on such a point, that when he crossed distinct species of native plants that had not been cultivated, he never once saw in the offspring any new character; but that, from the odd manner in which the characters derived from the parents were combined, they sometimes appeared as if new. It appears, therefore, that the point at which the line of distinction is drawn between reversion and variation depends in many cases on the state of our knowledge of the subject. In some other points, also, the relations between inheritance and variation are extremely intricate and difficult to unravel. These two principles are often spoken of as opposed to one another. The following case shows that any definition of variability implying that it is necessarily equivalent to a breach in the law of heredity is incorrect. Some kinds of sheep and cattle dogs are congenitally almost destitute of a tail; and this Stonehenge attributes to the fact that under the old excise laws only those dogs whose tails had been removed were exempt from taxation; so that this mutilation was universally practised until the deficiency became hereditary. The production of a tailless breed of dogs must certainly be considered a case of variation, yet in this case it is not a *breach* of the law of heredity, but a remarkable instance of obedience to that law, that is to say, of the transmission of the effects of mutilation. In other cases external causes produce some constitutional or otherwise imperceptible changes in the parent, and these in being transmitted to the offspring become correlated with some external or *perceptible* alteration, and in this way new characters may appear. This is undoubtedly a true case of variation; nevertheless, strictly speaking it is due to the inherited effects of a cause acting on the parent. And it seems illogical to separate it in a radical manner from cases such as that of the tailless breeds of dogs. Considering, therefore, the great difficulty in which the subject is enveloped, it will be well to abandon theoretical considerations, and merely to state that characters at least practically new do undoubtedly appear in the offspring. In every group of organisms a degree of variability, sufficient to give material for the breeder to work on, probably exists. The Laplander knows and gives a name to each of his reindeer, though, as Linnæus remarks, "to distinguish one from another among such multitudes was beyond my comprehension, for they were like ants on an ant-hill." A still more striking case is that of the old Dutch florist Voorhelm, who kept above 1200 varieties of the hyacinth, and was hardly ever deceived in knowing each kind by the bulb alone. These cases are important as showing that, even in natural objects which appear identical to the unpractised eye, perceptible differences do exist. Man can effect nothing until some of his stock begin to vary in the desired direction. But horticulturists have found by experience that when any particular character is desired, the first step is to get the plant to vary in any manner, and to go on selecting the most variable individuals even though they vary in the wrong direction, for the fixed character of the species being once broken through the desired variation will sooner or later appear. The great number of races of many domestic animals and plants—for instance, of pigeons, sheep, wheat, &c.—demonstrates clearly their variability in many diverse characters. In other domestic animals, however, very few distinct races exist; yet we must not conclude that these animals have not varied. There are several causes besides that of an inherent want of plasticity which may have been at work. It will here suffice to allude to a few of them.

1. If any particular group has not been especially subjected to selection, the absence of distinct races in such a group is no proof of want of variability. This applies to asses (in England only).

2. If the breeder has not a large number of individuals to select from, the chance of the required variations occurring is very small. Hence animals kept in small lots do not form races (*e.g.*, sheep on small holdings).

3. If intercrossing cannot be prevented, it is obvious that any variety which may appear will have no chance of being perpetuated, but will be diluted down to the normal type. This applies to cats, which, from their wandering and nocturnal habits, cannot be paired.

It may appear a truism to say that every variation must have a distinct cause, but it is a truism very often overlooked. The case of twins, each born with a peculiar crook in the little finger, is instructive, for here the conclusion is irresistible that the same definite, though unknown, cause produced the mal-formation in the two children. This case may also serve to illustrate the extreme obscurity in which the causes of any given variation are hidden, and the great difficulty of investigating them. Some general causes which induce variability may, however, be set down.

There appears to be no doubt that organisms subjected to the unnatural and changeable conditions implied by domestication are more variable than those living in a state of nature. Thus monstrosities are comparatively frequent among domestic animals and plants.[1] Domestication causes a number of changes in the condition of life; it is therefore of interest to determine which of these are the most important. Contrary to what might have been expected, change of climate is not an important cause of variation. This is repeatedly shown by A. de Candolle in his *Géographie Botanique;* and a change to a more genial climate is certainly not necessary, for the dwarf kidney bean, which is often injured by our spring frosts, and the peach, which requires the protection of a wall, have varied much in England. (See ACCLIMATISATION.)

