FACTS THAT THE ANIMAL BREEDER SHOULD KNOW ABOUT GENETICS

By DALE G. MULLINS, '25

Do You Believe in Evolution? A Few Principles of Genetics Explained to Show How the Scientific Breeder Has Improved His Livestock

UNDOUBTEDLY selection is the biggest single factor to be considered in breeding improvement. Man can not take the full credit for being the originator of this practice. If selection had not been carried on in nature before man's time there would have been no animals left upon the globe for man to improve.

We smile when we think of the myths we used to enjoy so much when we were children. "Why the giraffe has a long neck" and "Why the bear has a short tail," etc. All these things were explained on the basis of the inheritance of acquired characteristics, a belief promoted by Lamarck, which has been discarded. The purpose of this article is not to solve myths, but to state facts. If you were going to breed giraffes today for exceedingly long necks, how would you do it? In answer to this you would say, "I would discard all the animals with the shortest necks and breed those with the longest necks possible." This succeeding generation I would do the same thing until I produced animals with the longest necks possible." This is just exactly what happened in nature. The giraffe is an animal that depends on browse for its food, so naturally those with short necks died off when there was an over-abundance of these animals in proportion to their food supply. Those with the longest necks being well nourished were left to be the progenitors of the future population. Numerous examples might be cited to show how selection was practiced before man practiced it, but this example will suffice. This is just another way of saying, as did Darwin, that the fittest survive.

Today man has wrested the reins from the hands of nature, and it is intended that he do so for he is now breeding animals to serve his several purposes. Under the good care and abundant feed that man supplies to his animals the unfit as well as the fit survive, so it goes without saying that man must practice rigorous selection in order that animals will best serve him.

Since it has been noted briefly the animals in their native state it might be well here to note where man obtained his raw material. The exact origin of many of our breeds of domestic animals is veiled in obscurity, but it is known generally that the major part of them came from the British Isles, with the exception of the following: The light horses came from the eastern Mediterranean country, Brahma cattle from India, Angora goats from Asiatic Turkey, Karakul sheep from central Asia, and some of the breeds of swine from southwestern Asia, poultry came from two sources, southeastern Asia and the district bordering on the Mediterranean Sea.

It is remarkable to note how long man was satisfied with these crude unproductive animals. Probably Robert Bakewell was the first man to inaugurate an organized system of mating farm animals, and this was less than 200 years ago. Living in England he was in the country where animal life was abundant and he had, therefore, a good chance to study it. His success was so great that, about the time of the American Revolution, men were coming from all over England to learn what they could about his methods. They paid large sums for the use of his sires. We may call this the first awakening of the realization of the advantages of good sires.

Breeders using these superior animals were drawn together, and the pedigree system was established, which, in turn, furnished impetus to the formation of breed associations and the subsequent publication of herd books. The Short Horn Breed Association was the first one formed.

All of this work was being accomplished before the time of many great discoveries, which form the basis of all good modern breeding practices. Darwin's book, "The Origin of Species," had not yet appeared, and Francis Galton, his distinguished cousin, had not yet demonstrated to the world the value of heredity in breeding.

Heredity may be defined, to quote from Mumford's text, "The Breeding of Animals," as the "organic relation existing between an individual and its ancestors." The characteristics of the individual are determined by heredity and development. What an animal may become depends on its heritage received from its ancestors. No organic being can be developed beyond the limits imposed upon it by its inheritance. A favorable environment and good training will permit the individual to achieve the full limit of its possibilities, but no amount of training and no combination of favorable circumstances can ever lift the individual above the inheritance which it has gained through its parents. Heredity then represents what an animal really is or can become.

Walter gives a good illustration of the importance of heredity in his book on Genttics. He explains heredity as being the base of th triangle of life and environment and response as forming the other twi sides.

Our understanding of the working of inheritance is largely due to the discoveries revealed by the noted experiments of Johann Gregor Mendel, an Austrian monk, who, although a contemporary of Darwin, was unknown to him. Mendel, being a man of a mathematical turn of mind and a keen investigative spirit, set out to learn the truth about heredity and hybridization in the quiet cloister garden of the Monastery, unhampered by the lust for gold and unlimited as to time. In 1866 Mendel's work was published in a little obscure paper, the "Transaction of the Natural History Society of Brunn." The discoveries of this noted investigator were lost and not discovered until the year 1900. Mr. Mendel did his work with sweet peas, pollenating them by hand, crossing them and studying the subsequent generations. To quote from Walter, Mendel's law is this: "When parents that are unlike with respect to any character are crossed, the progeny of the first generation will apparently be like one of the parents with

