

GERMAN ZOÖTECHNY

Immense Strides Made by Live-Stock Industry of the Empire are Largely Due to Science of Genetics—The Importance of the Pedigree— Line-Breeding.

Review of a book by GEORG WILSDORF

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GERMANY'S large contributions to the science of genetics during the last half century are well known, but the extent to which they have been put to practical use by the Germans themselves is much less familiar to Americans. Some of the brilliant work in plant breeding is indeed recognized; but it is probable that few members of this association have any clear idea of the present state of the science of animal breeding in the German empire. It may be of interest, therefore, to review at some length a brief but authoritative statement of the situation from the pen of Dr. Georg Wilsdorf, general director of the influential German Genetic Association.

Dr. Wilsdorf's little book on *Animal Breeding*¹ was first published in 1912 as one of a series of popular hand-books on scientific subjects. In 1914 it was reissued as a bulletin of the German Genetic Association; it seems reasonable to assume, therefore, that its doctrines are those accepted by the leading zoötechnists of Germany.

The live-stock industry of Germany (reaching its highest development in the northwest) has increased until it now surpasses the agricultural and horticultural industries in importance, according to Dr. Wilsdorf, who estimates the yearly production of animal husbandry at \$1,675,000,000 as against \$1,300,000,000 for the produce of field and garden. And while he recognizes that this gradual preponderance of live-stock over the agricultural industries has been largely due to economic con-

ditions, he thinks it has only been made possible through an intelligent application of the principles of genetics. The demands made by the farmers on science have, he says, changed the whole character of zoölogy in Germany; while the zoölogists formerly concerned themselves almost exclusively with wild animals, the tendency now is rather to concentrate attention on the domesticated ones.

A CHANGED VIEWPOINT.

But the studies of zoölogists and the experiments of naturalists on zoötechny can easily be credited with more influence on the live-stock industry than they really have had; for, as the author points out, the fundamental fact in the successful application of genetics to animal breeding is not the discovery of any new law, but a change in the viewpoint of breeders. In the past, they have looked only at the generation or two before their eyes; the acquirement of a habit of looking as far back as possible, instead of merely at the animals immediately to be mated, is what has revolutionized animal breeding. In other words, it is the realization of the importance of the pedigree that has made animal breeding a science rather than an art. Such a statement might justly be considered the text of Dr. Wilsdorf's book, for to it he returns time after time.

The importance of pedigree above everything else was realized by the Arabs centuries ago, but is still ignored by many a breeder in Europe and

¹ "Tierzüchtung" von Dr. Georg Wilsdorf, pp. 110, figs. 23, price one mark, bound in linen M. 1.25; Bändchen No. 369 "Aus Natur und Geisteswelt" sammlung, B. G. Teubner, Leipzig, 1912; 17th Flugschrift der Deutschen Gesellschaft für Züchtungskunde, Berlin, 1914.

America. It is being emphasized on both continents, however, by the development of breeders' association and herd and stud books, with the subsequent premium put on accurate registration. In Germany the development of these instruments has proceeded on much the same lines as in America, but there has been more coöperation between the promoters of different breeds—a coöperation largely brought about by the huge and powerful German Agricultural Society, whose 18,000 members represent the advanced element in scientific agriculture in the empire; and largely directed by the German Genetic Association, whose principal function is the registration of pedigrees and their subsequent study. It is chiefly as a result of the work of the latter, Dr. Wilsdorf says, that sentiment in Germany has been changed on the subject of line-breeding. The verdict of the older school of zoölogists had been against it, but impartial examination of horse pedigree charts by Lehndorff and others convinced them that much of the progress made in the live-stock industry was due to line-breeding, and they began to recommend it. Then the value of a "genetic analysis" of each animal came to be realized—that is, an examination of its ancestry to determine how it should be mated. A good example of the way pedigree study can be put to use is his description of the work of the famous zoötechnist Dr. de Chapeaurouge at the national stud farm in Celle. He brought together pedigrees of many of the Hanoverian stallions there and found that the stallion Nording got good colts in some districts, but very poor ones in others. This fact had been recognized by the Celle breeders, but its cause was a complete mystery. Testing theory by fact, de Chapeaurouge was able to prove that the good colts were regularly produced when Nording was mated to a mare with which he was related. As the mares in his own particular district were much more likely to be related to him than were mares of more remote districts, the result was that he had been getting valuable colts in that district and comparatively worthless ones whenever he

went out of it—a result that would have remained a mystery, had it not been demonstrated that the principle of consanguineous breeding was sufficient to explain it.