In some moths the colour of the perfect insect is affected by a change in the food of the caterpillar, but there seems to be no evidence that this cause has been active in inducing variability in our domestic races. On the other hand, *excess* of food is probably an important cause of variability. This view was held by Andrew Knight, and the same idea is expressed in the following remark of a "great raiser of seeds:"—"It is a rule invariably with us, when we desire to keep a true stock of any one kind of seed, to grow it on poor land without dung; but when we grow for quantity we act contrary, and sometimes have dearly to repent of it."[2] Nevertheless it appears that many of the best varieties of fruit have not been produced under cultivation. Thus it is asserted that some of the finest French pears were originally found growing wild, and this was the case with an English variety of apple. The most interesting fact connected with changes in the conditions of life is that the results of such changes are capable of accumulation. It is this peculiarity that accounts for the fact that when new flowers are first introduced into our gardens they do not vary. Thus the Swan River daisy did not break from its original colour until it had been subjected to seven years of high culture. Many facts might be given showing by what slight changes of habitat the health and general development of animals and plants may be affected;[3] but with these cases we are not especially concerned. (See ACCLIMATISATION.) The causes, however, which induce an unstable condition of general variability are of great importance to the breeder. Of the causes not already touched on the most important is intercrossing. In considering variations under this aspect no attempt will be made to distinguish from true cases of variation the cases in which new characters are simulated by combinations of old ones. In the first place, it is probable that organisms propagated by *sexual* reproduction

[1] J. Geoffroy St Hilaire and Moquin Tandon.
[2] Quoted in *Var. under Domes.*, ii. p. 257.
[3] See *Var. under Domes.*, vol. ii. ch. xxiii., on "The Definite Action of the Conditions of Life."

are usually the most liable to variation. For here the offspring has a double chance of being influenced by circumstances affecting the parents; and by the concentration of a double set of tendencies into one individual, a better chance is given for the origin of variations produced by combinations of ancestral characters. In the same way, to a certain extent, a cross with a distinct variety produces a disturbance or loss of equilibrium in the reproductive system from which a tendency to the production of variations results. Thus Gärtner asserts that seedlings from *Dianthus barbatus*, when crossed by the hybrid *D chinensi-barbatus*, were more variable than those raised from this latter hybrid fertilized by the pure *D. barbatus*. Max Wichura insists strongly on an analogous result in the case of willows; and Kölreuter says that to obtain an endless number of varieties from hybrids they should be crossed and recrossed.

Some peculiarities in our domestic races are to be attributed to the inherited effects of habit and of disuse. Splints and ring-bones on the legs of horses appear to be certainly hereditary; and veterinary surgeons agree in pronouncing these growths to be the result of travelling on hard roads, and of the horses being shod. The effects of disuse are clearly shown in the skeletal characters of our domestic races. These effects are well marked in tame birds, which are necessarily prevented from exercising their wings in flight. Thus in the domestic duck the crest of the sternum is less prominent, the furculum, coracoids, and scapulæ are all reduced in weight relatively to that of the whole body; the bones of the wing are shorter and lighter, and the bones of the leg longer and heavier in comparison with the same bones in the wild duck. Closely connected with this class of facts is the subject of rudimentary organs. In organisms living in a state of nature the constant pressure of the struggle for existence tends to keep useless structures in a rudimentary condition. But domestication, in removing this pressure, does away at the same time with the principle of economy of growth; and accordingly, we find that organs rudimentary in a state of nature become developed under domestication. Thus cultivation has made true branches out of the thorns or rudimentary branches of the wild pear. Again, the rudimentary fifth toe on the dog's hind foot becomes in some cases considerably developed, and forms the "dew-claw" of a few large breeds.

Correlation has probably played an important part in modifying domestic races; for in selecting a given character man has frequently perpetuated many other peculiarities correlated with the first.

Finally may be mentioned the curious phenomena of "analogous variation." This term is applied to those cases in which varieties of one species resemble distinct but allied species. Where this occurs it is probably due to the two forms having originated in a common progenitor, so that modifying causes evolve similar varieties in the two cases because of the similarity of the material which these forces have to act on. Analogous variation is therefore, properly speaking, a branch of the subject of reversion, and once more points out the close connection existing between the latter phenomenon and variability.

In purely bred fowls of many races, birds may occasionally be found closely resembling the *Gallus bankiva*. Here the case is one of simple reversion, and has already been alluded to. The production of spangled sub-breeds of Hamburgh, Polish, Malay, and Bantam fowls is not an obvious case of reversion to a known ancestor. It may be due, however, to descent from the parent form of the Gallinaceæ, considering the frequency of spangled markings throughout the order.

