and Turkestan varieties which have been found best adapted to the Northwest and which are being bred for still hardier forms. Some of these are very promising in field tests. Since they yield sparingly of seed an effort is being made to increase the seed production of these hardy forms. It seems quite probable that these hardy alfalfas must be grown in warmer climates to produce seed for planting in the Middle Northwest.

Barley was represented by about 20,000 plants, 4x4 inches apart, one-third of which were of numerous hybrids from crosses made during the past eight years. One-third was under selection to produce new varieties and another third was devoted to theoretical experiments. Among these are efforts to find how to breed early and late varieties of barley and also varieties which will stand erect on the rich fields of the stock-raiser.

Of white beans there were several thousands of

plants, 12x12 inches apart, in the breeding nursery and twenty newly-bred sorts in field plots, where the final selection is to be made before disseminating the one or few best kinds.

Of sugar and stock beets there were many thousands of plants, of which 1,500 were mother plants, the mother roots of which had been siloed or pitted. They were planted late and owing in part to the very cold wet season only a partial crop of seed was secured. It has been proved by trials for three winters, however, that the mother beets may be successfully kept over winter in pits in this climate.

Corn was represented by about 20,000 plants in nursery rows, planted 42x18 inches apart. One variety, Minn. No. 13, has been distributed for several years by the station and hundreds of thousands of acres of it are now annually grown throughout the state, both in hills for ears and thickly in drills for dry fodder and for silage. It has been adopted by the South Dakota station as the best to distribute to the South Dakota farmers. Like some trotting horses this variety "performs better than it looks." In the breeding of this variety much more attention has been given to increasing the yield in the north zone of the corn-belt by statistical methods than to securing uniformity or to making it appear attractive. While most corn breeders are going far to the other extreme I am convinced that we could well have paid much more attention to appearance.

"We have stood up so straight that we have leaned backward" in breeding almost wholly for earliness and yield.

During the past two seasons the wet cold weather and heavy autumnal frosts caught many varieties in sections where this variety succeeded. We have latterly bred this variety for greater uniformity and it is responding to selection for looks as it did earlier to selection for earliness and larger yield. The experiments with this corn show that looks must not be ig-

nored any more than records of performance. We need the methods of show judging and the methods of the statistician combined. Bromus was planted 2x2 feet apart and should have been 3x3 feet apart in a few thousand nursery hills and as winter approached many of these plants, each from a single hill, had a spread of nearly two feet. This grass spreads so vigorously and its underground stems are so tenacious that the question has arisen as to whether we should not select it for varieties for moister climates which have less of the quack grass tendency of too great persistency when it is desired to destroy it in the rotation. The variation in height, in yield of forage and of seed in individual plants is very unusual in this variety. Eight new varieties originated seven years ago, each from a single mother plant, which have been in field tests for several years, promise to provide a few superior kinds of this species, which is still new to American farmers.

The cowpea nursery was well nigh a failure, both in 1902 and 1903. These were the coldest, wettest seasons ever experienced in Minnesota for late plants and none of the 2,000 cowpea plants, 3x3 feet apart, of either year matured seeds. This plant will require such radical modification to adapt it to producing seeds for use for forage crops in this climate that trying to breed it earlier in Minnesota is somewhat discouraging.

Red clover has been under experimentation in the plant breeding nursery for thirteen years and the results were very meager until the past few years. The efforts to secure hardier blood lines have been persistent and methods more recently adopted give promise of good results. In breeding this species the effort to select for distinguishing marks cost years of labor and resulted in not only the loss of the labor but the loss temporarily of an opportunity to give to the Northwest a hardier clover. We bred from white and pale pink colored flowered sports instead of going directly for hardy plants. Many breeders of plants and animals who are trying to breed for intrinsic value by selecting to some

peculiar color or form should take warning from this experiment. I am not sure but this and the experiment mentioned above with corn are the most important experiments we have finished in breeding plants at the Minnesota Experiment Station. Trying to breed values into plants by breeding to some color or to some fanciful form or to breed animals by selecting to color of coat or to some feature or form not based strictly on physiological grounds is like a man trying to gain enduring distinction by means of choice clothing or by skill in the mere social arts. Broad-minded breeding takes into consideration all essentials both of appearance and of performing ability, also of uniformity. Every variety or breed is such a complex proposition that breeding for one feature is not sufficient. The final economic unit is a combination of many units, some of which at first may seem almost antagonistic to each other.

Flax breeding as represented in the nursery by 13,000 plants, 4x4 inches apart, and by numerous varieties grown in field test plots. Starting with ordinary flax, which grows about twenty-six inches tall, adding ten inches in height has proved an easy task, thus apparently overcoming the fault of our dry climate, and making possible the production of long-line flax fiber in the Northwest. Numerous varieties bred for larger yields of seed are under trial in field plots, some of which are very promising. In fact, more profound changes have been produced in flax than in the case of any other crop. The common Minnesota and Dakota flax was used as the parent variety. In 1903 four stocks of the original variety, secured from four seedsmen, were planted in field plots in a rented field (not especially prepared) and beside these were planted new seed varieties and also four new varieties bred for finer fiber. The four original varieties averaged 11.9 bushels of seed per acre; the best four varieties bred for seed yielded 17.5 bushels per acre; while the four fiber varieties yielded only 10.5 bushels. The four parent

stocks stood 24 inches tall, while the four fiber varieties stood 35 inches tall, and the four seed varieties stood 23 inches tall. It is expected that half the increase in yield of seed will persist on the farms of the Northwest, and that the full gain in length of straw will be a permanent gain in lengthening the fiber in this climate, which is too hot and dry to produce long line fiber from ordinary flax.

Millets were represented by over 5,000 nursery plants, 4x4 inches apart. The millets are not as easy to breed as many other crops, but some good varieties have been increased in quantity sufficient for field tests.

In the oat nursery there were 16,000 plants 4x4 inches apart, and a large number have been increased for planting in field two plots and in 1903 these made a most favorable showing. Among these are numerous hybrids, some of which are being especially bred to stand erect on the richly manured fields of the stock farm. Many farmers are constantly seeking oats with stiffer straw and it is hoped that some new varieties now being tested will continue their present showing of great strength combined with superior quality and yield of grain.

Of winter rye 36,000 plants in nursery hills, 4x4 inches apart, show a good beginning for new varieties. Rye is nearly hardy, and besides working for hardiness especial stress is laid on increasing the yield. Rye is freely open-pollenated and the plans for breeding it are being radically revised.

Twelve thousand sorghum plants put in late did not ripen in 1902 and the old seed was used again in 1903 with similarly discouraging results.

Soy beans were the most beautiful crop in the nursery in 1902. The plants, 18x18 inches apart, standing over two feet tall in nursery centgener plots, 15 feet square, made a very pretty appearance. The frost cut most of them both in 1902 and 1903, though in previous years substantial gains in yield were being secured. The results of several years' work with soy beans give

encouragement. The small yellow variety commonly grown in Kansas is being used as the main foundation stock, but no doubt better varieties for this northern climate will be found.

The fourteen new varieties of timothy started fourteen years ago were in field plots planted in 1900, 1901 and 1902. It was necessary to plow under all but the plots planked in 1903, because the dry weather of the two previous years had caused stands of grass too poor and irregular to serve for purposes of comparison to determine which will yield best. In 1903 volunteer clover coming up irregularly in the plots on our crowded little experiment farm placed our field comparisons another year off. After fourteen years of work and waiting for statistical records, yet two years in the future, one feels tempted to follow the example of the breeder of meat producing animals and choose for distribution the plants which are best in appearance without more testing. And breeders must be practical, and it is as impractical to depend wholly on statistics as to be guided solely by appearance. But with the help of co-operating stations it is hoped that in two or more years we shall know which of these fourteen kinds of timothy should be sent out backed with a pedigree giving relative yields and values as food. A little more patient waiting may give statistical pedigrees which will fasten the interests of farmers and dealers to whichever kind we may find the best yielder of superior crops. Varieties which have no distinguishing marks must be backed by statistical records. Some of our new varieties of timothy have been bred for branched, or "barbed" spikes, and these may be able better to gain wide use because their statistical records can be attached to a description as well as to a name or number.

Of winter wheat 50,000 plants, 4x4 inches apart, were planted in August and September, 1902, and practically all survived the cold and made splendid yields in 1903. Some field plots planted to our hardiest forms of winter wheat came through the past two

winters and yielded nearly double the crop secured from our standard hard spring wheats, or 35 to 47 bushels per acre, which we count as encouraging for as far north as St. Paul. Winter wheat is moving northward and experiments to make it hardier are giving promise of being effective. Still larger numbers were planted in 1903 and are now going into the winter (Oct. 23) in fine form. We have found it necessary to plant winter wheat very early here in the North, preferably in August, that it may grow large and better endure the winter.

Of spring wheat 50,000 plants, 4x4 inches apart, were devoted to straight selection, selection of hybrids and starting new hybrids, and 35,000 to theoretical experiments in 1902 and again in 1903. Among the latter are experiments to increase rust resistance, selecting for strong chaff which will prevent shelling, time required to reduce hybrids to a uniform type, comparison of improvement by selection alone with improvement by hybridizing followed by selection, breeding wheat on good versus poor soil and so on. It is worthy of note in this connection that new wheats originated at this station are winning for themselves prominent places with the farmers of Minnesota. Minn. No. 163, of fife parentage, yielded at the University farm during the first five years of its trial 2.8 bushels more than its parent variety. It was distributed to over 100 farmers in 1899. Thirty-eight reports from these farmers compared it in a just manner with their own wheats and gave an average of 16.7 bushels for their wheats and 18.1 bushels for Minn. No. 163, an increase of 1.4 bushels or 8 per cent. In 1902 and 1903 it is estimated that 200,000 acres of this variety were planted and that it added a dollar in value to each acre.

Minn. No. 169 wheat, a newly bred strain of bluestem, was first distributed in 1902, nearly 400 farmers each purchasing of the station four bushels. Eighty-nine farmers made reports of tests where the new and their common wheats were tested under similar condi-

tions. The average for the common wheats was 18.2 bushels, and the average of Minn. No. 169 wheat was 21.5, a gain of 3.3 bushels, or 18 per cent. Wheat has been our most fruitful species in lessons in heredity and breeding, in part because it has been bred most extensively and has been most used in theoretical experiments.

The above summary is given mainly to show that this work is being taken up extensively as well as intensely, and that results of vast economic importance are being reached. The gradual evolution of systematic plans for planting, recording notes, harvesting, laboratory testing and summarizing results has made it possible to handle nurseries containing hundreds of thousands of plants. A force of helpers can be organized to thus breed plants as well as to run a large bank or a department store. The first thing is to realize the importance of work which may and will annually add many millions of dollars of wealth to the products of our farms. Complexity, extensiveness, and difficulty of organization should not be in the way of adequate organization and expenditure to greatly increase the efficiency of either animal breeding or plant breeding in America. Men have arisen who are capable of leading in the organization of capital in most complex lines of manufacture, commerce and transportation. Other men are being found to weld together into co-operative association the discordant units of labor interests. The first thing needing demonstration in animal breeding is that it must be undertaken in a large way. The use of large numbers under effective statistical and artistic methods makes necessary further co-operation and organization than are now in vogue. Our breeders' organizations and herd book associations, should be evolved so that they would provide for even more rapid progress than is now being made.

I recently had the pleasure of inspecting the plant breeding experiments of the South Dakota Experiment Station, (1904). A good start is being made in breed-

ing grain and forage crops. but the work of Prof. N. E. Hansen, the horticulturist, is phenomenal. The amount of fruit and vegetable breeding he has well under way with very limited resources is most commendable. On more than forty acres of land he has growing of his own breeding over a quarter of a million seedlings, mostly hardy fruits. He has made thousands of hybrids between the wild fruits of the Northwest and of the cold regions of Northern Asia and Northern Europe, with the better kinds of fruits which lack in hardiness. He has thus made hybrid pears which may extend the pear-belt hundreds of miles to the northward. Instead of doting on theories he is doing things, hybridizing many things that theories may be developed later. His faith expressed in works is of inestimable value to the Northwest. The orchard on the college farm at Brookings has in it possibilities worthy the name "South Dakota's Million Dollar Orchard." Prof. Hansen has hybrids between cultivated and wild species not heretofore hybridized and has devised most ingenious methods of doing two years' work in one, by growing shrub and tree fruit plants under glass and cross-pollinating them in winter. The Legislature of South Dakota should realize that the State has a large asset in varieties already originated at Brookings and provide Prof. Hansen with better facilities. No other experiment station horticulturist has grappled with so difficult a problem in plant breeding and none is doing the wonderful work of this Americanized Dane. Like Burbank of California he burns up great stacks of seedling sand cherries, raspberries, apples and other species, that he may find the one in many thousands which will be a material improvement.

CHAPTER XIV.

FREEBORN COUNTY JERSEYS.

There is no reason why America should not lead in animal breeding as in manufacture, transportation, commerce and education. Our people lack neither the brains nor the patience; they have the largest home market for pure-bred animals in the world and they have secured a full share of the best live stock of the world as a foundation. Yet we continue to pay financial tribute to the brains, the skill and the live stock instincts of the people on the British Islands across the ocean. They have a plan of co-operation or concentration by counties. They have cheaper labor, greater variety of food, especially more of succulent roots, a more equitable climate, and they have the faith that they are at the top. We need a better business plan, a broader philosophy of seeking by combined statistical and artistic methods the very few with the best blood from among immense numbers; a better knowledge of details, more faithful attendance to the wants of the animals, a greater variety of food; and we need an abounding faith that America is to lead the world in breed improvement and in breed formation. Our herd books, based too nearly on names, have led us and tied us into a general situation quite as full of folly as the trenchant editorial entitled "Thou Shalt Not" in *The Breeders' Gazette* of September, 1902, portrayed. The vastness of our country has led us to this method of breeding mere pure-breds rather than to a method of breeding on a basis of thoroughbred merit in each locality.

Breeding by counties is one of the secrets of success of the breeders of Britain. Here is our very greatest lesson. The writer spent some time in Europe in 1899,

in part to learn why many breeds have originated in the British Islands and few in continental Europe. The Lincoln County Fair gave the key. Here were many of the choicest ewes and rams of the famous Lincolnshire breed of sheep. Here the rival breeders met in friendly intercourse. The county is not so large but that the brightest breeders may visit any flock in which a ram has shown wonderful powers in upbuilding the quality of the flock. The sires with large transmitting power or "projecting efficiency" are thus found and their blood is secured for use. The production of a large number of sheep and the interest manifested by sheep experts in Lincolnshire result in the education of the breeders. The situation is such that not merely the best individuals but those animals which prove to get the best progeny are selected out of the very large numbers bred in the county. The fact that the people live in farmsteads on the farms with lanes leading out to the health-giving pastures, favors English stock, but the same conditions prevail here as in England. That the British farmer and farm laborer get close to the animal's every want is also a large factor. Having once made a success of pedigreed stock and having long reaped rich rewards from selling breeding animals to America and to other countries and supplying choice animal products to their own markets, the British have had a lasting and substantial paying basis for their pride and interest.

In continental Europe where animal breeding has not progressed, breeding by counties or other definite districts is rarely ever found. Too often the farmstead is in the village, with only a hoof-worn paddock for the animals to exercise in. The small and irregularly-shaped fields of each farmer are often scattered here and there in different directions from the village. Lanes to pastures are an impossibility; the animals do not have pastures in the summer time, and the farmers have not taken such interest and pride in their animals, and consequently they have not come in contact

with the great markets for high-priced registered stock and there has been no such general impulse to do high-class breeding as in England or America. With seeds the reverse has been true and continental Europe has bred beets, wheats, oats, rye, vegetables and ornamentals much more extensively than has Britain.

The Island of Jersey also has a lesson for us. Here the stock has been kept pure by a law making it illegal to import live animals. A thorough system of eye inspection, grading the cattle into registered, commended and not commended classes, has long been maintained and something has been done in basing the choice of breeding stock on records of actual performance. Jerseymen would be better able to ask even larger prices for their dairy blood if their records were based more on statistical records of ability to produce annual net profits. If one wished now to select the best possible foundation animals for a herd of Jersey cattle he would no doubt choose most of his stock from herds outside the famous island. Our own American breeders have more records of the average annual milk yield of entire families of cows than have the island breeders, to serve as a guide to purchasers. They also have more records of the richness of the milk in fats. Some Americans have still other facts more or less systematically kept, as to the fecundity of certain families of cows, their freedom from abortion and from failure to get in calf, their resistance to tuberculosis, their kindness of disposition and the like.

In starting a new herd, if a person were able to secure facts along all these lines he would have a basis for judging many of these cattle which he could not afford to ignore and he would not choose cattle from the Island of Jersey just because they were from that island. Authentic figures would be more potent in pedigrees than the word "imported," so often used as the chief point in the recommendation of animals. One or two decades of breeding Jersey cattle following a good statistical method by an association in an American

county, would result in the accumulation of facts and figures which would emphasize the value of the blood of the best animals in the hands of the association. The name of the county would take the place of Jersey. Freeborn County, Minnesota, for example, could so breed Jersey cattle that in 20 years it could gain the reputation of being a better place from which to secure Jerseys than Jersey Island. Breeders could make pedigrees emanating from Freeborn County have as fetching a meaning to the average mind as "imported from Jersey" once had. And in making these suggestions for breeding dairy cattle, because with this class of animals the subject can best be illustrated, it is clearly borne in mind that methods already in vogue are fairly satisfactory and are doing wonders in building up breeds of dairy cattle in this country.

To make this illustration more complete detailed suggestions concerning Freeborn County dairy breeding might aid. It should be stated as a reason for selecting this county that here the people already know how to co-operate. Freeborn is one of the banner dairy counties in Minnesota, and here Prof. Haecker, head of the Minnesota Dairy School, first found co-operative dairying, now generally introduced, in successful operation. The co-operative creameries have shown the farmers that they can co-operate among themselves and also with the experiment station and that by merging certain of their interests they can accomplish greater results individually and collectively. Would it not be practical for some such plan to be adopted as is here suggested?