respect to the character in question. The parent which impresses its character upon the offspring in this manner is called the dominant." The character that is not impressed upon the progency, commonly known as the F_1, or first filial generation, is known as the recessive character. When the first (F_1) generation is allowed to breed among themselves the second generation (F_2) thus produced will follow the mathematical formula, 25-50-25. This means that 25 per cent will be like the dominant grandparent, 25 percent like the recessive grandparent, and 50 per cent like the parent resembling the dominant grandparent. Another way to express this ratio is 3:1, meaning that three will resemble the dominant and one the recessive. The three dominants will again split up when crossed among themselves, one-third breeding true dominants, two-thirds behaving like their parents, again giving the same ratio, 25-50-25. True dominants and recessives breed true; these are known in Genetics as genotypes. The 50 per cent which do not breed true are phenotypes.

An important contribution to our knowledge of breeding was made by Weismann, 1834 to 1914. He is the originator of the chromosome theory. A theory which we might well call a law, because of its wide general acceptance. Every living cell contains chromosomes within its nucleus. These are the carriers and the physical basis of heredity. Every individual starts with one cell, which is a fertilized ovum, or egg cell. The number of chromosomes are fixed for all species and in order that they may unite and still carry the requisite number of chromosomes they must go through a process of reduction before fertilization is possible. The reduction of the number of chromosomes is known as ovagenesis and spermagenesis, female and male respectively. Chromosomes can only be seen through a powerful microscope and their study was made possible because of the fact that they could be stained with dye, hence the name. It is the various combinations of these little minute bundles of life that determine what every individual will be, be it man, plant or beast, other things, for example, environment, being equal. Since we understand the chromosome theory it makes it easier to understand why in-breeding is so conducive to results. In-bred animals are near to kin and their chromatin becomes simplified as they carry factors for identical characters. If they are genotypes, as Mendel would say, they will breed true. All the early English breeders accomplished wonders for their day, simply because they had a few good animals with homozygous chromatin material. Like begets like; however, it is difficult to tell by looking at two animals whether they will produce offspring resembling themselves or not. Herein lies the value of the pedigree. Do not mistake my meaning, however. Too many disasters in breeding have been wrought by simply referring to the printed pages of the herd books to make matings. The animals themselves must be studied. When you buy a purebred sire for your herd you practice individual selection. You buy a breeding animal not for what he is but for what he will produce. It is the germ-plasm that you are buying and it is your privilege to find out all you can about it. What factors does it carry? Were the animal's parents alike in the qualities you wish to impress upon your herd? If so, then you are more sure of the germ-plasm being homozygus, or simple, carrying the desired factors. What do the brothers and sisters of this animal look like? If they are all of the same type he is quite sure to be a good animal for breeding.

A great advertising scheme for the seller of purebred sires is to advertise some outstanding animal in his strain ten or twelve generations back. The part of an individual's inheritance that he gets from an ancestor so remote is almost negligible. For example, an individual gets half from its immediate parents, one-fourth from its grandparents, one-eighth from its great-grandparents, but there are eight great-grandparents, so one-sixty-fourth is all an animal could inherit from one great-grandparent, to say nothing of what it might get from a more remote ancestor. However, the fraction of inheritance from a remote ancestor is increased many times in pure inbred animals, for some of them have a minimum number of ancestors.

The character of prepotency is another element that enters into the successful breeding of animals. It can not be expressed mathematically, since its refers to the ability of an animal to stamp his characteristics on his progeny.

Although all of our best livestock has been improved more or less through inbreeding, the breeders are, in part at least, at variance in regards to the merits of this practice. The principal objections to in-breeding are that it lowers the fertility, lessens the number of offspring in succeeding generations, and thus is too expensive. In our practice of in-breeding, as in all other methods of improvement of livestock, we must never lose sight of that valuable instrument, "Selection," wherein lies the difference between success and failure. Animals must not only be selected in regard to conformation and external factors, but they must be selected for fertility as well. A noted example of failure to select animals in this respect was brought to the attention of the public shortly after the New York Mills sale in 1873. At this sale some English shorthorns were sold for fabulous sums. One cow, the English Dutchess of Geneva, was sold for $40,600, the top price of history for a cow. Some of these superior animals failed to produce off-spring and this event was the direct cause of the breedere changing from English to Scotch short-horns.