Selection.—Selection may be defined as the process by which the procreators of each fresh generation are chosen out of the preceding one. But with reference to the formation of our improved breeds something more than this is meant by the term. The modern development of the art, which has been distinguished by Mr Darwin as *methodical selection*, always implies that the breeder has before his mind an ideal form,—a model on which he attempts to mould his strain. To be successful in this respect a man must not only possess in the highest degree the powers of discrimination, enabling him to determine which individuals are tending in the right direction, that is, which most nearly approach his ideal, but he must be able to decide, in the most judicious manner, as to which of his selected individuals ought to be paired together. The subject, therefore, falls naturally into two divisions—(1) the discrimination of individual differences, (2) the arrangement of the pairing.

1. *Discrimination of Individual Differences.*—The extremely fine powers of perception and the great patience required by the breeder might be illustrated by numerous instances. Sir John Sebright is said to have sometimes spent several days in weighing the rival merits of five or six birds. In Germany the merino sheep farmers do not even trust their own judgment, but employ professional "sheep classifiers" to select the best of the flock for breeding purposes. Not merely outward form, but internal and constitutional peculiarities have been carefully attended to by breeders. Thus, Bakewell (the first true methodical breeder of whose proceedings we have any knowledge) bred almost entirely for the early maturity and fattening qualities of his strain; and again, in the improved short-horn breeds, the masses of internal fat or tallow have been increased to an almost incredible extent.[1] Professor Low states,[2] as an instructive instance of the limits that should be put to the exaggeration of any one point, that even the great Bakewell appears to have made this mistake in causing a useless accumulation of fat where it was not needed. It seems that the fat mingled less with the lean than even in the old breeds, and that it spread in layers under the skin, forming cushions of fat. He quotes a writer who observes that, having with great difficulty formed a race of cattle that would "make fat," Bakewell left his successors under the necessity of producing a breed that would "make lean." The same kind of error was at one time committed with the improved short-horns, whose progenitors were pre-eminently good milkers; here the breeders, by attending exclusively to other qualities, have in some cases injured the milking powers of the race. Youatt is convinced that this loss is not necessarily correlated with rapid feeding qualities.[3] He asserts that by careful selection a strain may be obtained (and this has, in fact, been effected) in which the cows are first-class milkers, and when dried fatten quickly and well.

In spite of these warnings against exclusiveness and exaggeration, it should be remembered that the difficulties of selection are greatly increased by attention to several points at once. An illustration of this may be taken from the less important art of fancy breeding. An eminent fancier in speaking of the almond tumbler pigeon (a breed having five points, viz., plumage, carriage, head, beak, and eye), remarks that "there are some young fanciers who are over covetous, who go for all the above five properties at once; they have their reward by getting nothing." Mr Darwin observes, "We may smile at the solemnity of this precept, but he who laughs will win no prizes."

It should be remarked, however, that "fancying" is not governed by rules identical with those which regulate breeding for economic purposes. The fancier often has to strive after extreme abnormal development, amounting to monstrosity; it has often been remarked that he will not tolerate anything short of this extreme divergence. On the other hand the economic breeder is prevented by solid monetary considerations from being misled, to any great extent, by fashion. Hence, instead of the wide differences observable in "fancied" animals, we find a remarkable uniformity in certain characters among many of those bred for use. Thus all the improved races of the pig closely resemble each other in their shortened legs and muzzles, their large hairless bodies and small tusks. Well-bred cattle of several distinct races exhibit a similar convergence of character.

2. *Arrangement of the Pairing* (including crossing).—We have already alluded to the remarkable case in which it seems an advantage to the offspring that one parent *only* should possess the desired quality in an especial degree. This may be considered an extreme case, yet it bears some relation to the principles on which breeders usually regulate the arrangement of the pairings. Generally speaking, individuals having certain points peculiarly well developed are matched with those excelling in other directions. It is probable that a physiological law which would formulate the exceptional cases above mentioned would also favour the more common practice

[1] Youatt, *Cattle*, 1834, p. 227, *et seq.*
[2] *Domesticated Animals*, 1845, p. 378.
[3] *Op. cit.*, p. 239.

now under consideration. For it would allow the transmission of qualities from either parent, undisturbed by the influence of the other, to the offspring. In this part of his work the breeder once more finds occasion for the utmost skill and judgment; but so difficult to formulate are the fruits of his experience that he often seems guided in his choice by instinct rather than by reason. Every new breed must originate in a few individuals possessing some special peculiarities. Therefore, nearly-related individuals must at first be matched; in other words, close "in-and-in" breeding must be practised, or the race cannot be "fixed." In consequence of the uniformity obtained by pure breeding, characters otherwise unimportant become valuable as marks of purity of race. Thus the dark red colour of the Devon cattle becomes a criterion of "blood."