Let a large number of farmers, 25, 50 or 100, form a co-operative breeders' association. Let each member have one vote for each registered and accredited Jersey animal he owns. Let the association adopt standards under which the animals may become accredited. Devise a system of records of average annual milk and butter yields. Devise, if practicable, a method of recording the cost of food

required by each cow to produce a hundred pounds of butter fat. A certain standard price of cattle foods could be assumed for this purpose. Keep track of and tabulate in the pedigrees of each animal all such important facts as freedom from tuberculosis; the number of strong calves each cow produces during her life; the temperament, docility or viciousness of each cow and bull. Use a score card system of records to preserve the facts concerning form, color, comeliness, weight and other general facts concerning each animal and family. Devise a system of tabulating these records so as to show the individual values and the transmitting powers of each mature individual. Show also the prospective breeding values of all young animals, as indicated by the average values of the ancestral blood lines centering in them. In this manner the poorest stock could be rapidly eliminated. Such a scheme of statistical pedigrees would soon so accredit all the best families of animals that the surplus of bulls and the heifers of the best blood lines could be sold at high prices to breeders and farmers in other counties, in other States and even in foreign countries. Let the association in some practical way own or, better, merely control, all the very best individuals of the best blood lines produced in the county, that they may not be sold but used as the basis of improvement of the county family or strain. Let the members keep on purchasing of the best procurable blood from other sources. In this way secure and keep in the county the choicest blood so that no outside breeder or other county can claim superior strains of the Freeborn Jerseys. No doubt some equitable form of organization could be devised that would allow each member to own his cows and sell all but the few which promise to be among the elect to be reserved for county breeding. It might prove best to have the association pay for and hold the ownership of animals which it desires shall not be allowed to be sent out or used outside the county. Every generation of cattle would thus become a bovine aristocracy above

the generation last sold to outsiders. And offerings would sell at good prices, both because of superior excellence as shown by performance pedigrees and because of the carefully sustained reputation of the county. It might even be best for the county to have charge of all sales, paying each owner the extra value secured above standard prices.

To carry out such a plan successfully certain essentials must be observed. The first matter of importance, after organization is perfected, is to secure superior foundation stock. The future success depends very largely on the animals from which the start is made. The opportunity for securing superior males and females is indeed very great. All the best herds in America, England and Jersey, and even herds in other countries, are a source of hundreds of thousands from which to select. If some one trained in such work were employed for one or more years to review by correspondence and by visitation all the best available herds and to select the best that could be purchased at reasonable prices some of the choicest Jerseys in the world could be brought together. The investment would necessarily be large and after testing those first secured and discarding those of lesser value it might be wise to purchase still others. The hundreds thus selected from hundreds of thousands should average high in value. But of paramount importance is the fact that among these there would surely be many which would become record-breakers under more rigid tests than are applied in present methods of breeding, and a fair number would prove to be strong in producing progeny of high average value, the most important test of all.

The next step seems difficult, viz.: testing and recording the values of these foundation animals and of their progeny, that all but the few very best may be discarded. No doubt records already gathered by dairy experimenters and by our most careful breeders would serve in formulating plans which would greatly aid in making these tests practicable. The many entire-

year records of food eaten and of product for individual cows in the Minnesota Experiment Station, for example would yield data on the frequency necessary to make tests. Experiments inaugurated by Prof. Carlyle at the Wisconsin station would give valuable facts as to the variation in food requirements of different cows. Mr. Glover's experimental studies of dairy herds in Northern Illinois would give valuable information as to how to make tests and keep records in the herd. Possibly weighing the milk daily and analyzing for fat once a week, with monthly checks by a disinterested inspector would be a sufficient basis for records of the product. The cost of daily milk weighing and monthly testing for fat would be small. Where the milk is weighed daily hired milkers are more careful to get all the milk, and the owner can more readily discover carelessness in milking, as shown by reduced yields, and a better knowledge can be had daily of the health and requirements of each cow. Weighing the milk often pays merely in securing cleaner milking, thus better keeping up the flow. The feeding experiments would necessarily need to be long conducted with uniform food in winter time, and might be better if the cows could be taken to a central test barn. These various tests will not appear so expensive when once it is fully realized that only the best cows and their female progeny would need to be subjected to them. On the other hand, large returns from future sales of breeding stock and superior animals for the dairy herd of the county would warrant a large expenditure in establishing a county strain or breed with its record based mainly on the solid ground of performance. Herfordshire has reaped profits which would have paid dividends on a large investment in working up the blood of the "white-face" breed A number of other counties in England have done likewise with their respective breeds of cattle, sheep, horses and swine.

To give the records actual value and to have them accepted by the public it would be necessary to safe-

guard against fraud. There would be need of disinterested supervision of all tests. After some years even larger values would begin to attach to certain blood lines than are now found in dairy breeds, and as is now the case with trotting-horse blood, for example, which has families with many representatives in the 2:10 list.

The owner of an animal could better exploit records made or at least verified by an official of the county co-operative breeders' association than if made by himself and his employes. The county or better the State might provide supervision and thus aid in breeding scientifically and in giving reputation based on authenticated records to animals of known superiority. The public has a large interest in animals which do not merely appear superior and hardly pay their board but which actually yield better profits. And especially farmers, who desire to purchase bulls for grading up their herds, have collectively at stake large sums of money. Six bulls, each used two years, will entirely transform a dairy herd. At the end of the twelve years there is very little of the blood of the original herd of females The projected efficiency of the six dairy bulls may easily modify the profits of the dairy farmer, so that instead of failure or indifferent success he can have a good income. The county and State might properly train, employ and support men to serve as county stock-recorders and judges.

Still other and better plans might be suggested but the objective point is to secure breeds with larger general average value, breeds that are not fanciful but in which there is more profit and connected with which is the evidence of superiority overcoming doubt and causing their general use. France found it profitable to own and to regulate the use of stallions, and supplying bulls at public expense has been suggested. But the writer has faith that we are coming to a period of agricultural co-operation under which associations will make far more rapid progress. Once our agricultural colleges earnestly enter upon experimentation in ani-

mal breeding the importance of these statistical methods will be magnified. Now these institutions teach the judging of animals by the eye and the laying on of hands, and this artistic work is a long stride in the right direction, but they will also devise and teach scientific methods of breed improvement and breed formation. The statistical and artistic methods will be combined, giving each due consideration.

There is a realm of effort yet untouched in hybridizing breeds and even in hybridizing species. Hybridizing in plants has become a most potent force in plant improvement. But in animals hybridizing requires so much time, such large numbers of expensive individuals must be used and there is after all such an element of uncertainty that individuals, large corporations, and even very large co-operative associations engaged in breeding as a rule had far better limit their work to existing breeds. One very important reason for this is that the animals bred by such an association, having originated from registered stock, would all be eligible for registration and would be available to use on all other registered herds of the same breed all over the country. Breeders of registered animals, not farmers who wish only to grade up, form the market for high-priced breeding animals. The general breeders, however, will in turn depend on the farmers for a market for their males and surplus females.

The greatest drawback to profits in breeding dairy cattle, as compared with breeding beef cattle, is that the bulls become a drug on the market and few can be sold at high prices. This method of statistical records to emphasize the value of the blood of certain strains would overcome the low prices now placed on bulls. Figures would help the farmer to see the value of blood potent at the butter-tub, and he would be willing to pay better prices for the best blood. The breeder of pedigreed cattle in turn, having bulls supplied to head his herd, with records of performance in the families behind them, could pay more and could command

higher prices for bulls sold to dairy farmers. Cows thus bred would have a sale at higher prices to breeders and dairy farmers depending on purchasing their milch cows would soon learn to pay for pedigree. Men would learn to develop breeders not merely for the high-class dairymen but for the average good dairy farmer.

Such an association could have system in its sales. A monthly county or township sale day might be found useful. Auctioneers, trained in displaying performance records, could greatly assist in securing long prices at State fairs and at other large sales. Auctioneers are hungering for such record pedigrees. The study of statistical pedigrees at schools of agriculture would take on a new meaning if each State had numerous county breeds of domestic animals under some such plan as suggested. Schools of animal judging would become more truly schools of breeding. The men who would embark in such a co-operative enterprise would find it necessary to invest in a rather long-time proposition. But the females purchased at rather large prices would serve well in the dairy and would pay the earlier expenses. The bulls besides serving the cows especially selected, would be very valuable to serve other registered and also grade cows. There would be some inconvenience to farmers in conforming to the rules of an association, but on the other hand there is an advantage in learning how to co-operate. Men grow under discipline, and such an association would serve as a most valuable school to develop men. The whole community would be united in a delightful way to accomplish a worthy object. The members would soon feel a great pride in the whole enterprise. Rivalry with similar associations elsewhere breeding Jerseys, Holsteins, beef Short-horns or dual-purposes cattle would have its value both in adding zest to the work and in insuring better results. The criticisms of our rivals often serve to best educate us as to how to excel.

In all this the large expense and effort are warranted

by that 5, 10, 20 per cent or more which may be eventually added to the income from the cows which produce the dairy products. The more systematic business, the more enjoyable occupation, the more extended touch with one's fellows brought about by such a plan would add to the remuneration. Ten per cent eventually added to the dairy products of Minnesota by thus breeding better animals seems possible. This represents millions of dollars annually. If 10 bulls and 50 cows of highest breeding quality could thus be selected out of several hundred of the choicest animals chosen from among the best dairy herds in the world, and these 60 animals be used as the basis of a distinct family of Jerseys, all with authentic pedigreed records of performance and under continual improvement, the cost could not nearly equal the gain. Since the breeders can secure for themselves only a small part of the gain could not the State well afford to help promote the breeding for the good that would come to all concerned?

All will admit the size of the goal, and those who would adversely criticise the suggestions will please the writer by pitting against the proposed plan either the methods now in vogue or other new plans. This is an age of discussion.

UNIV. OF CALIFORNIA

CHAPTER XV.

MOWER COUNTY SHORT-HORNS.

While dairy farming is one of the most profitable lines of production for the general farmer on small and medium-sized farms, beef production is nearly as profitable and is one of the most enjoyable. The dairyman in part pays for his larger profits by working longer hours, by housing more hired men and by himself and his family carrying greater burdens. The beef farmer gets less gross income and less net money profit, but his chores are done quicker; he needs hired help only at certain seasons of the year. Now that ranch production of meats has reached its zenith and the growth of our cities continues to increase the demand for meats, we can hope for the prices of beef to average higher in future than they have during the last decade of the past century.

Hereafter range production will not control the price of meats. The great regions of arable farms will regulate the supply and the price. When prices are high, Illinois, Indiana, Ohio and the States which surround them will increase their product, and when production exceeds the demand a less number of cattle will be raised in this great region of live stock farming. Special-purpose beef cattle will no doubt be raised in large numbers in the region named. We will have an increasing number of breeders of special-purpose beef cattle to supply bulls for ranches and for farmers who raise beef. These breeders will promote the business of raising special-purpose beef cattle among farmers to whom they desire to sell registered bulls and females. Prof. J. H. Shepperd of the North Dakota Experiment Station, in a paper before the recent meeting of the

American Breeders' Association, urged that ranchmen breed bulls for ranch use.

But the chief opposition the breeders of special-purpose Short-horns must eventually meet is from the breeders of milking Short-horns and other breeds suited to the production of both milk and meat. Some families of Short-horn cattle are specialized toward beef nearly as completely as are the Hereford or Aberdeen-Angus breeds. True, the atavic powers of these Short-horns to produce milk in paying quantities are not so weak nor so remote in the ancestral lines as in the other breeds named. In some cases this specialization away from milk has gone too far, even where the cows are never to be milked but are to raise baby beef on the farm or export beef on the range.

The large and profitable field for the production of registered pure-bred beef bulls and heifers to supply farmers and ranchmen and to fit our beginners in breeding registered stock will no doubt remain permanent. While this is true of Herefords and Aberdeen-Angus, as well as of beef Short-horns, the latter class of cattle will best serve the present purposes of illustration.

In no class of cattle has the combination of mere herd book name records and visual judging at shows led to greater mistakes than in the breeding of some families of Short-horn cattle. We have the anomalous condition of a bright lot of breeders having idolized the "reds" and neglected the "roans" till only the choicest roans are left, and the roans now naturally average better than the reds, as shown by the fact that they get far more than their proportion of prizes at shows as compared with the reds.

But of far more consequence is the fact that the Short-horn breeders have succumbed to the dairyman's philosophy, that special-purpose cattle are the "whole thing," and in some cases seem to have given up three parts in value of milk for one part additional in value of beef. In other words the dairyman's talk, the ranchman's need for beef sires and the show judge's assump-

tion that he was doing the impossible in accurately and finally measuring the general value by mere appearance, have often led the breeders of beef Short-horns too far along the specializing path. Families of cows in which a fourth of the dams cannot supply sufficient milk to push the calf forward for baby beef have too far departed from the mother function to be the most valuable, even as beef animals, to say nothing of helping to pay profits at the pail.

The farmers of the great agricultural States want beef cows which will make the most money per herd, not those which merely produce an occasional phenomenal prize-winner at fairs. And some of the old-fashioned Short-horns are really worth more to the stock farm than some of the newer families which have been fashionable.

Co-operative organization in breeding beef Short-horns would enable the use of large numbers and the making of statistical records under official inspection. Just as in dairy breeding, greater emphasis should be placed on families of superior value. Not only should the few intrinsically best out of immense numbers be chosen by the breeders, but their blood should be scientifically tested and systematically advertised, that they may gain much wider use than under present methods.

Besides Freeborn County, Minnesota, mentioned in the previous article, is Mower County, in which are located several breeders, mostly beginners, of Short-horn cattle. To aid in this discussion let us assume that Mower County leave the breeding of pure-bred Jerseys to Freeborn County and Freeborn County likewise allow Mower County to monopolize the breeding of special-purpose Short-horns. The farmers of Freeborn County who wish a beef Short-horn sire could easily go to the neighboring county and by inspecting a number of herds and by studying official records and comparing prices be able to secure bulls for upgrading their beef cattle. The dairy farmers of Mower County, in like manner, could readily study the registered herds

of Jerseys in Freeborn County, where they would find bulls to suit the needs of their respective herds of dairy cows. And from counties and States around breeders of registered Jerseys and beef Short-horns, and farmers who were grading up their herds for special dairy or for special beef production, could make pilgrimages there, knowing that one railway fare would take them to a number of superior herds of the kind of cattle wanted. Such methods of specialization are needed to crowd the scrub cow and the scrub steer out of the race. The strongest criticism made of our breeds of registered cattle is that they do not rapidly crowd out the scrub.

The general plan of organization of a county association of breeders of Jerseys mentioned in the last article could serve for the Short-horn breeders. The greatest difference required would be in relation to the methods of making statistical records of individual and of breeding values. Records of fecundity, of freedom, from tuberculosis and of mature weight could be made; while form, external signs of quality and general appearance could be judged with comparatively little modification from plans now in vogue. The difficult problems would be to get measures of the amount of food the individual and the fraternity group needs per 100 pounds increase in weight; and the value of the carcass as determined by the percentage of lean meat to the quality of the meat, the block value of the meat to the butcher and the like. No one has any right to say that methods cannot be devised to get at these values, though it must be admitted that some of the problems are difficult. Investigations carried on by State experiment stations and by the United States Department of Agriculture along this line might be very productive of good.

The Minnesota Experiment Station has equipped a building in part for such work, and Prof. Andrew Boss

is making progress in working out methods.* This station sees in these problems no greater difficulty than once appeared in the problem of securing the milling value of hundreds of new varieties of wheat. That has been accomplished so that with a quart of a new wheat its general value for milling may be determined approximately and at a very slight cost. Here the cost will probably be great, but will it not pay? Certainly the chances are large enough so that it will pay to make investigations. As often happens, while investigating a problem to ferret out the facts regarding some theory, we stumble upon related facts of large practical value. To illustrate, the Minnesota Experiment Station was experimenting to learn whether wheat could be more rapidly improved by having the breeding nursery on rich or on lean soil, and in carrying out that experiment we stumbled upon a plan of arranging nursery plats in plant breeding which permitted the use of planting-machines and otherwise revolutionized, simplified and made cheaper and much better the general plan of breeding many of our field crops.

No adequate methods are being made to improve our general methods of animal breeding. I dare say that investigations along this line will produce relatively as large returns as the system of feeding experiments now being carried out in a splendid way by experimentors. The United States Department of Agriculture and the State experiment stations should attack many of the problems of how best to improve breeds and how to form new breeds.

Private breeders of Short-horns will naturally ask themselves how their business would be affected by the work of county breeding associations should these be started in each State. In the first place these associations would become a new market and any breeder who could satisfy the purchasing agents by means of records, appearance of the animals and the like that

*See Farmers' Bul. No. 183. . . . U. S. Dept. of Agri.

he had something the purchaser of stock needed would win a credit for his herd larger than a State fair prize. The methods of breeding which would be devised by such organizations assisted by experiment station officers and by other especially employed men would be useful to all breeders. Once the association came into the market with bulls and heifers of accredited merit, the private breeder would have a source from which to secure male and female foundation stock which would soon give credit to his own herd. He could keep more careful records than now, possibly under public inspection, and would have the confidence of the public more thoroughly than now. The general diffusion of better cattle would give an increasing market among farmers for registered stock.

If the general plan here proposed succeeded elsewhere the private breeder might find it practical to aid in forming a breeders' association in his own county. One county would not sit idly by and see another secure State aid for inspectors and it receive nothing. Possibly the State for self-protection might find it necessary to limit the aid supplied to one county, as by assuming to help with only one or two breeds or by limiting the amount of expenditure allowed by any one county for all breeds. In many cases large breeders would be able successfully to compete with the proposed associations in the market for the choicest breeding stocks, as they have the advantage of a more centralized management with longer tenure of office of those in charge than could be expected in an association.

Once such associations became well established, and ready to offer superior breeding animals backed by performance pedigrees, private breeders would have a new source of bulls to head their herds. Such counties would be to the breeder what Durham and surrounding counties in England have been to Short-horn breeders everywhere. In fact, these associations might be able to discount England as a source of superior blood.

England could remain at the front only by devising better methods than the Yankees can devise. Having their pedigrees on a statistical rather than on a mere "certificate of names" basis would give them a great advantage. The difference in cost entailed by paying importation charges would be a very nice margin for profits to the members of a county breeders' association. Once superior stock were thus offered the outside breeder could no more afford to have the superior supply of males cut off than could the breeders of Shorthorn cattle a few decades ago have afforded to be debarred from purchasing bulls in England.