CONSANGUINITY WIDESPREAD.

The amount of consanguinity among the domesticated animals of any district is, as Dr. Wilsdorf points out, easily under-estimated. "Suppose we take, as illustration, a valley in which there are 50,000 head of stock of any given kind. If this number of animals had only parents, grandparents and great-grandparents which were unrelated to each other, then we would have—reckoning 14 ancestors for each animal—700,000 unrelated animals as ancestors of these 50,000. If one tries to find out whether such a condition could actually exist in practice, and examines the pedigree book of some large herd, he finds the actual number of ancestors is immensely smaller than calculation led him to expect. The same animal will appear over and over again in the ancestry of a given individual, so that most of the animals now living trace back to numerous common ancestors. In the herd which we have taken as an illustration, we would not find 700,000 ancestors, but perhaps half that many, or even less.

"In our studies of the history of various breeds, we next made the astonishing discovery that the best living individuals belonged to families which, when their pedigrees were traced, were found all to come from a single family—often from a single individual. By way of illustration I might cite the Hanoverian halfbloods, which we know particularly through the studies of de Chapeaurouge and Grabensee to have come almost altogether from three stallions, of which Norfolk has hitherto had the greatest influence on the breed—an influence that is increasing all the time. Researches into the swine breeding of the Visselhövede district, and into that of Hildesheim in Bavaria, have shown that in each case a single boar was the ancestor of various valuable families, today widely scattered. And Hoesch of Neukirchen has found that his valu-

able strain of swine is principally due to the blood of a single early boar Richard."

This means that the origin of most of the valuable strains of live-stock in Germany has been due to line-breeding—and the same is true of any other part of the world. The value of such breeding was known to the Greeks and Romans, but after their time it fell into great disrepute, partly from theological reasons, and until recently, the author says, it was considered not only a questionable, but a distinctly dangerous procedure in Germany, while even today many a breeder will pay a higher price for an animal if he feels sure that it is not related to any now in his herd. "The modern science of breeding, however, stands firm in its belief that for the production of definite types for special purposes in-breeding is the quickest and most certain method of procedure, and all great breeders who work toward any particular goal depend largely on in-breeding, knowingly or unknowingly."

REVERSION OR ATAVISM.

A certain amount of inbreeding is undoubtedly necessary to preserve the type of any purebred strain of stock; conversely, the quickest way to break up the type is to mate with some widely differing animal. Even if the mating be between animals which look exactly alike in respect to any given character, that character will frequently disappear altogether in the offspring and be replaced by some character presumably belonging to the breed or species very early in its history: this is the phenomenon of atavism, reversion or "throwing back." It is particularly common in our domestic animals because, as Dr. Wilsdorf points out, most of them seem to be the product of the union of several different races or even species, at some remote time in the past. The result of such mixture is seen in an interesting case he cites, of the herd of white cattle owned by the King of Württemberg and kept in Rosenstein Park near Stuttgart. "Here a pure white herd has been bred for many years, and new pure white males of many breeds (Schwyzer, Allgauer, Simmentaler, Limpurger, Swabian Haller, Hollander,

East Friesian, Shorthorn, Alderney and Zebu) introduced at intervals. But although no animal which was not white has been introduced, so far as is known, since the herd was established, a number of calves are born each year which are not white, but some other color."

Most existing breeds of live stock probably have an origin not very much less mixed than that of the King of Württemberg's white cattle: the mixture was made at a more remote period, however, and its complexity is therefore not so vividly realized.

With material of that sort to work on, it is evident that the task of the modern breeder is one of great delicacy. His chief object is to produce animals that are all of one type; and yet the very make-up of his stock makes it inevitable that nature will constantly strive to break away from that artificial type and return to the more primitive characteristics. How shall the breeder thwart this effort of nature?