Weismann, to whom we have referred above, inbred mice for 29 generations and each generation showed a diminished fertility. Researches of the Ritzma Brothers showed not only lack of fertility but also greater mortality due to weakened constitutions. On the other hand Helen Dean King, at Wistar Institute, Philadelphia, bred white rats for seven years, practicing rigorous in and in-breeding, starting her experiment with one pair of rats. At the end of the time she had studied 10,000 animals, increased the size of the males 15 percent, and the size of the females 3 percent. The size of litters among the stock rats were seven and after 22 generations of-inbreeding it was seven and four-tenths. Dr. King attributes her success to careful selection as expressed in her own words, "The results so far obtained with these rats indicate that close in-breeding does not necessarily lead to loss of size or of constitutional vigor or of fertility, if the animals so mated came from sound stock in the beginning and care is taken to breed only from the best individuals."

Cross-breeding is another system that has its merits. It may be roughly defined as the mating of unrelated animals, or commonly the mating of animals of different breeds. This system is peculiarly adapted to the production of market stock. Good results

can be expected from the first cross for as we have seen the F-1 individuals are generally quite uniform, vigorous and productive. On the next cross, however, the admixture or heterogenous chromosomes get in their work and the individuals are not uniform.

A certain individual in Washington State, working with poultry reports favorable results with a cross of Barred Plymouth Rock and White Leghorns. He says the egg yield the first generation was superior to either of the parents. At the University of Arizona Poultry Plant the writer has observed that chicks resulting from the first cross between the heavy breeds are more vigorous and thrifty than the parents. This practice is a good one to follow in producing spring broilers or capons for the holiday trade.

Many first generation crosses have been exceptional animals, but usually they are crosses between purebred animals. Yearling ewes resulting from a cross between Shropshire and Merino sheep took fisrt prize at the International Livestock Exposition in 1917. Lulu Mayflower, the grand champion beef animal at the International Livestock Exposition in 1921, was a cross between superior animals of the Shorthorn and Aberdeen Angus breeds. The producers of market pork often find it desirable to cross Duroc Jerseys with Poland China hogs. The offspring are good feeders and economical pork producers. Bates, the great Shorthorn breeder, bred in and in for thirteen years and then found it necessary to infuse fresh blood into his herd, not to improve the form of his animals, but to improve their lessened fecundity.

"The mule is a remarkable example of the practical advantages which follow a particular cross. This animal is more hardy and more enduring than either parent. As compared to the horse a mule is longer lived, less subject to disease or injury, and more efficient in the use of food. The mule can be safely put to work at a younger age, will thrive on coarser food, and seems to be much better able to avoid many dangers which menace the usefulness of the horse. The mule will endure the heat of southern latitudes more successfully than the horse and is therefore a popular draft animal in the South."

Cross-breeding may be conducive of mutants. A mutant is an individual that suddenly appears quite different from its progenitors and breeds true. This may be caused by some change in the germ-plasm not at present understood. "In 1791, a Massachusetts farmer, by name Seth Wright, found in his flock of sheep a male lamb with long, sagging back, and short, bent legs, resembling somewhat a German dachshund. With unusual foresight he carefully brought up this strange lamb because it was an animal that could not jump fences. It occurred to this hard-headed Yankee that it would be much easier to get together a flock of short, bow-legged sheep, unable to negotiate anything but a low hurdle, than to labor hard building high fences. So it came about that this mutating lamb, in the hands of a man who appreciated labor-saving devices, became the ancestor of the Ancon breed of sheep. Later on this breed gave place in public favor to another mutant, the Merino, which produces a superior grade of wool."

"It has long been known that in many plants self-pollination is habitual and is attended by no recognized ill effects." This may be called close in-breeding, as is the case with oats, wheat and the majority of the cereal crops. "In maize, or Indian corn, however, among the cereals, the case is quite different. Here enforced self-pollination results in small, unproductive plants, lacking in vigor." This condition is more or less directly applicable to domesticated animals. Some respond well to long-continued in-breeding and others do not, and there are a multitude of intermediates between the two extremes. There is a great difference between different families in the same strain. A man must study his animals and determine how long he can in-breed and when to infuse new blood.

Line-breeding is distant in-breeding or breeding within a single line of descent. The term is frequently used because so many people think that in-breeding must have some deleterious effect regardless of the degree and some of the breeders have thus adopted the name line-breeding. This system of breeding tends toward purity and it, therefore, provides opportunity for rapid improvement when combined with careful selection.