In like manner, we should have centralized or merged organizations for the breeding of Hereford, Aberdeen-Angus and Galloway cattle. While the forms of suggestions here made are somewhat specific they are so principally to make the matter clear. The purpose is to set our breeders to thinking as to how America can take the lead in animal breeding and how it can take advantage of the following three principles of breeding which must be taken into account before highest success may be expected. These three principles are:

(1) There is one very valuable breeding animal or plant in every 5,000 to 100,000 individuals. (2) To find this occasional one superior breeder, large numbers must be judged, tested and the recorded results of their breeding powers tabulated. (3) Once we have superior blood accompanied by the thoroughly authenticated, statistical evidence of its superiority adequate methods of bringing about its general adoption should be put into operation.

After all, these suggestions are not very remote from practices already followed in the breeding of trotting horses, except in the matter of cooperative organization. Why should it not be possible for farmers who cooperate in managing creameries and schools to cooperate in breeding dairy or beef cattle? States now furnish inspectors to bring up the grade of butter

and cheese in cooperative factories, so why could not the State do an equal or greater service by assisting in the breeding of animals?

The works of our breeders are truly wonderful. Whoever visited the recent International at Chicago could not but realize that most substantial progress has been made. The champion steer in 1902, for example, was a marvel of strength, richness and beauty. And whole herds of his black sisters and brothers in the show-yards of the recent shows have helped him to add highest glory to the "doddies." The Galloways in their beautiful coats have come forward in recent shows in splendid form. The Short-horns and Herefords calmly divided honors with the "black-skins," remembering past honors and looking forward to future conquests. The delighted visiting throngs of expert stockmen, of noted breeders and the interested lookers-on were enchanted. The consensus of opinion was that beef stock had wellnigh reached perfection. The writer visited the show of 1902 to place himself again in this spell of wonder and admiration brought on by these many show-finished animals, and infectious from man to man. He wondered for a moment if these articles needing final revision should be sent to *The Gazette* or would it be better to let well enough alone. But when his thoughts again went back to the seed laboratory, which is full of records for a dozen generations of the performing ability of myriads of wheat plants, oat plants, and of other wealth-producing forms of plant life, he again heard the silent message of these records. They remind the investigator that plants yield to science as well as to art. They urge that there are "Shakespeares in every species," "Messengers and Stoke Pogises in every breed" and that records of actual performance help not only to find the individuals with such marvelous breed-forming powers, but are useful in aiding the best of the breed to become the whole of the future breed. These records further recall the fact that our excellent breeds of live stock are

still sadly in the minority as compared with scrub stock, and they suggest better breeding and accumulated proofs of merit as a means of inducing more farmers to use pedigreed blood.

CHAPTER XVI.

BREEDING SPECIAL PURPOSE CATTLE.

The breeders of special-purpose dairy cattle are an energetic and persistent class. They have long and aggressively contended that specialization in cattle is not only highly important but that it is the only true philosophy. The large annual net returns from certain dairy cows in experiment station tests and in private trials have been used as a powerful argument against trying to unite beef quality with high dairy ability in breeds of dairy cattle. The theory that the breeder of dairy cattle should actually get rid of beefiness has few opponents. The advocates of this theory have done much to bring about a very useful change in the show judging of dairy classes.

The experiments by Prof. Haecker of the Minnesota Experiment Station have brought out clearly the general physiological proposition that large abdomen, good udder, spareness of meat and rather light weight of frame, together with vigor, are the combination of form which generally goes with the hereditary efficiency in giving the largest returns in value of dairy products above cost of food. As the years go on these general physiological characters become more and more emphasized, while such characters as slope of ribs, form of head, size and number of milk wells, escutcheon and length of tail are being relegated to the minor places they should occupy in the dairy cow score card, or are left out altogether. Prof. Haecker and other experimenters, who have made the best dairy cows stand out so very prominently as individual producers of values, have done no end of good to the beef and dual-purpose types of cattle, as well as to dairy cattle. By inaugurating statistical methods of comparing the

net cost of one physiological type with another they have set in motion statistical methods in cattle breeding. These men have not as yet realized the great importance of this phase of their work because they were studying problems concerning the cost of production with cows bred as they found them. In their zeal to study feeding problems they have overlooked the very much larger relation of their work to cattle breeding. They have aroused the breeders of beef cattle to an effort to devise statistical methods of studying questions concerning beef production from birth to maturity. Ways should now be devised of comparing the dairy herd as a unit with the beef herd as a unit in the general economy of the farm and of breeding the kind of cow best for each agricultural region and each farm, whether that be a dairy type, a beef type or a beef-dairy type.

The net profit from the mature cow in her individual capacity has been set forward as the prominent fact, whereas the net profit of the herd as a whole is, in the last analysis, where the farmer's interest lies. So far as I know there is no adequate data showing the relative profits of herds of the three classes of cattle. Presumably the dairy herd, as a general rule, brings in more net cash than the beef herd because people are less willing to do the more exacting work of the dairy, and as a consequence there is less competition. General-purpose types of cattle have not been so well developed for their dual office as the other two classes, and there is no very good basis of comparing a herd of them with a herd of either of the specialized classes.

A friend of beef cattle says: "General-purpose cattle suit a general-purpose man. Such a man will take poor care of cattle and highly specialized cattle must have good treatment. By combining dairy and beef qualities more than half of excellence cannot be secured in either line of production, and half of excellence is far below the point of profit."

The breeder of dual-purpose cattle retorts: "It is

easy to secure more than three-fourths of great excellence both in beef and in dairy qualities in the combined animals. Two times three-fourths is one and one-half, making the combined type more valuable than either of the specialized types."

A case in part parallel will illustrate one phase of this discussion. In Southeastern Minnesota many farmers grow two crops of seeds at the same time on some fields. They sow two-thirds of a full quantity each of the spring wheat and of flax. The combined crop often produces more value per acre than either crop would alone. The two kinds of seeds are very cheaply separated by the local grain elevator, and the farmers receive current prices for each grain. In some cases, where the land is weedy, it is impracticable to grow flax alone. Wheat sown with the flax crowds the weeds down, really taking the place otherwise occupied by weeds, and the combined crop in years when the price of flax is high sometimes sells for almost 50 per cent more than would either crop alone. It is often the "general farmer's" crop.

It is narrow to argue that the law of specialization is always wisest in cattle, in crops or in the education of men. We need men of general training as well as specialists. We must not hold our Jersey cow nor our Christmas show steer so close to our eyes that we cannot see the relation of the herd to the entire farm management problem, with its annual balance sheet.

Experimentation and statistical investigation of the broadest and most thorough-going kind will most likely prove that there is room not only for special-purpose cattle of the two kinds but for dual-purpose cattle as well. All men are not high-grade dairymen and cannot make money out of the highly constituted dairy cow. And broadly conceived and long-continued breeding experiments, the writer predicts, cannot fail so to combine milk and meat production in the same breed and for the ordinary farmer that it will serve to make

his farm pay as well as, or even better than the special dairy or the special beef classes. If we had such dual-purpose types, bred pure and to a high uniform standard of dual excellence, there would be a large field for each of the three classes. Beef cattle would hold the ranges and many beef farms, general agricultural regions would find a dual-purpose breed of real merit the most profitable, and dairymen would properly retain special dairy breeds. In fact, the beef types more than the dairy types would suffer by the competition of dual-purpose cattle.

Farms and ranches for breeding beef bulls will be a necessity in the agricultural regions. They will have three classes of markets, viz: beef ranches, farms devoted to beef raising and farmers using dual-purpose cattle, but not needing all their females for the dairy. These latter and even growers of dairy cattle, will desire to breed their less valuable cows to beef sires so as to have good steers and heifers for beefing.

On those farms where milk for city or for factory or home manufacture can be the chief product the specially-bred dairy cow will doubtless hold the fort. The amount of territory she will give up to dual-purpose dairy cows will depend upon the relative amount of brains and care put into breeding the two classes of cattle. It is easier to breed dairy cows, but the possibilities in breeding dual-purpose cattle, once properly developed, may prove so great that dairy cattle, even under the very intelligent breeding which is already coming in vogue with this class of cattle, may be crowded to a minor place. Their merits are now so great that they should help to crowd out scrub cattle. People often cling to the cow that produces steers as well as milk when they ought not to do so; but the likes of people will continue to be a part of the problem.

The general-purpose cow as a pure-bred type has her way largely to make. Red Polls, Devons, Milking Short-horns and other breeds have not as yet received adequate attention; they have not been bred in that

comprehensive way that their importance demands. At between beefy types and types stronger in milk within the same breed, and many breeders are offering two families of the same breed, one with more beef and the other with more dairy quality. They sell the prettier beefy types the most readily, but they say confidently that those having more dairy quality are the more profitable individual cows for the farmer. They have not more than entered upon comprehensively and thoroughly breeding the two types in these breeds. The small ring representing this important class at the International shows in 1902 and 1903 illustrates the fact that breeding the "farmer's cow," or the "general" or "dual-purpose cow," is in a backward state. This backwardness arises largely from the difficulties encountered. But the tabulated figures presented by at least one of the breeders exhibiting a cow in 1902 shows that the entering wedge is in place.

The still larger class at the St. Louis Exposition in 1904 shows that interest is rising in cattle which combine beef and dairy production.

Statistical methods have been invoked to show the value of these meaty types which can make money both at the pail and in the feed-yard. Records of annual yields and of net values in dairy cattle are the powerful levers which will hold special dairy cattle in public favor. The more comfortable work of beef production will hold up the special beef classes. Dual-purpose animals to gain a large field must make the farm pay with less milking than is required in dairy cattle, and produce nearly as good steers as do the beef types, and both of these classes of facts must find a prominent place in our dual-purpose performance pedigree records.

So long as there are superior individual grade and pure-bred cows which will give a large annual dairy product, using only a moderate supply of food, and will produce superior steers, there will remain in the

best their blood is usually made up of zigzag crosses minds of practical men the hope that the dual or general-purpose pure-bred type is a possibility in a distinct breed or breeds. If this hope can be realized by the production of cattle that will pay better than the specifically developed beef and dairy types the world will be blessed.

I have yet to hear anyone deny the commonly-made statement that there is occasionally an individual cow among common and Short-horn cattle which successfully combines large dairy value with large value as a dam of steers. Extreme advocates of the special types urge that, while this may be true, breeding to the two purposes brings opposite physiological forces into antagonism and we cannot breed that constancy of heredity required in pure-breds. Breeders of beef cattle, though they are devoted to the highly specialized beef type, are not usually so insistent as breeders of dairy cattle that there can be no middle class. The statement commonly made that milk and beef are such opposites physiologically that they are antagonistic is not on a very firm experimental foundation. That good milking capacity when in milk and good beefing capacity in the feed-lot are successfully combined in certain individuals is to me absolute proof that this question is at least worthy of investigation before any definite laws are laid down for practice.

Certainly not only those who are always hunting for the impossible in combined excellence, but many of our most substantial farmers and breeders believe in the animal which combines good beef and good dairy qualities. Not a few who set themselves up as teachers insist that dual-purpose cattle have usually appeared in a very weak position because of their having no acceptable plan for breeding cattle of this class. Some of these plans are too weak to need opposition, even though they may have emanated from sources to which people are inclined to look for better things.

Breeding bulls of high beef type on cows of high

dairy type results in the opposite of uniformity, with an average dual efficiency too often far below the point of profit. Radical hybridizing is practical in extensive long-continued scientific operations in experiments in breed or variety formation, but not usually in the practical breeding for immediate production, which plant breeders will call breed growing, though there are exceptions, as in the case of breeding mutton rams from the lowlands on the hardy upland ewes of Scotland.

"Buying good milkers of mixed breeding and breeding on them bulls of the beef type to produce steers" may be a good policy for the occasional dairy farmer who is a shrewd buyer, but as it requires that the producers of these cows shall have bred large numbers of unprofitable ones to secure the occasional one suited to the needs of the shrewd dairyman, it is poor general or public policy. It is hard on the other fellow. The entire problem rests on the question as to whether a practicable plan to produce dual-purpose pure-bred cattle can be devised and not on whether they are desired or needed on hundreds of thousands of farms. By what method can milking Short-horns, Red Polls, Devons or common cattle be so improved that they will fill the want? Or can a plan be devised under which we can form new breeds of the desired type by hybridizing existing kinds?

Possibly the best basis for forming a new breed of this kind can be found among our common cattle.

CHAPTER XVII.

BREEDING DUAL-PURPOSE CATTLE.

To define more definitely the problem under discussion, cattle may be divided into five classes: 1. Specialized dairy types. 2. Dairy types into which there has been engrafted or left some tendency to beef quality. 3. Dual-purpose cattle in which the stress is laid equally on dairy and on beef qualities. 4. Beef types into which have been engrafted, or left, some tendency to dairy quality. 5. Specialized beef types.

Few will argue for the second class. No one has the hardihood to advertise beefy Jerseys. Years ago Holstein breeders catered to beef, but the breed has since been vastly improved. The beefy ones were usually such poor milkers and were so tabooed by butchers.

In part without warrant except to get an advantage in the price paid, that they became very unpopular and only the best performers at the pail have been retained and now these latter dominate the blood of the breed in America. Sometimes great adversity which wipes out all but the best causes a radical improvement in the breed and here the dairy type has been much improved. It should be explained that the word "type" is not used in these articles in its narrow sense to mean mere form and outward appearance, but in its broad sense, including not only form but ability to perform, to live long, to multiply and to yield net profits per herd. Adversity developes character in breeds as in men. A "fashion frost" removed all the roan beef Short-horns but the best, and now they average better than the popular reds.

If fashion now turns to roans, the reds will be benefited by the retention of only the best. The kind

of popularity which causes every animal of a certain color to be bred causes retrogression. Domesticated animals are an abnormal product. Breed from the average and they will deteriorate through the operation of atavism. Breeding from the abnormally good is necessary to retain present excellence and to improve it.

The third class is the one mainly in dispute. If we can breed dual-purpose sheep, the Shropshire or Rambouillets for example, why not dual-purpose cattle? And if argument is made that wool and mutton production are not so physiologically antagonistic as dairy and beef production we have the general-purpose hens. The Plymouth Rock, Wyandotte, Rhode Island Reds and other breeds, or at least families of these breeds, successfully unite egg and meat-production, presumably in a way that makes the flock more valuable to the farmer than the special-purpose egg breeds or the special-purpose meat breeds.

Many things in breeding commonly regarded as impossible are merely difficult. Nature has evolved men for one class of work and women for another. Even in our cattle the males of every breed are powerfully masculine, while the other sex are mild-mannered and feminine, thus resulting in sex duality within the type. All through the animal kingdom we find examples which make it look quite possible to breed cattle of high dairy efficiency when in milk and very good beefers in the feed-yard and at the block. It must be admitted that we cannot secure highest excellence in each quality in the combined animal, but this is not an admission that the combined value does not equal or exceed the single value of either of the special-purpose types.

Breeders of beef cattle may have been inclined to lie down because special dairy breeders have held up their large records and said they were outdone. Possibly dairy cow statistics have needlessly paralyzed the

breeders of milking Short-horns and of other dual-purpose cattle. And it is not to the credit of the vast interests invested in dual-purpose cattle that this argument must be based on generalities gathered outside the breeds which combine beef and milk.

The devotees of classes 3, 4 and 5 will soon awake under the lash being applied by the dairy experimenters and breeders and we shall have performance records of herds. Records showing beef products, dairy products and net results from the best herds of milking Short-horns would set the dairy experts at a new task. They might find themselves on the defensive. In the meantime it is due that we take off our hats to the dairy breeders and congratulate them on the fact that their best dairy herds are making them better profits, and theirs is the stock we should be wise enough to use in dairy production, at least until dual-purpose cattle are bred up.

The dual-purpose cattle problem is of the future. Only a beginning has been made. The next step must be statistical methods of breeding or the special-purpose dairy cow will continue to dominate dairy production and the beautiful beef animal will dominate in meat production. And the emphasis need not be especially on dual-purpose breeding. It should be alike on breeding all three classes. The magnificent results attained in breeding dairy cattle and beef cattle should be pushed forward with far greater vigor that as many as possible may have the better blood to use, and that each class of cattle may set higher standards of farm profits for each other class to rise toward in competition. Systematic, statistical dual-purpose breeding is nearly a virgin field, and on that account may be open to more wonderful opportunities than breeding the special classes. Who knows?

The problem of the formation of new breeds lies in the method. Present methods have carried us farther and farther away from pure-bred dual-purpose types

of Short-horns, while the Red Polls and other general-purpose breeds have been ground between the upper and nether millstones till most of their devotees do not know where they are "at." Associations or very large firms have an opportunity to build up county families or breeds of milking Short-horns or of Red Polls, and their field for sales is practically without limit for stock which has the suitable form and the backing of performance faithfully and authentically recorded in statistical pedigrees. Plans such as have been outlined above but combining records of both beef and dairy qualities could, I believe, be worked out and put into operation in all these general breeds by co-operative associations. A resident of Grant Co., Minn., who has means and public spirit has expressed the firm belief that it would be quite practicable to inaugurate a co-operative enterprise in breeding milking Short-horns in his county.

Since this article is designed mainly to arouse students and breeders of milking Short-horns from a Rip Van Winkle slumber of nearly a half century to take up anew the study of the philosophy of breeding these all-round good cattle, it is thought that to take up a specific problem will be an aid. The assumption is that 25 farmers in Grant Co., Minn., would enter into a co-operative breeders' association and that they would each purchase an average of 10 cows and a bull to start with. The Short-horn breeder whom I regard as best qualified to pick up foundation stock for such an enterprise recently said that $200 per animal would be ample to collect the most promising cows for such purpose, cows which are known to be good milkers and not too weak on the beef side. A bull for each member of the association would cost more, and $500 each would be none too much to secure the best available bulls. Investigations would probably show the wisdom of securing part of these bulls from England or even from Australia, where, it is believed, there are stronger milking families of Short-horns than in Amer-

ica. This would make the expense for each farmer $2,500, or a fourth more than some of these men, no doubt, have invested in a draft stallion. As the years pass by and the poorer cows and bulls are discarded and as means accrue from the sale of young stock other purchases of males and females should be made. The final object is to secure the blood of those few Short-horns throughout the world which have the highest efficiency as dual-purpose breeders, then discarding all else, make of this blood the future breed of Grant County Milking Short-horns.