As suggested above, he does it by line-breeding, that is, by breeding in one blood-line as much as possible—"pure breeding." The so-called "purebred" animal, then, has been produced by line-breeding more than by any other factor.

"Strictly speaking, any introduction of foreign blood would result in the breed no longer being 'pure.' But frequently it is to the interest of the breed to introduce a new blood stream, that is, new and valuable characteristics. Speaking by and large, one cannot then say that the breed is no longer pure; the word 'purebred' is relative, not absolute, in its meaning. Our producers of purebred stock frequently speak of 'crossing' when they employ stock for breeding which is not quite their ideal in type. Here again the idea of 'purebred' is pretty narrowly construed. The practical breeder understands it more broadly: for him the mating of animals of the same type is pure breeding."

To sum up, the triumph of scientific animal breeding has consisted in the suppression of natural diversity and in breeding animals true to a fixed type: the study of pedigrees and the utiliza-

tion of the information they gave by means of line-breeding have been the chief instruments of the scientific breeder.

FIXING THE STANDARDS.

It will be obvious from this that nothing is more important than to have a satisfactory fixed type. If our standard is wrong, then increase in skill in breeding, improvement of the technique, is of little value. The genetist's ability to use the laws of heredity will be of little avail, unless the standard toward which he is breeding is as good as science can define. Dr. Wilsdorf therefore emphasizes the great advance that has been made in this direction in Germany as in most other parts of the world during recent decades. It was not long ago, he points out, that breeding was merely a matter of mating two animals, without much regard either to their pedigrees or to their performances. Now it is recognized that these two factors must go together, each supplementing and interpreting the other; and the development of performance tests has therefore become a part of the breeder's work not only important but absolutely necessary. In horse breeding, the race track justifies itself largely on this ground; horse shows do, too, when the practical element is not wholly submerged by the sporting element; while endurance tests and work tests for the heavier horses are now being developed, particularly at the national stock farm of Warendorf, where the annual "Warendorf Week" draws draft animals from many regions, to be submitted to tests of hauling cars loaded with sand, that will give any competent judge a good idea of what kind of a constitution they have inherited and are likely to pass on to their offspring.

Cattle breeders took up the idea of performance tests far later than horsemen did, for in earlier times cattle were largely valued as draft animals, and milk production was an insignificant side issue. During the last century, however, the development of the milking function, through conscious or unconscious performance tests and se-

lection of the best producers for breeding, gave marvelous results. The average yield of German cows at different periods is stated by the author in the following table:

| | |
|-----------|----------------------|
| 1790..... | $\frac{3}{4}$ quart |
| 1800..... | $1\frac{1}{2}$ quart |
| 1810..... | 2 quarts |
| 1820..... | 3 quarts |
| 1830..... | 4 quarts |

This quantity was maintained for three decades. Then, with the collapse of sheep breeding in Germany, dairy cattle again received an unusual amount of attention, with the result that the figures were increased to:

| | |
|-----------|----------|
| 1860..... | 6 quarts |
| 1870..... | 8 quarts |

From this point on, the physiological limit began to appear in sight, and the increase was necessarily slower. But the nearer the physiological limit came, the more careful were breeders to test and select only the finest milk-yielding strains, with the result that at the beginning of the twentieth century, Dr. Wilsdorf thinks the average daily milk production of German cows may be placed at 10 quarts. In one century, their yield was increased more than 1000 per cent. by intelligent breeding—certainly as good an example as one could ask of the practical value of genetics.

FORM VS. REAL VALUE.