In the light of the previous discussion of animal improvement, the fact is obvious that we may occasionally expect to have trouble with fertility among our best livestock. In view of this fact it behooves us to employ any methods of feeding or breeding that will make for better and increased fecundity. Over-fat beef animals suffer fatty degeneration of the sex glands. For this reason animals for breeding should not be maintained in show condition. Some sheep breeders feed scantily just before the breeding season to make the ewes lose weight, then, just before turning in the ram, they increase the feed so that the ewes are on the upgrade at the time of conception.

All breeding animals require exercise. In Europe it used to be the custom for the stallion to be ridden fram farm to farm. In this country it is the custom for the livestock men to take the mares to the stud for service. As a result of this practice the fertility was much better in Europe than it is in this country at the present time.

One fertility factor that is of recent development is vitamin X. Little is known about it as yet, but in the future it will undoubtedly be considered of major importance. It is contained in green feed. For this reason, then, as well as for providing exercise, a good roomy pasture is an ideal place for the breeding herd.

That the scientific and systematic breeding of livestock has given wonderful and remunerative results can easily be verified by reviewing the past history of most any breed. In 1815 our original sheep sheared about 2 to 2½ pounds of wool per head, now the general average is from 6 to 8 pounds. To see the improvement man has wrought in hogs one needs only to look at a picture of the original porcine stock. The various breeds of horses have been developed to suit their several purposes by careful selection and breeding. The Shorthorn cattle were created from the Longhorns. The American breed of poultry originated by crossing the heavy Asiatic breeds with the lighter Mediterranean breeds. The original hen laid only one clutch of eggs a season, now it is common for hens to lay better than 300 eggs a year.

What the future of our domestic animals will be it is impossible to predict, but they are going to be better and more productive than they are today. In order to meet the needs of increased population and competition,

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HARVESTING AND CURING ONIONS

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the tray system is to be used, they should be constructed with slatted bottoms and should be not over six inches in depth with plenty of clearance between the trays in the stack. The onions should not be over eight inches in depth on the trays; therefore, one tray per foot is enough to insure proper ventilation.

Where the onions are cured in boxes the operation is relatively simple. The boxes of onions are stacked in the house in such a manner as to provide for ventilation between the stacks of boxes. The boxes should be filled not over three fourths full so that air may pass freely over the onions.

In the tray system the onions are carefully placed on the trays to a depth of six to eight inches. They should be turned once during the curing to see if any rot or burning is taking place.

Leave the onions in the curing house until they are thoroughly dried down and are good and firm. A good sign is when the top has dried completely down to the surface of the bulb. At this time they are ready to go to the storage house. With warm days and no rain it should not take over two or three weeks to completely cure the onions to the point of being ready for storage.

In removing the onions to the storage house they should be culled and all injured or burned specimens removed. The roots are rubbed off and the tops clipped back to three quarters of an inch from the bulb. They are loosely packed in boxes or stored in shallow piles in the storage house until ready to be packed and given the final grading before going to the market.

A good onion storage house should be dry, uniformly cool both day and night, capable of being well ventilated and should be kept dark within to prevent sprouting. An adobe house offers an excellent opportunity of being converted into an onion storage house by making small vents at the bottom and building a flue at the top. These should have small doors that may be shut to prevent too cold or too warm air from entering. They should be opened every day for several hours to permit ventilation of the house. In case of freezing weather a small stove may be used to keep the inside temperature above freezing. Onions once frozen will quickly rot.

When onions are well cured they will keep for several months in good condition if stored in a cool, dry, dark and well-ventilated place. Too much attention cannot be paid to proper harvesting and curing, as it will be well paid back in the resulting quality and lack of damage from storage rots.

WIPING MACHINES TO REMOVE ARSENIC

To remove arsenic spray residue on apples, the Okanogan Growers' Union at Okanogan, Wash., will install five fruit-wiping machines to cost $2500, in its central packing shed.

Box labels will show that the fruit has been wiped and the organization will capitalize the feature. It is thought that in some cases it will be possible to command a premium price.

The wiping machines will be installed just ahead of the fruit grading machines. In the wiping process, the fruit will pass over horizontal rollers and be slapped by 500 pieces of canvas. The machines are electrically driven and are provided with a fan to remove dust and debris.

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progress will be made. The unproductive herds will perish from the globe and give place to the super-animals of the future. The successful breeder of the future will profit by the past, and in addition will build a structure as enduring as granite and marble. He will lay a foundation of heredity and make frequent use of the fundamental building stones of environment and response, laying each stone with judicious precision and cementing them carefully together with the cement of "selection."

The owner of the store was trying to give the new boy a little fatherly advice.

"Why, young man, even I started out in life as a barefoot boy."

"Well, I wasn't born with shoes on myself, sir," replied the youngster.