The policy after the first few years should be to introduce other blood into the new blood lines only after it has been tried in combination with some of the less valuable members of the county breed or sub-breed. Carefully-kept records would show how the various breed roots selected as best would niche together in producing progeny.

While incestuous breeding has dangers, the limitations of which have not been clearly worked out for the bovine species, three bulls and six cows chosen as the best from among the whole lot selected in the county association could be so inter-crossed that no trouble could arise from too close breeding, and yet give range for avoiding unhappy blending.

It is not probable, however, that so few basic individuals would finally be chosen. On the other hand, a single very remarkable sire, or dam, might be found with blood so excelling both in projected efficiency and in the ability to endure in and in breeding that its blood should be concentrated with comparatively little admixture and adulteration of less valuable blood. The necessary inbreeding would possibly help to intensify the prepotency of the new blood, so as to make it more effective when bred to outside registered or to grade herds. Not only the good or bad effects of this line of breeding could be made a matter of statistical record but the prepotency of the blood lines thus compounded when the bulls were used on the general stock

of Short-horns could be measured and recorded. Breeding power within the family and prepotency when outcrossed on other families of the breed may not always be the same. It is to be hoped that better breeding, better methods of recording values, and sales based on statistics, will some day greatly increase the use of pure-bred cattle, thus lessening up-grading, which is a mere pioneer necessity and which too often means the mixing of the adulterated blood of one breed with the pure blood of another; in other words, constantly hybridizing, which, except in certain cases, does not pay as well as breeding pure-breds known to give uniformly good results. Only by means of pure breeding can there be attained a uniformly high average of efficiency of breeding stock and of individual excellence in practical herds on our farms.

The value of the crossing reasonably nearly related families needs investigation. The present thought may be too much in its favor. It may be a help in case of some families and an injury in case of others.

The Short-horn breed offers a large market for heads of herds and for foundation females to start or improve herds, and many animals highly bred in dual excellence could be sold at high prices for these purposes. The other dual-purpose breeds would offer a more restricted market because there are not so many engaged in producing pure-bred stock of the other classes of cattle. Such an association could make money selling bulls and females to farmers but the best profits would come from bulls sold to breeders who in turn supply bulls to farmers. It is also true that Red Polls, backed by accredited figures of butter production, beefing quality, fecundity and disease resistance, might easily be made so popular that men would pay large prices for foundation females with which to start new herds, as well as for male stock.

In co-operative breeding of dual-purpose cattle methods of organization, dividing the expenses and profits, retaining the choicest animals within the county

or association and other general business matters could be arranged much as suggested in connection with breeding beef cattle and dairy cattle. The standards of excellence and the methods of recording values would be more complicated and even more difficult.

No doubt it will require a longer time, more expense, and most difficult of all, more patient waiting on the part of the members of the association, to breed dual-purpose cattle than to breed either of the two special classes. But the possible outcome is larger, and I believe that only a few years would so reveal the large possibilities that those in the co-operative enterprises would become enthusiastic. Of course the personal equation is here, as in most experiments, a very important factor. Much would depend on the leading spirits and on those responsible for directing and performing the details of purchasing foundation stocks, feeding, testing, tabulating, and interpreting the results, and in their use in mating animals.

Breeding cannot be all reduced to cold formal statistics. Personal experience, judgment and even intuition must always be recognized as playing very important parts in the selection of foundation animals. Some plant breeders have developed to a marked degree intuitive faculties of selecting useful forms, oftentimes selecting intelligently long before the desired flowers or fruits are developed. And our best animal breeders claim that they possess intuitive abilities which they cannot express in language. A prominent Hereford breeder recently said he could often discern that a certain young bull would be a remarkable breeder, yet he could not express to another the basis for that belief, and I am ready to believe that he is correct. Life is too subtle to be wholly subject to the measuring rule or the weighing scales.

CHAPTER XVIII.

BREEDING SWINE.

The history of breeding Poland-China hogs in the corn and clover belt of the Mississippi Valley is an open book full of interesting philosophy. It illustrates the rapidity with which changes of vast economic importance may be brought about by animal breeding; it also illustrates how an entire generation of bright men may pursue a policy which is on the whole somewhat narrow and may be misled by mere artistic appearances. A proper interpretation of some of the leading factors operating to modify our breeds of animals for better or for worse can best be set forth by illustrations from the porcine family. Owing to several facts, hogs are our best farm animals with which to do some of the many needed breeding experiments. They have large litters of young and a new generation can be produced every year, because the female at a year old will produce a litter and annually or oftener thereafter. They are docile and intelligent, easily managed in feeding experiments, generally free from disease (except cholera), and there is such a variety of domestic and wild forms that relationships may be secured for mating near relatives or for hybridizing distinct forms. They are profitable animals and the experimenter can raise them in large numbers with remuneration, thus basing facts upon averages secured from large numbers.

But the above digression is only anticipating suggestions for breeding experiments to be offered in a future article. The present purpose will be served by a brief review of certain historical facts in the breeding of Poland-China hogs. This breed was formed by hybridizing several fairly well established types of hogs

brought together in the Miami Valley in Ohio in the middle of the last century. It is said, by the way, that one sire, purchased from a Polander, was a veritable "Messenger" as the parent of this breed. He seems to have been that one in many thousands the blood of which when multiplied makes the better variety or better breed. In color these types carried little but black and white. There was brought into the mixture the blood of large white hogs, of coarse black hogs and doubtless the blood of small black hogs of the Eastern continent. The sturdy Ohio breeders used at first mainly the larger constituent elements in making up the Poland-China breed of a third of a century ago. But the atavic elements of the early maturing small hogs remained in the blood of this hybrid breed. Attenuated by not being allowed to dominate for generations these recessive characters only awaited a chance to become active participants in the general blood mixture. In fact, even in the earlier decades of this breed an occasional "chunk" was but a sudden assertion of the inherent force of the latent blood of these more or less remote blocky ancestors.

A certain general type early became dominant, because the breeders formed an ideal toward which they bred. All who can remember a third of a century back can recall the old type of this most famous breed of hogs that ever lived; size rather large; body long, tending rather to coarseness as shown in the large leg bones and feet; hair abundant, curly, alternating white and black areas; ears large and pendant; vigorous of constitution; rather quiet and sluggish of disposition; bearing large litters with little trouble at farrowing, and generally good milkers. The average of the breed was probably of greater value then than the average Poland-China of today. This is a terrible indictment of the hog-breeding fraternity, but it is a fact more or less clearly sensed by the leading philosophers among the breeders of the present time. In many respects the present breed is an improvement, but may

be likened to the Irishman's fence. He was building fences for his employer. At dinner a discussion arose as to one's duty to join the church. The farmer contended that though he was not a church member he expected to go to heaven. He said he was willing to be compared with the average church member. He enumerated such good qualities as paying his debts, giving a helping hand in times of need and so forth, yet frankly admitting that he had faults declared that he would average up all right. At supper the farmer asked the Irishman how the fence building was progressing. "Sure," was the reply, "I am setting the posts well and the boards are nailed on to stay. There may be a gap of several feet here and there, but the fence will average up with other good fences which keep out the cattle."

Improvements have been made by refining the animals, somewhat shortening the body, reducing the size, bringing about earlier maturity and developing the rectangular and pretty lard form; the hair has lost its curl, has been made finer and the white spots have been nearly all eliminated; the ears have been shortened and turned up nearly like those of a pert Berkshire; the quiet disposition and good feeding qualities have been retained and the lard padding so long bred into the fiber of the breed is possibly attended with less vigor of constitution; the milk-giving tendencies may have been reduced, but worst of all the fecundity has evidently been reduced in some families. The loss in fecundity and vigor, and presumably a loss in the percentage of lean meat on the carcass, are gaps left in the fence. The largest improvement, no doubt, comes in the smaller amount of food required to produce a pound of gain, avoiding the more expensive feeding later in the life of the hog. These gaps allow such ungainly "critters" as some of the modern bristly so-called bacon types of swine to enter the field which should have been held by this great American breed. Along with the good qualities secured, others, such as

high fecundity, increased milk-giving, larger proportion of lean meat to total weight and strong constitutions could have been retained.

The next step in the discussion is to consider how these changes in form, color and fecundity were brought about. Poland-Chinas, on account of their origin had in their inherited constitution numerous dominant and atavic characters of nearly pure original types; and many combinations of these new characteristics produced by the hybridizing were possible. In the seventies a crusade was begun among meat stock leaders for the early maturing, rectangular, short-legged, compact, thick-meated types of hogs, cattle and sheep, and as one looks back little was said about fecundity, milk-giving capacity, longevity or disease-resisting power. The score card was incomplete, narrow and only a one-sided result could be expected. Swine responded the most rapidly and the Poland-Chinas, being a hybrid breed and therefore full of variations, were especially susceptible to rapid change. Breeders could choose by appearance in changing to the types mentioned. And while observing men had for a long time more or less clearly realized that chunky fat females will not average high in fecundity, they bred on in extreme eagerness to excel each other in producing these forms plain to be discerned by mere inspection, pleasing to the eye, "demanded by the trade," and leaders in getting ribbons at one-sided shows.

Cheap, rich foods and especially corn had here a profound influence. Certain individual hogs were especially responsive to the rich fatness of a clover and corn diet and, developing early into the breeder's ideal of fatness and rectangular beauty, these types were chosen out of the bunch and retained for breeders. Since only the few out of many were necessary to become dominant in the future herds those which especially responded to strong feeding and therefore became heads of herds soon dominated the blood of the breed.

Thus relatively a few peculiarly constituted germs of the breed came to be the basis of the breed, the rich feed being simply the selecting agency, not directly the producer of these germs. In the original hybrid mixture were a sufficient number of elements to be framed as dominants into the ideal of form commonly desired by breeders. Far more of the latent elements, small, early-maturing blood were, no doubt, brought forward from their atavic or as Mendel would say, "recessive" retreats, while less of the coarse white and large black blood was allowed to remain dominant. The speculation seems reasonable that entirely new combinations of characteristics were formed in the blood and became dominated; that is, hybridizing created new forms.

An extreme case of how this plan of selection for mere appearance of individual form affected the breed came recently to my notice. A certain breeder of Poland-Chinas in the Corn-belt produced annually a goodly number of pure-bred pigs which he sold early in the autumn at auction to the farmers of his county. He was breeding two families. One family raised an average of eight pigs per sow. The other family raised an average of only four. The sows bearing only four pigs were fairly good milkers and brought their pigs forward to the auction in excellent form, large and very attractive. The sows bearing eight pigs per litter, though slightly better milkers, produced pigs which could not compare with those of the other family, because each of the eight pigs had only a limited supply of his dam's milk. The thriftiest and most enterprising farmers were after the best and would vie with each other for the plump, fine pigs from the well-fed small litters and would bid the prices up to $35 apiece, netting the owners $120 or more per litter from the sows bearing few pigs. The smaller though comely pigs from the sows strong in fecundity would sell at from $7 to $10, bringing on an average only $75 per

litter. The breeder followed the demand and bred mainly the family which was popular, because that paid him best and apparently suited his patrons.

After a number of years his Poland-Chinas became unpopular. Farmers got the notion that hogs from his herd were not sufficiently prolific to be profitable. This illustrates the fact that mere show qualities are not the whole, but are far less than half compared with the centgener or breeding power of the family or breed. Our shows should emphasize this principle by putting their largest prizes on the get of a sire and on the product of a dam. In wheat-breeding we have come from extending experience to pay little attention to the relative yields of parent plants, once we have a comparison of the average values of a hundred of the progeny of each. Individual excellence is necessary both for itself and as an index to breeding power, but real evidence of breeding power is the final guide. Recently Mr. Carlyle, the foreman of the plant-breeding nursery in the Minnesota Experiment Station and myself were selecting out of about 1,500 hybrid wheats those which were most worthy of further trial. In selecting 175 of the best to continue in the tests we had for inspection the yields of the 1,500 mother plants, also the average yields per plant of 100 of the progeny of each of the 1,500 mother plants. These mother plants were in family groups and, as annually happens, when we had finished we realized that our minds had instinctively given very little weight to the yields of the mother plants. The selection had been based almost entirely upon the relative yields and grades of the grain of the average progeny of the respective mother plants and much weight had been attached to the fact that certain families showed throughout a tendency to large centgener yields and high quality of grain as breeders become really scientific and expert artists the individuality counts for less as compared with authentic evidences of projected breeding efficiency.

Some years ago the writer accompanied one of our

leading feeding experimenters on a tour of inspection of the hogs in a national show. When asked if breeding would not be a better and more economical way to increase the percentage of lean meat on the carcass than by special feeding he replied practically as follows: "Nature gives us the proportions of bone, lean and fat. All we can do is to add a little to the lean by giving a ration especially rich in protein." The fallacy of this reasoning has been disproved to my satisfaction by inspection of numerous hogs slaughtered by myself and by my present associate and former assistant Prof. Andrew Boss. The first two hogs slaughtered a dozen years ago in the instructional work of slaughtering and handling meat in the Minnesota School of Agriculture opened up to the writer a large field of study. These two young hogs were equal in age and had been raised together. One was a Small Yorkshire, the other a Poland-China-Duroc-Jersey hybrid. It is worthy of note that the word "hybrid" is coming into use wherever distinct types of plants are crossed, and as it has proved preferable there should also be used in animal breeding, the principles in this respect being quite similar in plant and animal-breeding. The Small Yorkshire carcass had muscles outside the bony framework, the thickness of which we may represent by one inch, while the outside fat was two inches thick. The other hog had a much larger frame, but the percentage of lean meat was much larger in proportion to skeleton, dressed carcass or to live weight than in the Small Yorkshire carcass, and its proportions could almost be stated in reverse order, as lean meat two inches thick and the fat covering one inch thick. Prof. Boss has numerous photographs of cross-sections of hog carcasses, showing larger and smaller percentages of lean meat. These differences occur not only between animals of different breeds, but among those of one breed and even among those of one litter. And the variation is not slight; it is often marked, just as there are marked differences in the yields of wheat plants of the

same variety or differences in the percentage of protein or fat in ears of corn. There is no character in any species in which there is not more or less variation and in all cases the variation is sufficient to serve as a basis for vast improvement by breeding.

Following the universal law of variation there is no doubt that hogs vary in the strength of their breeding powers and in the efficiency with which each valuable character is projected by heredity into future generations. In breeding hogs, as in breeding wheat, dual-purpose cows or business drivers the work must be done on a broad basis. The herd is the financial unit in hogs and to be profitable there must be blended in the male and female individuals all those good qualities necessary to financial success in the herd. While the breeding has often been along too narrow lines in the past many families of this great breed contain the desired qualities to a marked degree.

CHAPTER XIX.

CARVER COUNTY POLAND CHINAS.

It is probable that an association or a large breeder could better become both famous and rich by breeding pure-bred Poland-Chinas than by hybridizing them with other breeds. At the same time there is an abundance of proof that it is not very difficult to form new hybrid breeds of swine and that it does not require very many years, and that also by this means progress can be made. The Poland-Chinas and the Davis Victorias are examples of rapid work in reducing new breeds to a type. Profound changes can be made within the breed, and with properly-recorded evidences of changes of intrinsic qualities attached to certain individuals and blood lines there is a large source of profit in supplying improved and highly accredited males to head the best herds of the entire breed. In originating new hybrid breeds or in choosing some of the breeds of which the number of pure-bred herds is comparatively small, there is no large market for high-priced individuals for heads of herds, as was mentioned in connection with breeding milking Short-horn cattle. Only breeders with large or valuable herds of pure-bred hogs will usually pay high prices for males or females for breeding. They can do so only because they have a large market for breeding stock among smaller breeders of registered stock and among enterprising farmers. Breeding Poland-Chinas with performance record pedigrees would be profitable because of the large field for the sale of very choice stock among the thousands of American breeders of registered Poland-Chinas.

A county swine breeding association, with Poland-Chinas containing the good qualities of the best existing families, and in addition strong in fecundity and in

milk-giving, high in per cent of superior lean meat, possibly more resistant to cholera than the average, and with such facts properly attested in statistical pedigrees, would have a gold mine. The breeders of pure-bred Poland-Chinas everywhere would be in a line to pay good prices for males and females. To carry this idea further, let us suppose that in Carver county, Minnesota, such an association were formed. Let this be done under co-operation with the State experiment station, 40 miles distant. Let there be an organization of farmers similar to those mentioned in previous articles for breeding cattle. In order that the type sought shall become clearly fixed in the minds of breeders let investigations at the experiment stations on the relative percentage of lean meat and also on the relative fecundity and the relative milk-giving capacity of sows be continued. Let the breeders' association and the experiment station join in deciding upon the characteristics desired in the proposed new family of hogs. Let the association and the station each appoint a man, the two men to act together as a purchasing committee. Let this committee by correspondence and travel review the available facts concerning all the best families of Poland-China hogs in America. There might be purchased for each of say 20 members of the association 10 sows and one boar, or 200 sows and 20 boars. All members should arrange to have their sows farrow at about the same time, so that the pigs may be properly compared. When the pigs are four months old part of each litter could be properly marked and sent to the experiment station or to some central point in the county and fed under the direction of the station or other officials. For this purpose, after discarding any abnormally poor pigs, the litter could be divided. The best could be retained for breeders and the remainder sent to the trials. The results of the feeding tests of the two, three or four from each litter could thus be averaged and used as the "centgener" or family records of the two parents. The tests could include a

feeding experiment of say 60 days during the fifth and sixth months of the pigs' lives, allowing uniform rations. Each litter, but not each pig, would need to be fed separately so as to secure a coefficient as to the amount of standard food required by each family to produce a pound of pork.