Production tests for beef cattle, on the other hand, have helped to make clear to breeders the difference between bodily and germinal qualities. There was a period when the study of type was the prevailing fad, and when it was believed that if you had animals conforming to a certain ideal beef type, you would have ideal animals to breed from as well as to butcher. This gave rise to a number of herds that were very pretty to look at, but caused disillusionment later on, for as the writer tersely says, Handsome is as handsome does:—"The level-headed farmer properly considers an animal beautiful, when its production is beautiful." It was soon found that bad form and considerable departures from the ideal type might be associated with

first-class production-capacity, and this brought home a realization of the fact that the latter quality was a matter of inheritance, and might or might not be identified by the "show form" of the animal in question. Now the practical breeder spends more time studying pedigrees and less in measuring the relative proportions of the parts of his animals; "for if an animal has nothing more to show than a beautifully proportioned body, and is a second-class producer, there is no room for it in practical animal husbandry." After 40 years of careful tests, made possible by the invention of suitable apparatus, the dairyman knows that the family to breed from is the one that yields the best quantity and quality of milk, not the one that produces calves most like the pictures in some "Standard of Perfection."

During all this time an effort was being made to find some connection between form and capacity—to find correlations, as the professional genetist would say, between some features of the body and the milk yield. One after another was advanced; many writers established imaginary "milk types," some of them on the most unbelievable grounds. "It has not yet been proved," in Dr. Wilsdorf's opinion, "that any certain characters or forms give any reliable indication about the milk yield of a cow." He does not hold it impossible that such correlations may eventually be found, but points out that the careful experiment of Gaude with nearly 1,000 cows in East Friesland showed "that the influence of such factors as feed, work, care, pasturage, etc., caused so much change in bodily conditions as to make the probability of recognizing 'milk indications' very unlikely."

Of all civilized countries, Germany has the greatest number of breeds of cattle—probably a hundred, many of the smaller of which are now dying out. But only in two places are the herd books sufficiently full and ancient to make pedigree breeding satisfactory: among the Shorthorn breeders, and in East Friesland where the Holstein-Friesian cattle are bred. In the latter

district, the records show that most of the good animals trace back to one of a very small number of good bulls: "Primus," "Matador," "Bernhard," and "Max."

PRACTICAL PEDIGREE STUDY.

"How important pedigree study is may be illustrated by an experience of my own. For 12 years I have been a member of the live-stock purchasing committee of the Brandenburg Board of Trade in East Friesland, and at the very beginning of my activity learned that a promising looking black and white bull in one district of the province of Brandenburg, although bred to excellent cows, got offspring of mediocre value, both in form and in color. Investigation showed that the bull was from a herd of black cattle in East Friesland, which a few years before had been 'graded up' from a herd of brown cattle. This fact, extraordinarily unfortunate for the breeders of the district in which he was located, gave me occasion to begin investigating personally the pedigree of every sire which was thereafter brought into the region, and to require from owners of calves by him periodical reports in the future. I checked up these reports at every sale of East Friesian cattle and in the course of a few years had satisfactory evidence as to the breeding value of practically every important strain of cattle in the region, so that little by little we were able in our yearly purchase to get cattle of greater breeding value into the province. What we did must be done sooner or later by the breeders of every other district: they must find out the actual value of all stock offered them, from a genetic point of view."

While science has been applied to horse and cattle breeding with results highly gratifying to German pride, the sheep breeders seem to have fallen behind. Lack of careful selection, and inbreeding of bad animals rather than good, are blamed in part for the ruin of the industry—among other troubles, it is stated that a failure to select fecund strains led to a decline of fecundity in German sheep

In swine breeding, too, science has made slow progress; but as successful swine breeding is easier than successful sheep breeding, Germany still holds an important place in this field. Most of the swine are in the hands of small breeders, among whom there is a widespread prejudice against line-breeding; this leads to the constant introduction of foreign blood and the result is a failure of the herd to improve, or frequently an absolute deterioration of the strain.

An example of the changes that may be made by systematic breeding is offered by the widespread goat industry of Germany. In the last 20 years the goats of the empire have almost wholly been changed from horned to hornless, by the introduction of hornless Swiss breeding stock. The same cause has led to the disappearance of the old colors and their supplanting by white and brown.

Turning to a consideration of the formal laws of heredity, Dr. Wilsdorf shows himself to be a conservative. He frankly recognizes that most of the knowledge now in the possession of animal breeders on this subject is the result of the research of plant breeders, and he sees no objection to this state of affairs, since it is now pretty generally admitted that, on the whole, the laws of heredity that apply to one section of the living world apply to others as well. He further recognizes that formal laws of genetics as yet can give little real help to the animal breeder.