The pigs in the feeding test could then be sent to the abattoir at the experiment station and slaughtered under test. The tests here could include percentage of lean meat, freedom from diseased conditions, percentage of dressed carcass to live weight, value of the several cuts in detail and of entire carcass and such other data as might prove of value and be practical to secure. It now seems feasible by experimenting on a few scores of hogs to establish a tabular scale applicable to the readings of a planimeter used to measure the areas of lean meat, fat and bone in cross sections made at definite places of the carcass, thus cheaply securing the percentage of lean meat in each animal placed in tests, as already mentioned. These measurements can be made on the cuts as made for commercial sale, thus not lessening the value of the meat. The State could well afford to help pay the extra expense of the careful feeding, do the slaughter testing and work out the coefficients of value and thus give them official standing in the association's statistical pedigrees. The experiment demonstration that breeding could thus be advanced would many times over be repaid to the State in the added revenue to farmers and breeders which this would produce. All the young animals should be judged on foot before dividing each litter into reserved breeding and test stock, the station assisting, that the general appearance and particular form of each animal may be recorded and in so far as useful, officially incorporated into the statistical pedigrees.

The association would know approximately at the end of the first season the values of each male and female selected for original foundation stock. All the poorer blood lines could be discarded. The best sows

and the very best males of the original purchase could thus be retained from among the many and brought together and made the foundation animals. The exploration for superior foundation animals might also be continued. The year's experience in mating, rearing and testing and the acquaintance gained by seeking the original foundation stock would all be of assistance in knowing how to secure other blood lines from the outside. Experience might prove that thousands rather than hundreds of foundation animals should be secured and their powers as breeders tested. In preliminary work in selecting foundation individuals, parents of breeds or varieties in breeding hogs as well as in breeding wheat or timothy, large numbers must be tested and all but the very highest in breeding value or "projected efficiency" discarded. Here more than half the battle will be won in securing from among the myriads of Poland-Chinas in America those which are best. By mere inspection, inquiring of breeders, examining herd records of performance, by learning of the patrons and neighbors of the value of the stock of breeders who contest for the honor of having the association try their hogs, can the largest part of the elimination be done. And this is cheaper if done for the first rougher selections, thus avoiding so much of the feeding and abattoir laboratory tests mentioned. The writer has added 45 per cent to the height of common flax bred for fiber, and a lesser amount to the yield of other varieties bred from the same foundation varieties but bred for seed instead of fiber. Four-fifths of this increase, in case of the fiber, at least, was added by the first year's work of selection, in securing the few tallest from fields of immense numbers of plants and at almost no expense. The addition of the other-one-fifth of the increased height was added by several years of careful plant breeding in the nursery and at considerable expense. The original selection of foundation stock offers the greatest opportunity for making

improvements and should be done with intelligence and with great care.

In case of wheat, oats and other close-fertilized plants we form permanent varieties successfully from a single mother plant. In corn the plants are accustomed to free open or cross-pollination and incestuous breeding is disastrous. In swine too close breeding is unwise. The fewest blood lines, blood of individuals used as foundation stocks, which may safely be blended and yet avoid too close inbreeding have not been determined. It would ordinarily pay to err on the safe side. It is quite probable that the blood of a dozen foundation animals, especially if two or three of them were males, could safely be so managed that continually crossing their blood lines would avoid the ill effects of breeding too close relationship and would allow for a few blood lines to be discarded, as pedigrees showed that after all only a few blood lines were really dominating the entire new breed. This has been the experience in breeding Thoroughbred horses and doubtless would occur here. It may be that families would be secured which would stand very incestuous breeding, as there is variation in this as in all other characteristics.* As the elimination goes on from year to year the few choicest original foundation animals, or those animals of exceptional breeding power which may be produced in the course of this blending (really hybridizing) of the best obtainable Poland-China blood, will rapidly become the whole of the county breed. If the tests are kept up theories of close breeding and line breeding may be developed and even proved. But the tests for intrinsic quality will do the guiding. Branches of the new family which are inclined to go to pieces because of inbreeding will fall out. The blood of only those which stand the rigid tests will be perpetuated. And those blood lines which are best suited

*See N. H. Gentry's paper on "Inbreeding Berkshires" in Vol 1. of the Proceedings of the American Breeders' Association, W. M. Hays, Secretary, Washington, D. C.

to the food, to the method of breeding pursued, to management and climate, and which come out victorious in the tests through a long series of years, will have guaranteed that they will not go to pieces in the future. Our newly-selected wheats, which excel in the nursery for four years, in field plot tests for four years and in the farmers' fields for two years, in order to earn their performance pedigrees of superiority are not liable to degenerate as soon as they are disseminated. Likewise our new hybrid wheats which are given free rein for three years to pass through their first stage for variation and then subjected to 10-year tests, the same as mentioned for selected wheats, are not likely to sow more youthful wild oats when they are used by the farmer to earn him a dollar or two additional per acre. Mendel's law gives renewed confidence that dominant characters, once they gain the ascendency, are permanently dominant.

The blood of a superior boar or sow may be multiplied with such astonishing rapidity that once value is given by acceptable pedigrees showing peculiar breeding efficiency the blood of a few of the best animals may soon have full sway in a herd or in all the herds of an association and will soon be widely influential throughout the entire breed. It is not a difficult task to add 10 per cent to the value of a State's stock of wheat or flax. Twenty farmers could produce a new race of valuable hogs in much shorter time than they can bring their boys from birth to manly maturity and with no more strenuous attention to duty nor larger exercise of patience. Plans, organizations, cooperation, capital and energetic attention to details are necessary in all lines of human endeavor. Why leave all the merging of interests of those who deal with the farmers?

It is quite probable that discussion, and especially putting them to the test of use, would show serious faults with the plans here suggested. The writer hopes to at least arouse breeders from their lethargy and to

induce the development of new propositions in animal breeding. We need to see that the subject of breeding offers virgin pages upon which our young men can prepare to write. Swine is the best species with which to conduct many of the needed experiments. The generations come rapidly and in large numbers and the products will pay most of the bills and in the end will increase production that they will be a source of much much added wealth.

CHAPTER XX.

BREEDING BUSINESS DRIVERS.

The love of show, catering to fashion and the sporting instinct, and the desire for useful, pretty and interesting horses have been powerful factors in breeding drivers. While the demand is large for driving horses bred for use in the family carriage, the doctor's wagon, the business man's road-wagon, the light delivery wagon, and other vehicles there has been little effort to breed directly and specifically for that class of horses. The racing thought has entered into the ideal nearly all along the line and instead of having horses bred to a driver's type we have a mixed type, yearly approaching more and more the grey-hound-like racing type, though the tendency to breed a class of drivers with more body and less racing instinct is also growing.

While the breeding has been more especially for trotting racers the proportion of really speedy ones has been small, and that of really first-class drivers still smaller. In the absence of any adequate plan of breeding drivers with more body, more strength, more toughness, more docility, more beauty, more grace and more uniformity, breeders have been content while trying to breed for the occasional speed horse to use the left-overs for driving. The clear, vigorous and continued attempts to collect the very best blood suited to founding breeds or families, which would be uniformly toppers for drivers, not racers, have been few and feeble. As a result we have a racy lot of driving horses for family and business use, with an occasional individual standard-bred or more often grade horse, which nearly meets the ideal. The trotting breed would be better off if all but its best ten per cent were crowd-

ed out of existence by a breed of non-racing substantial drivers.

Some of the collections or famililes of drivers and coachers already in existence are being used as basic groups with which to make a beginning without too much further crossing and disturbing of blood. The starting of a newly compound breed of horses is truly a long-time proposition and from that standpoint very difficult, both from a financial and a breeding point of view. The foundation stock, if used in the necessary large numbers, is very expensive; the generations revolve slowly, as each female has only one young at a birth, does not uniformly bear a colt every year and the young require several years to mature. On the other hand the ultimate object is large. Individuals and co-operative associations with capital and with the disposition as well as the ability to wait for results, could reap large rewards from well-directed efforts carried out on a large scale. Large corporations or co-operative associations in working out standards in the keeping of records and in assuring continuity and high character to the work and giving authenticity to the pedigree records of breeding powers, aided throughout by the State or United States Government, could do this work. It has proved wise in Ontario, Wisconsin, Minnesota and in other states to invest public funds in dairy instruction and dairy inspection, so as to better the quality and sustain the reputation of the output of creamery butter and cheese. Proportionate expenditure in breeding a class of driving horses which might be remarkable at high prices in all the markets of the country and even in other countries might be equally profitable to the State. The nation, the State, the county, co-operative associations, corporations and separate individuals are all capable of co-operating with each other to the mutual advantage of all and to the profit of the entire public. We do not hesitate to apply this principle when we are improving harbors, subsidizing railways or building highways, as well as in the com-

mon defence of our country. Why should we be averse to applying this principle of co-operation of public and private interests to improving our live stock, as well as to breeding wheat or devising better schemes of farm management? In case each problem be found too difficult for the farmer to solve for himself, the commonwealth may properly co-operate with him in order that all may bear the expense and all share in the advantage.

Wabasha Co., Minn., might be a good field for co-operation in the breeding of driving horses. The farmers have the means, their lands are rich, they have to a greater extent than any other county in the State the habit of sending their sons to the agricultural high school at St. Anthony Park. There is no reason why an association of twenty or even fifty farmers could not be successfully inaugurated in that county. It is less than 100 miles from St. Paul and Minneapolis and about 300 miles from Chicago, with their great horse markets. The whole West is a growing market for driving horses and will always have a full purse for those having the proper size, finish and quality. The wealth of this country is increasing rapidly and fine horses are practical necessities and luxuries which people will pay well to secure.

Let thirty or more farmers form an association and purchase an average of five mares each. Let the association purchase ten stallions and have each stallion serve fifteen of the 150 mares and also do service in his neighborhood. Other farmers could easily be induced to raise grade colts, possibly giving the association an option at a certain price on all colts at a given age, as at one year, at two years and at three years of age. The stallions could be used in rotation, as mentioned for males in other breeds, and their breeding efficiency could thus be compared so that in several years all but the few best male blood lines could be dropped. The mares, being bred successively to several horses, could be compared in their colt-rearing

ability, and all but several of the best female blood lines could be gradually discarded. The statistical pedigrees thus systematically worked up would soon show which combinations of the best blood gave the highest average of values in producing desirable animals, uniform and capable of being sold singly or in matched teams at good prices. The dealing in grades raised by patrons of the studs, sales of mares and geldings from the registered stock, and the sale of males to be used for upgrading in other counties and States, also the sale of males and females to other breeders of driving horses, should become very profitable. By some means, as by a system of options, all the very best stallions produced by the different members could be retained to serve as association studs. Once established on a profitable basis the production of registered Wabasha drivers would be attractive to other Wabasha farmers and the more the better.

The agricultural college could well afford to arrange a special short course and bring to it the best teachers of horse breeding in the country, if such a country organization of breeders were in position to demand or to utilize such instruction. After a number of years the experiences of the members, the accumulated records, the rich blood lines in the possession of the association, the beautiful and useful horses growing up, the activity of the best markets for Wabasha drivers, the nice profits and the general enjoyment and higher intelligence resulting from successful co-operation would add to Wabasha County's civilization and to its charms as a place for country homes. Such schemes do away with but little of individualism, but the co-operation makes possible greater opportunities and liberties for all. The co-operative creamery is our most wonderful example of how co-operation may do away with the individualism of drudgery. At one stroke the wife has thus had the milk and churning burden lifted from her shoulders and at the same time butter production has been made to pay better. The

breeding of drivers does not end with raising horses. Educating them is quite as important a branch of the business as breeding them. Let Wabasha County become as deeply interested in breeding high-priced drivers as the Island of Jersey is in producing Jersey cattle, or as Herefordshire is in breeding Hereford cattle, and a county horse training school would be a necessity. The bright young farm boys of that county have thought they had not work of sufficient importance on the farm, as shown by the fact that too many of them are seeking to become clerks, barbers, bookkeepers, stenographers, conductors on street cars or railways, locomotive engineers and professional men. They are giving the farm labor and the farm opportunities over to raw recruits from Europe. Hon. F. W. Knapp, chairman of the legislative committee of the State Grange to especially urge appropriations for the agricultural high school and for agricultural instruction in rural schools, a resident of Wabasha County, says practically as follows:

"The sons of the old New England stock, who as pioneers settled Wabasha County, are inclined to leave the farm to the foreigner. The numerous graduates of the agricultural school are bringing back a better state of affairs. We need new methods, special lines of business on the farm, which will meet the desires and use the abilities of the superior New England blood which settled the country that we may keep more of this superior blood on the farm."

The merger idea is rampant in all lines of activity, the printing press, education, the railway, the telegraph, the telephone and other agencies have given mobility to affairs. As in lines where co-operative organization or corporate arrangements greatly increase the value of the product individual efforts cannot compete, so in the foundation of a breed of drivers the individual cannot so well cope with the problem.

Think of the Wabasha County horsewomen in a community making a specialty of breeding and educat-

ing drivers. The sisters, wives and daughters can enter into the work of developing, training and matching colts. Picture the Wabasha County Fair with such an interest to hold it up to a high standard. Realize the victories of sales day, when the buyers come commissioned to bring to their rich city patrons the beautiful drivers, the family pets, the matched beauties and the prize winners. Let this industry, if you please, set a pace for other lines of farm effort, co-operative and otherwise. Such organizations have a most useful function in the agricultural affairs of a State. With a large number of such co-operative organizations acting in unison, through representatives in the State agricultural society and in other general agricultural organizations agricultural interests would receive their just share of emphasis and attention. In such organization farmers would learn better how to co-operate, and better team work would result in political, school, church and other organizations devoted to county affairs.

There is no need of here going into details about the construction of score cards, methods of keeping score card judgments and of recording the performance records of individual animals or their "centgener" powers as breeders. These would be worked out by the leaders in the movement and officers of agricultural colleges and stations interested in breeding and in good horses would be delighted to assist in the development of score cards, of pedigree plans and even of business organization. The horsemen of the county, especially those experienced in the statistics of performance records in breeding trotting and running horses. have a store of information which would here be of value. Knowledge would develop apace and the bright men in such an association would soon form a school for one another.

The words "individual merit" are used in referring to the measure expressed on the score card when comparing animals or when comparing an animal with

an ideal standard. The words "breeding power," "centgener power" or "projected efficiency" serve when comparing values of individual animals as parents, or as prospective parents as foundation blood for new families or new herds. But there is no common terse expression to be used in comparing the farm value of one herd or one breed of domestic animals with another herd or breed. "Farm value" expresses the idea only fairly well. The words "agrogenera value" (agro —field or farm, and genera—of one family) is suggested for use in comparing a herd of one line of breeding with a herd of different breeding. Thus the agrogenera value, or profits, to the farmer on Wabasha drivers would be larger than that of herds of standard-bred trotters. The occasional very fast trotter is valuable, but the farmer generally gets only a moderate price, the profits going mainly to some future owner who develops the speed. All but the fast ones sell at only very moderate prices, as the average for a series of years, and the mares do not serve so well to do the farm work. Mares of Wabasha driver breeding on the other hand if bred to larger size with more body would serve well as farm horses, and by breeding directly for the driving purposes there would be a larger number which would sell for high prices for driving so as to bring the average sale-price higher than that of the standard-bred product. The racing interest has too much control over the breeding of drivers. Would not our country be better off if it had in place of the poorer two-thirds of the standard blood and grade trotting horses, registered herds of larger, stronger bodied, tough, long-winded, long-lived, docile, good acting, handsome drivers?

CHAPTER XXI.

BREEDING FUNK PERCHERONS

Many lines of agricultural effort are progressing more rapidly than animal breeding. Wonders are already being done in this line, but our present achievements will, no doubt, seem tame beside what may be accomplished before many decades. Had we a man in animal breeding who had accomplished such wonderful achievements as Burbank in plant-breeding, animal improvement would be given a new impetus. I am not pessimistic over what has been done, but very optimistic over what can and should be done. Men are needed who can do for artificial evolution—evolution under the influence of man—what Charles Darwin did for natural or historical evolution. Schools of the philosophy and practice of breeding in its broadest sense should produce such men. The subject is so broad; the philosophy so deep; the details so vast in number and varied in character; many of the facts and theories so buried in abstruse reasoning; the human interests affected are so diverse; the economic and artistic needs are so varied and capable of multiplication into such a maze of forms, and the entire wealth at stake is so stupendous that the science, art and business of breeding form one of the largest human interests. The finding, developing, measuring, making records of, emphasizing and purveying the blood of the few germs with the very highest projected breeding efficiency represent greater riches than a Klondike.

To further emphasize the subject and to incite constructive thought I will indulge in a line of specific suggestions in breeding draft horses. For convenience let us assume the point of view of the big seed company in Central Illinois. Here nearly two dozen men of one

family—the Funks—owning 25,000 acres of exceedingly fine land worth over $3,000,000 are already joined together in a co-operative association organized somewhat after the manner of a co-operative creamery, to breed corn and other field crops, their farms being conducted individually, the breeding of the corn and the sale of the seed corn only being done through the co-operative association. They are beginning to taste the fruits of dealing in very large numbers of individuals in their operation in corn-breeding and to sense the future possibilities of federated energies in a large business enterprise devoted to purveying the projected efficiency of the blood of a relatively few germs rigidly selected and highly accredited by statistical records of performance. They are, partly unaware, uncovering a gold mine. Nature's slow processes required ages to accomplish results in the evolution of species. These men are ready to incubate the plans, organize the forces and operate the enterprises scientifically to evolve new values with a new rate of speed heretofore not dreamed of. If these men can approach the possibilities of the opportunities they already see they will have done wonders for themselves and for their country, and newer and greater possibilities will continue to rise before them. There is no set limit in the artificial evolution of economic forms of plants and animals. The lines of improvement are well nigh numberless, and the degree of change possible to secure is a sufficient reward for every intelligent effort.

Let us assume that one of these men is not only interested in handling and educating horses, but is gifted in regard to horse breeding, and that the company should so be organized as to make him manager or director of breeding Percheron horses for all the farms which are managed by the separate owners. There would necessarily be the preliminary period of his going to the fairs to be associated with show judges, attending sales in large cities to learn the wants and the philosophies of the markets, of visiting breeders at

home and abroad to get their ideas and to know their stock, of studying pedigrees and family values, of learning where the horses are to be found which would have greatest permanent value in the new stud, what prices to pay, how to buy, transport and how to care for, breed and develop the animals, once foundation stock should have been secured.

The farm work on 25,000 acres under rotation—growing especially bred seed corn, seed grain, grass seed and clover seed—would surely need 400 mares to do it—one for each 40 acres of land under plow. It would be neither practicable nor wise to stock up with so many mares at first, but the 100 mares, more or less, which might be collected at the start could be chosen from among the best Percherons in America and Europe, and to go with them a number of stallions, we will assume twenty, should be purchased. The mares could be divided into twenty groups of five or more each and placed upon separate farms or merely recorded separately, and one stallion could be bred to each lot. The stallion is "half the herd," and stallions should become foundation individuals. As a stallion's blood can be multipled from fifty to 200 times as fast as a mare's the females are especially useful to get the centgener values of the stallions, and incidentally to give their own centgener values and to serve as foundation mothers.

The second year the stallions could be shifted, as by shifting the stallion with the first group of mares to be with the second group, the one with the second to the third group and so on to the tenth, if there were ten stallions on ten farms which would go to the first group. Each year a similar shift should be made. In three to five years, possibly sooner, the colts of certain stallions would show their sires' superior breeding values, and in other cases the progeny would warrant discarding some of the sires used. In place of some or all of these discarded stallions other purchases could be introduced. As the years passed the tabulated records,

showing measures of centgener values of stallions, would begin to designate certain horses as of very peculiar merit as breeders. The records capable of being averaged so as to give the centgener values of the mares would accumulate much more slowly. But in eight or ten years there would be accumulated data of a sufficient number of colts from each mare bred to a certain group of sires that could be compared with a similar number of colts from each other mare bred to sires by years respectively, thus giving the breeding values of each mare in the terms of her average progeny.

The first available evidences of strong breeding powers would come in the side of the males. As soon as really superior male blood should be found at hand the full complement of mares to stock all the farms might be secured and the blood of the superior sire used on them, possibly utilizing the multiple impregnation scheme where necessary and reasonable. Soon there would arise young stallions and females having blood lines proved especially efficient. These and the best foundation stallions and mares would take prominent place on all the farms. The mares and stallions of second quality, and the young things with blood lines less emphasized by the statistical pedigrees would sell well, because they were all selected originally with unusual care from among the best studs. Whether inbreeding would do serious harm or would prove harmful only in certain families may be a mooted question in breeding Percherons, but it would be better to be safe and not base these Percherons on too narrow a foundation, that is, not on too few foundation parents. The blood of at least the best three to five sires and the best five to ten dams should probably be retained in the foundation group of parent blood lines. Complete records with the demonstrated values worked out for each individual, would in time show whether close breeding causes injuries. But whether closely bred or outcrossed, the blood of those animals making the best showing under statisically kept facts would eventually

be chosen and the blood of the one best parent or of a group of those breeding strongest would prevail. Breeding Percherons on a large scale on these farms would not injure the business of Percheron breeding elsewhere. It would emphasize the breed, furnish stallions highly accredited in centgener breeding value and would otherwise aid in placing draft horse breeding on a permanent basis.

An occasional large country estate instead of only farms of 160 acres might have a good excuse for its existence if its owners would make it serve the general welfare. The large farm has great advantages in breeding operations, because large numbers can be used. The Continental German Coach Horse Co. of South Dakota, for example, with 3,500 head of pure-bred and grade German Coach horses on its ranch could soon outdo the Germans in producing high-priced stallions of this breed as well as make much money out of matched teams and single drivers for the wealthiest city customers. The large number of stallions this company requires would soon enable the owners to select those whose get averages a large number of high-priced individuals. The necessary system for marking the sires and the dams, for recording the values of the progeny of each parent, and for averaging so as to secure the relative breeding values of each parent could be worked out much easier than might seem. The stallion placed on the ranch with his consorts retains his harem (or bunch of mares) and defends it against all interference during the season. Such careful records would pay on a ranch of this size simply for the larger number of high-priced drivers which would be produced, and the possible sale of breeding animals at long figures would be added clear profit.

Graduates of the right kind of a breeding school would be valuable employes of a firm with the possibilities of such a business. Records of the breeding of bronchos may seem a little far fetched, but who has such a rich opportunity for high-class breeding as the

cattle, sheep or horse ranchman who has thousands and tens of thousands of animals under his command? Especially where the ranchman has a part of his range fenced and possibly supplied with buildings and paddocks can he control the breeding of his choicest animals, kept separately during the rutting season and the season of giving birth to their young. Our ranchmen have not had a knowledge of how easily and practically to keep track of their blood lines. Would not experience put them in possession of the necessary simple plans?

Not one, but a number, of co-operative firms are needed to improve the Percheron breed; and each of the other draft breeds in like manner would serve as a magnificent foundation with which similar firms or associations could make profits. Profits in these undertakings will not accrue the first or the next year, as in importing the best from a county or a province in Europe, but eventually the money returns and the satisfaction of having thus created new wealth and of having artistically built up new forms of beauty as well as of intrinsic value should be incomparably greater. We need a class of brush artists to paint the beautiful and optimistic sides of our American country life, word painters to portray the strong and delightful features of our farm homes, and we need more breeders of the highest art and broadest scientific sense to build up beautiful and useful forms of horses and other animals.

But in breeding draft horses we must count days' work in the lives of the family of horses as the first consideration. The qualities discernible in the judging ring are very valuable indices of quality and even of breeding value, but if each horse of a highly accredited family could be marked as by tattooing inside the ear and if his yearly records could be returned to an official recorder, real life-time values would be made available. The States or the United States Government could well afford to experiment to see if such records

kept under the auspices of experiment stations or by the United States Department of Agriculture could not be made a practical aid in breeding draft horses. A family of horses which could show for a goodly numbed of its members a high yearly average of days' works through long life on the pavements of large cities, in "the woods" or on farms would have another record of performances to aid breeders to secure a wider market for good blood. Once we have more records of real merit mere talk will not "sell stallion beef at a dollar a pound," too often regardless of real quality.

No doubt some of the records of intrinsic value cannot be secured, as the expense will be too great or the avenues through which the data must be secured would not be reliable. But investigation as carefully and intelligently conducted as is given to better methods than the present plan of importing from other agricultural problems will certainly result in Europe, where breeding is carried on not very systematically. While inventors are devising new locomotives, automobiles, autocycles, bicycles and airships, and the public is paying vast royalties on these mechanical motors, should those interested in the horse fall short of bringing into use every possible device in science or art to improve man's noblest beast, the horse, which helps man to subdue the earth and has a place in our houses and in our hearts? The call is rising for as strenuous improvements in our control of living matter as over the non-living matter. Our scientists are ready to escape from studying dried specimens of plants and mummified advance from mere growers of European breeds and all unite in making America the great world-center of creating new values in families, in breeds and even in the new species of both plants and animals. A generation or two from now the problem will not seem to

have been a very difficult one. Only to overcome our conservatism and to allow the billions of dollars at stake to lead us into the work thoughtfully and energetically is difficult. Let the will command and the way will be found.

CHAPTER XXII.

INTRODUCING ANIMALS FROM FOREIGN COUNTRIES.

The multiplication of breeds in the British Islands suited to the different conditions of climate, soil and people of these small islands, serves to show the necessity for comprehensive knowledge of the subject of breeds suited to each region in a great continental country. The adaptation of grains, grasses, clovers, and especially of fruits, vegetables and flowers to each soil in every climate, and even to the artificial soils and climates under glass, illustrates the complexities and possibilities of the entire subject of suiting the varieties to the conditions of each locality.

The idea being urged by Mr. W. T. Swingle, the great "suggestor" of the National Department of Agriculture, that life history studies be made of every species of plants and animals, is entirely to the point. Under these plans men would be detailed by the National Department to study each economic species wherever it may be scattered throughout the earth. Their life history as species, their habits and adaptabilities, their uses and weak points, their variation and adaptation to various climates and uses would be studied in relation to every condition of climate, soil and market needs. The possibilities which might come from breeding them pure or from hybridizing different species, varieties or breeds would also be studied. Thus we need men who know the wheat species in all its characteristics and habits. Others are needed who know alfalfa in all climes and who will suggest experiments to local investigators, and thus set in motion the necessary research to secure better yielding hardier disease-resistant forms, and alkali-resistant strains, to fit every cultivated area, whether in a tropi-

cal or in a temperate or cold-temperate region where other field crops are grown. Men are needed who know the whole range of sheep life, the regions to which each form is suited; the possibilities of hybridizing each wild and cultivated form, the one with the other. Possibly new breeds of sheep could be created 10, 20, or even 50 per cent better for some of our conditions than those now available. All will admit that most of the greatly enlarged efforts should be used in improving these best breeds which are already improved. But there may be new realms of effort and no one has sufficiently explored the field to know their limits.

When Prof. Hansen of South Dakota, the first explorer sent out regularly by the United States Department of Agriculture, returned from his quest in Asia for hardy fruits he blocked out some new work. His hardy Turkestan alfalfa importations set the North seeking other hardy forms of this species, with which to bring this most valuable forage plant into the Corn-belt and even carry it far to the Northward, Eastward and Southward. It helped to infuse new hope in those who were trying to push the Northern zone of the Corn-belt farther North. It made us look with new admiration on the rapidity with which our horticultural friends are pushing the apple further toward the north frigid zone. Prof. Hansen saw that the macaroni wheats had pushed out farther into the arid zones of Asia than had the bread wheats and on his return urged the Secretary of Agriculture to arrange for their importation. His faith has already resulted in a 10,000,000-bushel crop of this wheat in America's "short grass country." Though not an animal specialist he saw forms of domestic animal life which he urged should be studied and possibly introduced with a view to their improvement and use here, and possibly to hybridizing them with our improved kinds. The fat-tailed sheep, he has repeatedly urged, should be

studied and imported and possibly hybridized with some of our improved breeds.

There is not nearly enough work done on improving the breeds which originally came to us from Europe, and the total expenditure and effort in this line should be greatly increased. But while making improvements in the European sheep blood, should we not spend enough labor and money on the Asiatic blood to at least see if it has elements of efficiency which could be woven into our sheep industry? Likewise the Asiatic races of cattle may have in them elements which might correct some of the palpable weaknesses of our West European cattle. We might possibly find infusions of blood which would enable us to breed types resistant to tuberculosis, blackleg, to Texas fever and to milk-fever. What a blessing to the great hog regions would be an infusion of hog blood which would resist or better resist cholera and plague. The many millions of loss would justify a search for such blood.

Mr. D. G. Fairchild, the regular agricultural explorer of the Department of Agriculture, took up in a systematic way the study of climatic and plant relationships of the world. Owing to a remarkable friendship forming between Mr. Fairchild and Mr. Lothrop, Chicago, the latter paid their combined traveling expenses for some years in making trips about the world and through nearly all of the important countries. The Department of Agriculture paid only Mr. Fairchild's salary and the freight on the seeds and plants forwarded to be distributed through the Office of Seed and Plant Introduction at Washington. In making these tours Mr. Fairchild not only learned of climates, plants and peoples but also has made a preliminary survey of the animals which might be of interest in improving our domestic races. At the recent meeting of the American Breeders' Association in St. Louis he called attention to the adaptability of Sind cattle to dairy purposes in very warm regions, while the monstrous Matas breed on the River Plata might be of value in parts of

our country, at least to hybridize with our stock. He suggests that some of the water buffalo might find a place of utility in some of our Gulf States or in some of our island possessions. He mentioned the availability of zebras as well as the donkey as a source of blood which might advantageously be mixed with the horse.

Who knows but that by mixing together the blood of some zebra, the donkey and the horse that a triple hybrid might be produced which would form a fertile race of mules? If the admixture of some zebra blood would thus make fertile our mules it is possible that we might develop a breed with feet and limbs as tough as those of the mule, with as heavy weight as the draft horse, with great longevity, with small food requirements and even superior in docility and intelligence. Some results in plant-breeding suggest that such an achievement might be possible.

Mr. Fairchild suggests the wisdom of at least studying the sheep of Tripoli and the milch sheep of Malta. Even if used only to increase the yield of milk in breeds designed for producing baby mutton they might be useful. This subject has been viewed mainly by plant men, except in Western Europe. The plant explorers have learned what are the possibilities in introducing new crops, and they all agree that animal introduction, though a far different proposition than plant introduction is very important. The number of available forms is less, though there are more than fifty breeds of cattle in the world, and a goodly number of kinds of horses, asses and zebras are known. The swine types have not been brought into use, while there seems to have been no very thorough work in introducing goats into regions new to them, but where they might prove very useful, either to be improved in their pure forms or to serve as basic blood in making hybrid breeds. Dr. Kuhn, President of the Agricultural College at Halle, Germany, the Zoological Gardens at London and other institutions and private persons in various parts of the world are experimenting on

hybridizing related species of animals. Prof. Cossar Ewart's work near Edinburgh, Scotland, with zebra-horse hybrids, Mr. Goodknight at Texas, Tex., with buffalo-cattle hybrids, which he calls catalo, are examples. Mr. Goodknight has a catalo bull seven-eighths Jersey which he wishes some interested institution or person would use on Jersey cows to study the effect of a small portion of this blood in a milk strain.

Mr. J. J. Hill, of St. Paul, has started a splendid line of investigations with cattle-buffalo hybrids on his farm near St. Paul, Minn.

These experiments are of interest in determining whether different species will produce fertile and vigorous hybrids, but they are not in the realm of the work of the practical breeder. His life is too short, his interest too fleeting. But the State or the Nation, representing the interests of the race, "will live after we are a long time dead." It is more than probable the experience already at hand from animal-breeding and especially from plant-breeding would enable men to devise problems and methods which would be well worth the while for the State or National Government to follow. The United States produces nearly two billions of dollars worth of animal products annually. There is certainly a profit on this product of 10 per cent, or $200,000,000. One part in 10,000, one-one-hundred of 1 per cent of the total production is $200,000. The use of this sum, or even ten times this sum, would be justifiable if it would add another 10 per cent to the profits. In fact, there is now, doubtless, more than $200,000,000 spent annually by private persons in animal breeding. But a large part of this experimenting is done in a poor way and the results are relatively meager, both to the individual conducting the experiment and to the world at large. National, State and co-operative organizations could better conduct the experiments.

The practical grower of pedigreed stock and the producer of live stock products want live stock blood

upon which they can depend. They have neither the large numbers, the skill nor the facilities for adequate experiments to create new values in breeds. The splendid results in breed formation and in breed improvement already achieved have been most wonderful, but hardly up to the rapid pace being set by the other lines of improvement in the world's affairs. Experiments wisely conducted in this line will relieve private persons from undertaking so much expenditure, as in many other lines taken up by the experiment stations supported by public funds. But the main reason for the co-operation of the Nation and the State is the far more rapid improvement made possible. The figures suggested for public expenditure may seem high, but our present live stock blood does not average very high in value. The case seems to be parallel with plant improvement in most ways. The expence is far greater with a given species or a given hybrid, but the number of new species and the number of possible hybrids are far less. The plant products are two-fifths larger in value, and since there is such a diversity of forms and more need of closely adapting plants to each local region, it is quite probable that the aggregate cost of plant improvement will prove greater than in animal improvement. The magnitude of the enterprise need not deter a nation which can support such large affairs as our postal system, our merged railways, our steel combines, our political parties or our federations of women. The time seems more nearly ripe for great merged farmers' enterprises than earlier, when the dangers such organizations encounter when they try to mix business, manufacture and politics had not been discovered. In some States the federated farmers' organizations have already made successful combined movements to better finance agricultural research and education. But such a long-time proposition as breeding animals or even plants must have those largest federations, the States and the United States, to support

it. The sudden awakening of our nation to a world relationship, a world leadership, has done away with the old cry against a strong central Goverment. All now look to Washington and want there the strong hand mightily clad with power to deal with the exterior and with any threatening power within that the National influence may work out its full destiny. A powerful central Government can not only wield a powerful army, but it can take up large questions of internal policy, policies for the future as well as for the present. Under President Roosevelt, aided by such strong men as Secretaries Wilson and Hay, and Gifford Pinchot and others, a National forestry policy is being actually inaugurated; the most stupendous irrigation enterprise ever conceived is being put into successful operation; the long-desired Panama canal is about to be dug; but greatest of all are our diplomatic achievements. Our annual forestry products at their highest point represent only $109,000,000 or 6 per cent of our annual animal products, yet a few hundreds of thousands of dollars spent annually in forest protection and improvements is not too much, it is modest.

The splendid relations being worked out between the Department of Agriculture and some of the State experiment stations in plant-breeding suggest a similar arrangement in animal-breeding. The great temptation in National affairs is to be paternal rather than co-operative, as is shown by the distribution of free seeds. The Government giving free seeds or free pure-bred animals destroys the initiative of private business. Breeders of pedigreed animals should consider with care any scheme for supplying free to producers of live stock products, or even to growers of pedigreed stock, animals to head their herds. Experiment with seeds have demonstrated that the more proper function of the Nation or State is to create new values, thoroughly prove them, and then launch them at their full value upon the commercial field for the production of pedigreed and highly accredited blood. Thus a new wheat,

the performance record of which showed high value, was sold by the Minnesota and North Dakota Experiment Stations at a high price to many seed growers and dealers. This sale established a high price for seed of this variety and it is now being distributed by hundreds of thousands of bushels of seed by the men who find profit in growing it for seed. This variety is being thus brought into use far more widely than if the Minnesota and North Dakota stations had injured it with the faint praise of free distribution. Superior breeding animals, as wheat, must be accredited by sale at their real value, which means high prices. President Jas. J. Hill of the Great Northern Railway gave away hundreds of superior bulls and boars to the farmers along his railroad. When he takes an invoice of the resulting improvement he loses faith both in those receiving gifts and in the efficiency of a system of free gifts of breeding animals. Many of the animals were killed for meat long before they were used their allotted time. Organization—profits that pay for skill, for advertising and for hustling, is necessary in breeding either plants or animals. A county in Dakota has recently begun to supply males to the farmers free of cost. It seems easy to predict that the same amount of money used to help an association: to secure, improve, accredit and exploit county families of the best pedigreed breeds would pay better in the end. Possibly the Nation must lead out in forming a plan for better arranging the promotion of breeding by the use of public funds.