MUCH YET TO BE LEARNED.

"When the architect builds a house," he writes, "he can say in advance, 'The house will be like this: it will have such and such a height, such and such a shape,' and so on. The gardener who has to lay out a garden or park can tell in advance just how the result of his work will look. He picks out the places where the paths will run, where turf will be planted, where flowers will appear; and he can say to himself, 'In this place such and such a tree will grow.' Architect and gardener alike know beforehand how the finished product of their work will look; but not so the animal breeder. He is dealing

with laws of nature which are not yet well enough known to enable him to predict with absolute certainty how they will work. One knows well enough that the offspring of two parents usually is like them, but whether it will more resemble the father or the mother can not with certainty be foretold. Exactly in this uncertainty lies the difficulty of the animal breeder's work. It has therefore long been the aim of experimental breeding and particularly of experiments in hybridization, to find certain rules with which heredity complies. We are well aware that there are animals which transmit their characteristics with unusual prepotency, and we can say with a good deal of certainty that the product of most of these animals will have a large proportion of those characteristics. But frequently enough comes a case where we are deceived, and the number of cases in which we can speak of a 'rule' is proportionately very small: the part of the breeding industry in which we still walk in uncertainty is much larger than that in which we can advance without groping.

"The search for these rules, however, has occupied a great number of naturalists during recent years, and still occupies them. The work hitherto accomplished is a great one and, even if the goal is still a long distance ahead, we have nevertheless taken a big step forward. Plate distinguishes four different methods of heredity, as follows:

1. Mosaic heredity.
2. Blending or intermediate heredity.
3. Mutational heredity.
4. Alternative, segregating or Mendelian heredity.

"In mosaic heredity the characters of the parents exist side by side in the offspring—as in a mosaic. As example I may cite the barred progeny of white and black fowls bred by Davenport; or the color of the well-known Blue Andalusian fowl, where the pigments black and white, intimately mixed, produce an apparent blue color. Hilzheimer cites the Baldinger Tiger Swine as an example of this sort of heredity: it was produced by crossing the white native race with the black Berkshire.

"The second method of heredity is the blending. In it the characters fuse together so that the product stands half way between the two parents. The mulattoes resulting from crosses between negroes and whites may be cited in this connection: their color is constant in succeeding generations."

"In mutational heredity a form appears in the first generation which was not present in either of the parents. As an example genetic literature usually cites Bateson's cross of fowls with rose comb and fowls with pea comb; the offspring had a walnut comb—that is, an entirely new form; which however, could not be bred pure in succeeding generations, but segregated in the second generation, in the following proportions: 9 offspring had a walnut comb, 3 a rose comb, 3 a pea comb and 1 a single comb."

THE VALUE OF MENDELISM.

More important than these to the breeder of live-stock is the fourth method, Mendelism, Dr. Wilsdorf says, but after he has explained it at some length, he feels obliged to conclude:

"Now if we ask ourselves what importance Mendelism has for practical animal breeding, we must admit at the very outset that the development of the rule is still too new to admit of sure conclusions. In this day no one is likely to deny that a thorough knowledge of this rule, which solves so many problems that before its discovery were absolute mysteries, is of the first importance. In agricultural animal breeding, however, we are confronted by one almost insuperable difficulty—that our most important domesticated animals bring only one offspring into the world at a time; whence the conditions of heredity are naturally not easy to observe. It is only with such animals as swine, which produce larger numbers of young at a time, that one can derive much immediate help from Mendel's Rule."

Furthermore, he points out, "it is by no means assured that *all* characters Mendelize." On the whole, he considers Mendelism an instrument of great future promise, but one which is hardly likely to be of much value to the practical breeder at the present day.