At present the immediate need is to induce the people to learn of and to adopt the best blood of the pedigreed breeds we now have. The Nation is losing hundreds of millions of dollars by using scrub stock. Our methods of accrediting our best animals so that farmers will discard scrubs and low grades are weak. We need a thorough shaking up. More agencies should be put into operation to show the growers of live stock products what are the best available blood lines for each farm and to show them the greater profits in using

them. These articles are urging different ways of getting at the improvement of live stock largely that breeders may have better methods of accrediting their animals in the minds of the farmers who ought to use the improved blood. Statistical evidence of real values would help to sell what we now have to offer. More shows, more interest in sales, more subscriptions to breeders' periodicals, more judging schools, more teaching of the principles of breeding in our colleges and more Government and State support are needed all along the line.

CHAPTER XXIII.

EDUCATION IN BREEDING.

The literature of breeding is from the practical standpoint of today in a backward and unsatisfactory state. The academic texts on breeding used in our agricultural schools are ill adapted to their purpose. Their body of thought is not along lines which would benefit the breeder or experimenter and is weak or to say the least misleading. They have been conveying the idea that upon completing a theoretical course of study in the curriculum, they had mastered the very complex, abstruse and mysterious subject of breeding. In this respect they suggest the effort to "learn Greek in six easy lessons." In this way too many minds which might have given an impulse to original thought and investigation have been lulled into a beautiful and satisfied repose. As a nation of wonderfully progressive people we have been doing little in working out the facts and philosophies of this subject.

Charles Darwin made a grand stride forward in the theories of breeding. His main contention, however, that natural evolution has been the means of developing plants and animals up to their present estate so overshadowed in his own mind and in the contentious thought of the times any practical economic application of his facts and theories that the full power of his suggestive findings has been largely dormant. The lesser contemporaneous and subsequent lights in the discussion of heredity have hovered about, fought over, interpreted and misinterpreted Darwin's great work. They have proved his main theory ten thousand times, and have become "chesty" when they have discovered that some of his statements of facts have been only partial statements or that some of his theories on lesser points

have been erroneous. Scientists have too often clung to the tail of Darwin's comet and thought they were making marked advancement when working on some matter of very small consequence. Some minds have been most satisfied when working out the exact contour of the last studied of the many minute knots or depressions on the surface of the bones of some fish, fowl or quadruped. The heads of some of our great university botanical laboratories, even in prairie states, have been very successful in instilling into their students a burning desire to devote their lives to the study of small plants in salt water, called deep sea algæ. The fishes have been studied minutely in our geological laboratories, the non-economic as well as the economic species. Doing all this in the name of science has generally meant in the name of another proof that Darwin was correct in his main premises.

Not a few men who pose as broad-minded thinkers disdain the practical relations of science as below their talents. They shrug their shoulders and say: "Oh, I am working on the scientific question." As the science of mechanics, of electricity and of chemistry have passed beyond this contracted phrase in the minds of their devotees, so biology is about ready to become a creative science. As the sciences relating to non-living matter are pushing the world forward, a science of living forces will make fast advances in the world's affairs. These men have too nearly forgotten that the powers of heredity which Nature used slowly to mould forms into higher forms might be subject to the will of man. Darwin's work of suggesting that man could utilize the laws of life or breeding in rapidly and vastly improving his plants and animals has hardly appealed to these men, conservative only in economic relations.

The time has come for workers who have the opportunities and responsibilities of biological laboratories to study the laws of life from the standpoint of evolution under the direction of man. Their work permeates the lesser schools, including the smaller

colleges, the academies, the high schools and even the graded and country schools. The assumption of these men that the whole interest of biological science is in natural evolution is more than stupid, economically it is doing a downright wrong to the world. It is not merely shooting over the people's heads with what is wrongly assumed to be higher education; it is actually leading to the theory that natural evolution is educationally now and henceforth the larger of the two parts of this question. Instead of natural evolution being the main interest, we can now assume that Darwin's theory is proved and proceed to make use of the laws and possibilities he leads us to.

The scientists and the practical breeders have been far apart in their methods, in their theories and in their interests. We have had few scientists who were studying the business problems, the everyday work of breeding. On the other hand, we have had very few breeders who were deeply interested in the underlying science of enforced evolution. Once scientists come fully to realize that the science of enforced evolution is the most fertile field for scientific exploitation now open they will be eager to cultivate it.

The methods of research used in studying natural evolution cannot be generally adopted. New methods must be devised. The crucible, the scalpel, the staining fluid and the microscope will be relatively less prominent. Animals and plants may be studied in embryo. The study of the cell, called cytology, may be highly developed and may give us some facts and some methods of thought. But a dozen years' effort at theoretical experimenting with paints leads me to say advisedly that the facts, the theories and the best business principles for enforcing evolution will be wrought out mainly by studying mature individuals. These studies must be broad, statistical, vast numbers must be employed and long periods of time must be consumed. The sometimes rapidly reached results of the physicist, of the chemist or even of the classifier of

natural forms, must not be expected. That type of experimenter is here needed who will lay out definite problems, devise clearcut methods, change wisely as his developing results warrant and expect to follow the streams of heredity through the blood of many generations of more or less mobile living forms or types to reach desired theoretical results. Often the side light suddenly appearing will have far wider value than the point to which the experiment was directed. Thus, as stated on previous pages, in studying proportion of wheat which is self-pollinated in nature, we found a method of planting crops in the breeding nursery by machinery and were thus made able to work out many things of theoretical and economic importance not before found practical to study.

But to return to the test book, to the philosophy of breeding, as presented in our schools of agriculture. Manly Miles formulated into a readable text the facts and theories amassed by Darwin. J. H. Sanders, Geo. Curtis, Wm. Warfield, Alvin H. Sanders, John A. Craig and Thos. Shaw have each added substantially to Miles' work, while L. H. Bailey has ably written on plant breeding. But most of our basic theory as formulated by Miles has not been greatly improved.

Animal judging at the fairs and especially teaching animal-judging at the shows have been much developed. While this feature is none too prominent it is relatively too prominent because of the backwardness of the general theory of the business of breed improvement and breed formation which has improved relatively little since Miles' book was written. The work of Sanders, Goodwin and others in word pictures of show animals, and of herds offered for public sale is art of high order. This literature has been a potent force not only in giving prominence to superior animals and to herds which excel, but in greatly adding to the growth of expertness in studying animals with the eye. This able literature has given great emphasis to the superior values of ped-

igreed stock in the minds of those who have been fortunate enough to read it. The improvement given to good stock and to good feeding by national, state and county shows of stock has also been productive of much good. The high average excellence of imported stock has had a powerful influence both in bringing superior blood and by setting standards which breeders and growers try to attain.

Lately the class work in our agricultural colleges, the special courses in stock-judging and the public addresses of men advantageously situated where they can learn as well as teach have begun to tell in a very large way. Methods of judging are being developed that educate the judgment of stockmen as to the value of animals which are of high educational value. Principal D. D. Mayne, of the Minnesota Agricultural High School, recently said that modern methods of teaching the judging of stock and corn are unsurpassed in their educational features. He said: "True education is mainly the education of the judgment.. Here is a line of teaching which trains the judgment at every turn." These studies have another very great advantage over Latin or Greek as a means of mental culture. The mind once quickened to the forms, the values and the breeding possibilities of animals and plants are not separated from their implements of study as soon as the text books are laid aside. The student of economic animal and plant forms reads his primer and first reader in school and the higher books, the real objects, the animals and the problems, are before him throughout his career as a breeder.

Our educational fathers made a great mistake in using for their educational machinery too large a proportion of tools which are not used in the business that most of the students are to follow. It would be wrong to try to educate a man for a chair in Greek by training him in modern horticulture, irrigation, farm machinery, or in modern architecture. It is quite as wrong to throw away too much time and expense by

devoting a goodly portion of the time of a school for rural pupils in teaching Latin. In Ohio I found a rural high school with four years of Latin and no agriculture or home economics. How much better would be the system if there could have been these more interesting as well as more valuable studies to put the pupil in closer touch with the things of his or her country home and business? Not a little of this stock-judging and study of enforced evolution may be brought into even the consolidated rural schools. These schools are bound to come—in articulation with the agricultural high schools—and the whole range of country life education will be worked out along the line of technical education for farmers and farm home-makers.

The great educational pyramid built up for developing city life is turning more and more to the practical in education. More and more are the teachers learning to see, what outsiders first see, that practical matters of nature and of industry may finally be shaped into pedagogical tools as effective as any during the school period and the edges of which remain sharp after graduation.

Some practical things are being brought into the city graded schools, which are at the base of the city school pyramid. The city high schools, the middle of this pyramid, are rapidly developing the mechanic arts and other technical subjects of city industry, transportation and commerce. These schools are making rapid progress in arranging the inexpensive yet effective facilities for teaching home economics. The universities, at the apex of this pyramid, which are mainly devoted to preparing men and women for city life, are more and more becoming technological schools for the professional and technical vocations of other cities. Their educational machinery is annually becoming more and more the materials with which the student is to deal in his life work. And the old-time educators who said, "Educate the man first and the specialist afterward," are being laid to rest with their fathers.

The new educational machinery is being made more effective than the old to induce mental growth while in school and has the additional values of better continuing this growth throughout life, and is more useful also in helping to produce the wherewith not only to live but to own the position and the facilities for continuing the education throughout life. The classics and special literary training have become in large part technical specialties.

Our schools to build up country life need also to be articulated into a unified system, with primary and high schools at the base and the middle of the pyramid leading by natural steps to the agricultural college at the apex. As nearly 50 years ago the city high school began its conquest for the field of secondary life education, crowding out the academy so the agricultural high school has started a successful conquest for the field of secondary education for country life. The first of these schools, started in Minnesota in 1888, now has 600 students. The agricultural colleges of North Dakota and Oklahoma and the Universities of Nebraska and Maine have successfully inaugurated similar schools as parts of their organizations. And in Alabama an agricultural high school has been started in each congressional district.

It seems reasonable to hope that the wonderfully successful plan of consolidating rural schools will gradually become general. The rural school of three to six rooms to which pupils are hauled in vans from the largest practical area—the county to be systematically divided into districts four to five miles square—and extended through the second high school year, promises to become the strong base of the new pyramid. Agricultural high schools each serving ten or more counties in which the pupils are supplied their junior and senior years of high school training seem best adapted to supply most of the technical portion of the secondary school—the so-called people's college. The agricultural college, with its numerous long, short and special

courses is developing into a strong apex to the country life school pyramid.

The consolidated rural school on its ten acres of demonstration land, with its cottage for the principal, who should be an agricultural graduate, with one of his helpers, a woman, trained in teaching home economics: with its fields, trees, shrubs and vegetable gardens; with its rooms for practical work for both boys and girls; with its location in a neighborhood which may be made to serve as a great laboratory of Nature and industry, and with its possibilities in the way of traveling instructors and illustrated lectures; with its technical library and with the most earnest support of a delighted and improved rural community—with all these things and more, the consolidated rural school will furnish facilities for some education in agriculture and home economics for all the people.

Primary education in animal improvement can here reach everybody. The agricultural high school with numbers aggregating thousands and even tens of thousands in a state will be able to reach nearly all who are to be our breeders, as well as many other specialists as horticulturists, gardeners, foresters and dairymen, general farmers and homemakers. As shown by the development in Minnesota's school, these secondary schools of agriculture and home economics are developing into highly organized technical institutions. And as the years go on the technique of the subject of breeding will here be so developed that many students will return home not only with the knowledge but with the spirit of faith which will lead them to enter the work and to succeed in building up our plants and animals.

The agricultural colleges, with their experiment stations, all assisted by and co-operating with the great national Department of Agriculture will continue to originate a technique of agriculture and home economics which, when carried to a system of consolidated rural schools and agricultural high schools, open to all those

who are to farm, will revolutionize methods all along the line. Then creative breeding will grow into a scientific art of the highest order. The growing of pedigreed stock will have the thought and daily care which will produce breeding animals of greatly improved average excellence. And the producing of live stock will be carried on by a race trained to it from earliest childhood. The men who are organizing the research work and the pedagogics of animal breeding are writing on virgin pages in many lines, and every item which has the merit to live will be used in an ever-widening field. America must have technical education in live stock, general agriculture and homemaking that she may permanently have a relatively large production of value per acre and per worker.

CHAPTER XXIV.

THEORY AND PRACTICE IN BREEDING.

The theoretical problems of breeding are complex and need investigation, demonstration, illustration and discussion. The different theories need to be given their relative values in relation to practical breeding, to the business of creating new values and bringing them into general use. Some of the old fogy notions too often given undue importance, should be publicly analyzed until they recede to their proper places with other outclassed material. Statistical investigations in the theory of enforced evolution promise to clear up much that is now seen in a wrong or but dim light. Experience with large numbers of individuals of many breeds of varieties, under plans for producing practical values, will give many men more practical knowledge of the creative work, also of the office of the multiplier of new forms. Practical breeders must learn that there is rising a better body of thought on the underlying theory of heredity and practical breeding. Students of the theory on the other hand must realize what a weak statement it is now possible to make of the principles involved in effective breeding and by more and better research improve the forms of statement for text books.

Every student of practical breeding who has had the opportunity of using large numbers of animals or plants under close statistical observation realizes what a complex study individuals are. In some cases of hybrids known to carry the blood lines of three or more distinct races or species we are able to analyze the animal or plant. We can often trace each characteristic to one parental stock or to another. Analysis means the separation of a unit into its component parts. Synthesis on the other hand means the placing together of

the parts and constructing a unit. The first great problem is: "How can the desirable characteristics of two or more parental kinds be picked out and blended into a group of progeny and at the same time discard other characters which we do not desire." Another problem: "How so to blend two kinds as to create entirely new valuable characteristics or to create increased values in existing characteristics."

When two differing organisms are united and all of the dominant and atavic elements of each are thrown together the most complex synthesis takes place. There is ample proof that all characteristics of both ancestors are inherited, though only a part of the mass of these inherited characters can be dominant, effective and visible in any one progeny. There is not room for all; some must remain as dormant atavic elements.

The complexity of characteristics of each of the parents may crudely be likened to a rope of 10,000 threads, of a thousand kinds of colors, each of a different strength, no two colors or strengths represented by the same relative number of threads. The rope thus becomes a complex whole, made up of characteristic parts; and a large group of similar ropes becomes the variety, breed or species.

A river may further serve to illustrate that the living organism is made up of very many active correlated forces acting and reacting upon each other and upon their surroundings. Place in the flowing water 10,000 chemical compounds in varying proportions. There will at once be formed many stable compounds, some of which will remain in solution and may be termed active or dominant; others will be insoluble and will sink as insoluble or atavic elements to the bottom of the river, but always there and ready to arise when their affinities are better satisfied by some passing substance than those which hold down the elemental substances. If we could now divide the broad stream into many streams with narrow islands between, it would roughly represent the race blood or the species blood divided into as many in-

dividuals. Let each minute stream have its own environment and run over a bed with varying heat, the flowing mass absorbing new chemical compounds from its substratum of characteristic soil. New qualities would be added and others created by the modifications of the old by the new, and some characteristic qualities would be dropped. Now let us assume that two rivers have been found, each coming from its own country. Let the second river hold as complex a load of chemicals as the first, yet different. Let it be divided up as are the blood streams in individuals and give each of these a long time to be influenced by its own local environment. Let Nature cause two of these streams to flow together or let man pick out two which especially meet his desires or needs and run their waters together.

When the blood lines of two species or widely differing varities are brought together by hybridizing their individuals the dynamic forces, are in a wonderful ferment. All characteristics from the parents cannot become dominant in this one individual; there is room for only one correlated set which will act in a harmonious whole. There is high art in the correlating powers of heredity, in its building up the individual. Some characteristics must sink to the bottom and become atavic. Where the same characteristics of size, color, strength or mental habit occur in both parents the progeny will usually have the same qualities dominating, but where one is tall and the other short, one light and the other dark in color, one early-maturing and the other late maturing, the conflict leaves dominant in the progeny the characteristic of one parent and perchance another characteristic from another parent. In one case all of the characteristics of one parent may be dominant in one progeny, while another of the progeny may be a composite. The possible combinations of dominants in a radical hybrid, as between Jerseys and Short-horns, between macaroni wheat and bread wheat

or between Italians and Germans, are almost numberless.

A new hybrid, especially if of an open pollenated plant species or an animal species, is usually very unstable and the internal war for supremacy continues. The dominants formed up into groups, held together by their affinities, in competition with eager atavic elements, ever under the influence of environment and the readjusting relationships of atavic as well as dominant characteristics, are here unstable. Natural or artificial selection is required to discard the chaff and select the grain. We can enforce uniformity, if for generation after generation we can select for one purpose especially if we can find the rare individuals in which the desirable group of dominants hold tenaciously together in a stable way. Soon the dominants in the new combination become strongly affiliated; the atavics are held down with a hand strengthened by time and the fraternity group becomes a stable family, breed or species. There is great variation in the persistency of variation among the individuals, from which varieties are formed by close pollenation, as in wheat or barley, and especially in the interbreeding groups of open pollenated plants or animals. Some stocks of plants or animals will settle down to uniformity in a short time, possibly with a certain select class of dominants in the ascendency. In other cases variation continues with persistency, even where the selection is under systematic guidance by man.

The object of breeding is to obtain the best foundation blood lines and from them secure by simple selection or by hybridizing followed by selection of fraternity groups which will so combine the better qualities as dominants into stable economic units of enlarged value per plant or per acre or per animal or per herd, or through hybridizing to increase in value or quality, some of the existing characteristics, or by combination create new characters of larger value and then collect

these as units into nicely correlated forms with large economic or artistic value.

It is not strange that Nature creates very many mediocre and undesirable forms for each superior one which springs from her complicated laboratory. To rise above the level, the individual or the interfertilizing group, which we call species, breed or variety, must be fortunate enough to have in its make-up in a permanently stable equilibrium a large number of dominant characteristics, each of which is exceptional in strengthening the desired general unit in its artistic or economic value. Possibly the law of chance operates. We get a Messenger with his combination of strong parts projected with high efficiency into his progeny only once out of thousands of times. It is not strange that the use of large numbers is a first necessity in forcing the improvement of a variety or breed or for securing the best out of a complex and for the most part unstable mass of a new hybrid. The stubborn fact that there is only one individual of special breeding power out of many thousands is of such paramount significance that we can well afford to encourage theoretical philosophizing, a priori reasoning or drawing of conclusions from too few data. Edison has been greatly assisted in his practical experiments by his theoretical studies. The deeper philosophies of mathematics are constantly adding new possibilities to engineering.

These illustrations are given to show in part that the theory of breeding should receive more scientific study. Practical men should encourage investigation along these general lines. Our ideas are dim and our halting language inadequate to deal with breeding. Breeding does not all consist in one man securing a few phenomenal animals, with which he wins prizes and which yield him a snug fortune. Some of our most practical and most successful breeders may be narrow in relation to the general subject. It is unfortunate that so little thought is put into these theoretical ques-

tions and that so little theoretical formal experimentation has been done in breeding.

During recent years there has been a movement into studying these subjects statistically. Plants and small animals, which can be grown in large numbers with little expense and under control conditions alike for each and all, serve for making records for determining facts.

Mendel, a German monk, thus used peas and worked out some most interesting facts. His results, now known as the Mendelion Laws, were very surprising. He found that where two varieties differed in some strong dominant, as one pea white and another pea blue, one pea wrinkled and the other pea smooth, that the progeny was in the first case part pure white, part pure blue and in the second case part pure mixed, or unstable in their heredity. That is, in the self-pollenated species, a characteristic long inbred so as to be strongly dominant in the plant form would not readily coalesce or mix with an opposite character. In the second year part of the pea hybrids were part white and part blue, and these peas which followed one or the other of the original parent, when planted and their florets allowed to self-fertilize, produced progeny which all followed the white, the blue, the wrinkled or the smooth-seeded parent, as the case might be. It was as if the dominant Roman nose followed the family through succeeding generations where there is marrying into another race. A portion of the seeds, however, retained the mixed dominance of their hybrid character but these also generation after generation partly broke up into pure white, pure blue, pure wrinkled and pure smooth forms until nearly the whole race had reverted back in its individual characteristics to the several original forms. And stranger still, this breaking up seems in some species to occur in mathematical proportions.

Mendel thus worked out facts which may be worth much in breeding. It may assist in combining as dom-

inants the excellencies of two or more different forms, though as a direct help in breeding its value has not yet been developed except in a general way. But it has done vastly more than that. It has set many scientists at work making statistical investigations in the heredity of living things and at devising better statistical methods of breeding. Mendel separated out a few characters which were not only strongly dominant, but were not too closely interwoven with other characteristics of the species. This gave him the opportunity of studying some fundamental laws.

But in the ordinary economic plant or animal the desired dominant characteristics are interwoven with a maze of other characteristics. The economic unit per acre or per head is not made up of easily separable dominant units, all of which may be studied. We are all too prone to look at the few characteristics most easily seen or measured rather than to judge broadly of the value of the whole. The value of the variety or breed depends upon how the parts are blended into the artistic or economic whole.

Breeding is worthy of our brightest minds, as are transportation, manufacture or diplomacy. It seems reasonable to believe that extensive effort will develop this subject as rapidly as it has developed mechanics, theories, our inadequate nomenclature, our stumbling electricity on general business system. Our weak language relating to the complex concepts of heredity and our temerity to enter these subjects are beginning to take on improvements. Many of our college graduates should broadly prepare themselves to study the philosophy of breeding and to be leaders in the creation of new values in plants and animals. Country breeder's associations with young men employed by the Government and State to keep their records and otherwise assist would be a great school in which to train leaders in the theory and practice of breeding.

These articles have covered such a long period of

time that a brief summary and general statement seem necessary in closing.

Breeders may be divided into three classes: private breeders, firms and associations, and public enterprises. In most cases plant breeders require a long time to wait until the newly-created varieties are ready for distribution and bring results to the breeder; and with some species the necessary equipment and expert services necessary for succesful breeding are quite beyond the ordinary individual farmer or horticulturist. Every observing man who grows field, orchard, garden or greenhouse crops, and under whose observation are reviewed annually thousands and hundreds of thousands of individual plants, has the chance of securing occasional individuals of great value as foundation parents from which to make new varieties. For example, many of our varieties of apples come from rare trees found growing in fence corners or other places where seeds have been accidentally deposited. And in other plants propagated by cuttings, where the entire variety is all from a single seed, the plants being sexually mere parts of the original plant, each on a separate set of roots, growers have an exceptional opportunity to originate new varieties by finding a new plant and propagating it. The character of the variety is here fixed in the original plant. This class presents the simplest kind of breeding, though in many species a long time is necessary to fruit and test the varieties so as to select only the blood of the very best mother varieties. The planting of seeds, the hybridizing to create new variations, the long time of waiting, the selection of mother plants, the testing of their progeny in one or more localities, the necessary systematic efforts in the introduction of valuable kinds, make of breeding even this class of plants a complicated business. Even here large firms, or better still governmental control or governmental co-operation with associations, are necessary to encourage this breeding on a sufficiently large scale

to insure that the country may enjoy the possible increase of wealth from this source.

In the case of the self-pollented plants like wheat, barley and peas, where it is practicable to originate a new variety from a single mother plant by seed production, private breeders also find a field of operation. But even here there is a grave question as to whether private breeders and seed and nursery firms will enter upon plant improvement on a sufficiently large scale to really produce the improvements the times demand. The large wealth at stake makes it imperative that there be organized adequate systems of breeding these crops that the 10 or more per cent possible to add to the annual yields may be secured. Breeding these crops has passed beyond the experimental stage. The investment annually of large sums of money by the nation and the State is fully warranted on the basis of each dollar expended bringing back from ten to one hundred fold.

Breeding the open-pollenated species reproduced by seeds is in some ways even more complicated, and only a few species will be bred on an adequate scale by private parties. Corn stands out as the one species of this class which is being and must be bred by many practical farmers and seed corn specialists. But even here the creation of specific varieties for particular uses, as for manufacturing starch, will probably not be pressed to its limit except for restricted areas. Even in corn it is improbable that private initiative will carry the improvement forward on that extensive scale which will result in varieties especially suited to each soil type in each climate region. In any event public institutions may have large function in testing varieties of corn, so as to compare the yields of value per acre of one variety with another in each general region thus to assist both growers and breeders in a knowledge of which varieties thrive best in each locality. The breeding of corn has gained a foothold through the efforts of Dr. Hopkins, Prof. Holden, Mr. Shamel and others which assures to it large efforts. The demand for seed corn

at remunerative prices will give corn breeding that continuous and large attention, both from private breeders and from public institutions, which will insure its rapid development. No plant in the world has better prospects of earning a distinguished set of pedigrees suited to all climes and all soils where corn will grow. It will be bred a king.

Progress in animal breeding, while considerable in the aggregate, is slow in comparison with what it might be. The efforts with most breeders are with small numbers and cover relatively short periods of time. The best fraternity groups or families produced by the most effective breeders are not usually perpetuated as effectivly as they should be. Under the dominance of methods too exclusively artistic, fashion often works economic injury fairly extensive in character and vast in scope, along with its good achievements. The loss of the larger part of the Morgan horse blood, of part of the butter-producing capacity of Short-horn cattle and of part of the fecundity of Poland-China swine represents a sufficient sum to have paid for much additional expenditure in breeding these classes.

Another extensive source of loss is in the expense of unsuccessful experiments now carried on by private breeders of plants and animals. This of course is small in the aggregate as compared with the possible values arising from breeding operations which would add even 1 per cent or forty million dollars annually, to the worth of our plant and animal products.

It would seem that only its difficult nature causes conservatism in breeding, while mechanical and electrical engineering are making such strides as they are. Wider interest, more extensive co-operation, increased expenditures, more investigation into the theory and increased markets for pedigreed plants and animals are all needed.

The whole field is in that stage of development where very great progress is coming into view. Preliminary experiments in breed and variety improve-

ment and in breed and variety formation have given important results; for example, the American trotting horse, the Poland-China hog, the Burbank potato, the Wealthy apple, Minnesota No. 169 wheat, cotton resistant to root rot and flax resistant to flax wilt. In the plant world varieties and species long successfully grown are being hybridized and large numbers of forms greatly varied in character are being formed from which many useful varieties may be selected.

The workers in the United States Department of Agriculture, the State experiment stations, seed and nursery firms and private breeders are all rapidly gaining the experience, developing the methods and securing the necessary equipment with which to hybridize, select and develop the new forms being made possible. Furthermore, broad plans for co-operation are being projected and are slowly but surely coming into operation. Not only are successful methods of plant breeding being put into operation, but the distribution of varieties is the subject of investigation. The United States Department of Agriculture and a group of State experiment stations in the Middle Northwest in co-operation have demonstrated those valuable new varieties of wheat, oats, barley and corn originated by public funds may be given the widest distribution, brought into the most general use by selling them, and at commercial seed prices.

While the free distribution of seeds or even the sale of pedigreed seeds and plants at low prices lessens the business of commerical seed and plant growing, and merchandising in seeds and nursery stocks, selling highly bred seeds and plants by State experiment stations at rather high prices is an advantage to the commercial seed and plant business. It places the new varieties on a commercial basis. By bringing forward new varieties it enlarges the basis of materials in which the seed merchant and the nurseryman deal. By means of long tests under statistical records the experiment stations accredit to the farmers many superior new va-

rieties for which there grows up a permanent demand which the trade may supply.

Professor J. L. Budd of the Iowa Agricultural College,* now emeritus professor of horticulture—a number of whose students have become prominent plant breeders—and a pioneer breeder, performed many valuable experiments. His apple, plum, rose and other work is bearing fruitage. But the most valuable thing he did was to help to work out the relations of the public improver of plants and the commercial seedsman and nurseryman. By selling from the Iowa Experiment Station Russian fruit trees at prices lower than is possible for commercial growers to produce and sell them he demonstrated the futility of a State experiment station ignoring the commercial agencies for distributing seeds and plants. The difficulties he met from the opposition of nurserymen who are pure bred tree men as animal breeders are pure bred animal owners, and the opposition the seedsmen have given the United States Department of Agriculture in its free seed distribution, have led certain experiment stations in co-operation with the United States Government to experiment on methods of distributing seeds on a commercial basis.

By starting out new varieties at a high price they are taken up by seed and plant growers and dealers and pushed to the front. The margin of profits to the seed-grower or dealer, established by the experiment station starting the sale of new varieties at a relatively high price, serves as the motive power in bringing the new variety to the attention of every farmer in the State. "Money talks" and "makes the mare go." Strong margins of profit set in motion the wheels of commercial distribution, and keeps them greased until a still better variety is found, yielding to the grower of pure bred seeds, and the seed dealer, still better profits. Prof. Budd damned his Russian apple trees with faint

* Deceased.

praise, by selling them at the nominal price of 10 cents apiece. He also aroused the bitter antagonism of the commercial growers of nursery stock. Instead of conservatively waiting, thoroughly proving which varieties were best by long-continued and thorough trial, he too early offered his new importations to the general farmer, as well as to nurserymen who were experienced in testing new varieties. In the end the most excellent pioneer work done for Iowa horticulture was partly neutralized by this wrong method of distributing varieties new to the State. And Prof. Budd today is not accorded nearly the credit due him from his State because he was over-zealous in distributing almost free the varieties he prejudged were of great value to the people.

When an experimenter settles down to the fact that there is only one really first-class variety out of very many which is worthy of distribution and that the one is of exceeding great value he is ready to calmly wait the full fruitage of evidence which will give him the right variety and the statistical evidence with which to win his case before the open court of commercial use. When one has promising new varieties of wheat, flax, barley, oats, millet, alfalfa, or, perchance, new varieties of horticultural species which promise soon to be ready to make conquests for commercial supremacy, it requires the German power to calmly wait to avoid prematurely discharging the powder. "A few things thoroughly well done," only varieties sent out which do supersede the common kinds in use, form the only road to that confidence which a State station or United States Department breeder needs, to enable him to give his tested varieties a good hearing. The breeder under State or Government employ who builds up a reputation on only varieties worthy of wide commercial use is able to command prices which will place his new creations at once in the strongest current of commercial seed growing and merchandising. The station or Government cares little for the initial price received;

it seeks the widest rise of the new variety for the sake of the growers and for the general good.

The United States Department of Agriculture is rapidly gaining prestige lost by the long period of weak methods of seed and plant distribution. It is effectively breeding everything from the microscopic bacterial partner of the clovers to forest trees. But its work has just begun. It has only begun to chart the virgin field in plant breeding. It has led the way and now suggestions coming from many sides of the Bureau of Animal Industry join the procession.

If the world has stores of domestic or easily domesticated animal life which we should study in its native habitat, and which we should bring here and study, what is to hinder?

As our central Government grows stronger and stronger, that it may cope with world problems and that it may control the threatening powers within, Uncle Sam is more and more ready to lead in this great co-operative union, where the nation, the States, the lesser organizations, the individuals, all, may co-operate to mutual benefit.

The word Americanism is coming more and more to stand for true co-operation of individual, community, state and nation, grouping the elements of these four classes of powers into whatever co-operative organizations private and public good demands.

The legislative and the executive branches of the Government in their foresightedness are reaching out to help the people. Lest this help be more paternal than is best the nation and the States may need to revise their plans. Our State legislatures are not so far-seeing as is the national Congress. They too often have not so much the spirit of co-operation as the desire to secure paternal assistance from the Government. The strength of the States need not weaken with the growth of nationalism. That the States are many times less liberal in building up their agriculture, their harbors and other internal affairs than is Congress is

no doubt a temporary phase of our development. The national Government is taking the lead in promoting breeding and it is to be hoped that the States will make it a co-operative, not a paternal work.

The study of the foundation stocks of animals and plants, and especially the creation of newly-created forms, are "long-time propositions." The State experiment stations are close to the problems, to the actual stocks under development and in use. The men who are to be the students of life histories of species, who are to formulate plans for breeding and to direct the work must be so situated that they will have long tenures of office beside the objects with which they work. In ten years only a start may be made. Many of the plants can be bred at the stations and much plant breeding by the people can be directed and assisted from there. Comparatively little animal breeding can be done on these public properties. To make possible the use of the requisite large numbers of animals co-operation with large numbers of breeders must be arranged. It is not likely that this will be done in an adequate way unless it is subsidized by public co-operation.

Expert official service is a relatively inexpensive form of assistance and probably in the end the most effective way of using public money in animal breeding. Assistance in choosing and even in purchasing foundation stock might be admissible, but the ownership of the young breeding animals should be left in the regular lines of commercial production where profits will push their dissemination and bring them into general use. The introduction of blood from foreign countries, conducting experiments on the theory of breeding and the education of all the people to discern and appreciate superior varieties and breeds are all most legitimate forms of public aid.

Those to whom the proposed public expense appears large should devote some time trying to comprehend the significance of the nine figures required

to designate 10 per cent of the $4,000,000,000, worth of plants and animals annually produced. He who doubts the practicability of increasing the product 10 per cent or even increasing it 1 per cent may properly say that the possible cost of extensive Govermental and State co-operation represents a visionary sum of money.

(1) We have many excellent breeds and varieties to serve as foundation stocks, and more may be imported.

(2) In improving a superior breed or variety or in forming one there are found in each species, breed or variety numerous individuals which excell in their individuality; and among these there is an occasional one which proves superior in its projected efficiency when used as parental blood, alone or in blood mixtures with other parents superior in breeding power.

(3) By hybridizing, i. e. croosing families, breeds or varieties, or even species, individuals with even greater projected breeding efficiency may be created. and these rare individuals may be used singly in some species of plants, and in other species of plants and in animals they may be used in groups in forming more valuable varieties and breeds.

(4) Practical methods are being wrought out for ferreting out from among their fellows the occasional pure-bred individual and the still less frequent though sometimes superior hybrid individual which will serve in improving or forming a superior breed or variety.

(5) Fixing the character of new families or new breeds and new varieties; gradually improving them; testing and recording and thus accrediting the excellencies of the best blood in each and multiplying them and securing their general substitution in place of less valuable forms is being better organized into a breeding business.

(6) Theoretical studies by practical breeders, by the United States Department of Agriculture, by the

State Agricultural Experiment Stations and Colleges, by the biological laboratories, all federated in the new American Breeders' Association, promise to make clearer the theory of breeding.

(7) Valuable new varieties and breeds originated at public expense are beginning to justify the expenditure of large sums of Government and State money in breeding experiments, wisely, effectively and economically conducted, in part in co-operation with private parties and with associations.

(8) The organization of wider co-operation in breeding, already exemplified in the Funk Bros. Co., and in the Minnesota, North Dakota, South Dakota, Iowa, and Wisconsin Experiment Stations co-operating in breeding field crops under the auspices of the Bureau of Plant Industry of the United States Department of Agriculture, should be extended as rapidly as men can be trained and the foundation stocks secured.

(9) Breeding stations and schools of breeding should be established in connection with several of our agricultural colleges that the full force of modern scientific research and educational method may be directed into building up our plant and animal forces.

(10) In addition to the money expended by private enterprise the possible tens or hundreds of millions of increase in plant and animal products through better blood warrant the expenditure of liberal sums of public funds. While people of wealth are endowing institutions for research in natural evolution and other phases of science they should not fail to consider the claims of the science of enforced evolution which has a relation to the improvement as well as the wealth of man.

(11) To displace scrub and low-grade stock and scrub and low-grade seeds and plants with families which have earned the highest places in contests, to produce net value per herd and per acre, is the worthy object which should command money, leadership and co-operative organized effort long continued.

The writer has not sought to arouse controversy, but earnest thought. In future months and years the course of public money in the promotion of breeding, the development of different forms of co-operative organizations and the rising faith based upon the substantial improvements which one by one come forward in plant and animal development will be shown.

The American Breeders' Association with committees of specialists to encourage the study of many scientific and practical problems in breeding and to promote breeding generally has a most promising field. That organization has just begun its campaign for memberships. It proposes to include in its annual reports along with the papers and discussions a directory of breeders and of scientists and others interested in the problems of breeding. The membership fee of only $1 per annum makes it impracticable for breeders to keep their cards out of the directory and the campaign now on by the general membership committee and by the sub-committee in each State gives promise of a very large membership. Nothing is more hopeful than the enthusiasm and the faith in the permanency of the American Breeders' Association shown by a number of breeders taking life memberships at $20. The organization of the association marks the new impulse in the movement of living things.

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