Telegony and maternal impressions are mentioned as supposed factors to which many breeders ascribe unexpected variation. As Dr. Wilsdorf says, these can no longer be considered anything but superstitions, yet they are still widely held. "In East Friesland, the Eldorado of the German cattle industry, many breeders still believe heart and soul in the power of maternal impressions on the cow. If a red or red-and-white calf is born in a herd of solid black-and-white color, the mother must have looked at some red object. You can argue as much as you like, this explanation can not be shaken in East Friesland. And yet the true explanation lies right under their noses! either the neighbor's herd is red-and-white, and one of his bulls has jumped the fence, or else it is a case of atavism such as I have already spoken of. A belief in maternal impression, like a belief in telegony, is a superstition with which no serious breeder will waste time; but it cannot be easily eradicated from the minds of the great mass of farmers, because it has sunk in so deeply."

A proposition which extremists sometimes class with the foregoing, but for which Dr. Wilsdorf shows more tolerance, is the belief in the inheritance of acquired characters. Stockmen, particularly in regions where breeding has been the occupation of the same family through many generations, have amassed rich stores of experience which satisfy them that animals under the influence of better care, feeding and housing change their form and characteristics, and that these changes occurring in the life of the individual are inherited by their progeny. This conclusion, which

*This is denied by C. B. Davenport, "Skin Color of Mulattoes," *JOURNAL OF HEREDITY*, V, 12, 555, December, 1914. The color seems to be due to numerous separate factors which act as units in inheritance. Dr. Wilsdorf might better have mentioned height as a character which shows blending; although in this case too the blending is very likely due merely to the fact that the unit characters involved are too many and too small to permit the observer to see their segregation. —The Editor.

found its first clear expression in the teachings of the zoölogist Lamarck and was in part at least accepted by Darwin, was strongly denied by the zoölogist Weissmann who is followed in this respect by most present day naturalists. The strife between adherents of Lamarckism and adherents of Weissmannism is bitter and continuous, and Dr. Wilsdorf does not think that, on the whole, it is very profitable to the science of animal breeding. Most of the alleged cases of inheritance of acquired characteristics he admits may be dismissed without much hesitation, but he sees others in which the influence of the environment seems to him to be transmitted directly to succeeding generations. "If we observe the well-known Arabian horse at home, we recognize in him a definite type, which is common to the whole breed in Arabia. The Arabs say of him, 'The Arab horse remains an Arab horse only so long as he breathes the air of the desert.' For centuries Arabian horses have been brought to all civilized countries and have astonishingly changed. The English Arab is different from the Hungarian, and both are different from the Prussian or Saxon or French. Whence comes this inherited variability in form, size, looks?

THE SIMMENTALER CATTLE.

"In the Bernese Oberland are the huge and beautifully formed cattle called Simmentaler. These, too, have been carried to all other countries, and at present there exist abroad a multitude of Simmentaler herds which in part, indeed, are similar, but in part show great differences. One more example: on the steppes of Hungary is found a breed of Steppe Cattle, of little value because of its low milk production. The increasing demand for milk has led the Magyars and the Hungarian government to seek in every possible way to

increase the milk yield of this breed. High producing cattle from other districts have been brought in; sometimes these have been maintained and further bred pure; sometimes they have been crossed with the native cattle. At first, fine results were secured, but with further generations the newcomers became more and more like the old steppe cattle in form, size and milk yield, until finally the progeny of the North German and Swiss bulls and cows came to be almost exactly like the steppe cattle. Such cases, small or large, can be found in almost any cattle country in the world today."

In conclusion, the author warns his readers, let there be no misunderstanding as to what the science of genetics claims to have accomplished in Germany. Progress has been great—astonishingly great considering the short time involved—but the distance yet to go is still greater. "The question of the inheritance or non-inheritance of parental qualities, the problem of changing the inherited characters of animals during their youth, the maintenance of high fecundity joined to high production, the finding of tests of the fitness of animals for the purposes for which they are desired, the tendency to greater variability in many breeds, the prepotency of the different sexes, the determination of sex of progeny, artificial fecundation, the inheritance of diseases: all these questions and many others have either only been touched, or are wholly unexplored. As Dr. Müller of Tetschen, the founder of the German Genetic Association, aptly said, we stand before riddles,—but riddles whose solution we can attack with more hopeful zeal than ever at the present day; their solution will mean an immense gain to the live-stock breeder, the agriculturist, but perhaps no part of this gain will be greater than the light which will be thrown on the nature of Man himself."