The advantages of in-and-in breeding have been insisted upon by the improvers of our domestic breeds, and some of them have declared that no ill results follow from the practice. But in spite of this assertion it is generally admitted that degeneration either in constitution or in other ways does ultimately ensue; so that at any cost the breeder is absolutely compelled to admit blood from another family or strain of the same race. In speaking of this necessity in the case of sheep, Youatt says that the breeder will choose "a ram from a soil and kind of food not dissimilar to his own, . . . with points as much resembling his own sheep as may be—quite as good as those in his own flock—superior if possible in some points, inferior in none." But in opposition to Youatt it may be argued, from the practice followed by some great poultry breeders, that animals having the same physical characters, but which have been kept under different *conditions*, ought to be selected for crossing. By this means tone and vigour are infused into the stock without materially altering its character. In other cases a different plan has been followed. For instance, Colling (for what purpose is not clear, on account of the secrecy in which he carried out his art) crossed his short-horns with a distinct breed—the Galloway. He thus produced a sub-strain or family, called in reproach the "Alloy," but possessed of great merits, which, by recrossing with short-horns, became quite equal to the pure breed,[1] and produced animals which sold for enormous prices. This method of making one "violent" cross, and trusting to subsequent recrossing with the pure parent form (together with long continued selection), has sometimes been followed where some especial quality is required. Lord Orford's well-known attempt to infuse pluck into his greyhounds by means of a cross with a bull-dog is a case in point. Stonehenge records a carefully-observed experiment of the same kind, which shows that the objectionable form of the bull-dog can be thoroughly eradicated even in four generations. In other cases a cross with a distinct variety is effected with the object of forming an intermediate race which shall transmit its characters.

Crossing.—An injudicious exaggeration of certain qualities, as in some cases before alluded to, has taken place in breeding long-woolled sheep. Here the fleece has been almost exclusively attended to, and the quality of the carcase allowed to deteriorate. No doubt, an improved breed remedying this evil might have been formed by selection, but this process would have been slow and extremely difficult; and, fortunately, there existed the readier method of forming a cross-breed race combining the desirable characteristics of both varieties. Messrs Druce and Pusey[2] have pointed out the great increase of profit yielded by a cross between the long and short-woolled sheep. The following table gives in the first column the number of Cotswolds, Southdowns, and sheep of a "cross breed" intermediate between them, which a given area will support; the second gives the total value of fleece and carcase in each case for the number of animals given in the first column:—

Cotswold	100	£496
Southdown	120	488
Cross-breed	115	587

Crossing has, in fact, entered largely into the formation of nearly all our improved sheep.[3]

In some cases the offspring of a first cross between distinct species possess valuable qualities, but owing to their sterility an intermediate *race* cannot be formed. If, however, the combination is valuable the cross may be repeated at will. The breeding of mules is a familiar example of this method. In the same way cross-bred cattle, which though not sterile are yet incapable of transmitting their valuable qualities to their offspring, are bred for the butcher by a repetition of the first cross.

Some of the more important points in connection with methodical selection and the modern art of breeding have now been briefly indicated. The results obtained have been truly astonishing. Lord Somerville graphically remarked that the modern sheep-breeder appeared to have "drawn a perfect form and then to have given it life." These extraordinary improvements have been effected almost within the last century; and it may be objected that because selection as now practised is of modern date, the differences which characterize many races of great antiquity cannot have been produced by man. This objection, however, is not valid, for it can be shown that an unnoticed and therefore unrecorded cause of modification has long been in existence. This important agent has been named "unconscious selection;" it is illustrated by the following case. In speaking of two flocks of the New Leicester sheep possessed respectively by Messrs Buckley and Burgess, Youatt remarks that "both of their flocks have been purely bred from the original stock of Mr Bakewell for upwards of fifty years. There is not a suspicion existing in the mind of any one at all acquainted with the subject, that the owner of either of them has deviated in any one instance from the pure blood of Mr Bakewell's flock; yet the difference between the sheep possessed by these two gentlemen is so great that they have the appearance of being quite different varieties."[4]

Now we may feel sure that neither of these breeders intended to alter the character of his flock, he merely strove to produce the best possible New Leicester sheep, and selected those which approached his ideal most closely. Yet owing to slightly different standards of excellence having been unconsciously aimed at in the two cases, the important results pointed out by Youatt arose. It is an exceeding remarkable fact, that changes so small as not to be perceived by the trained eye of the modern breeder may by accumulation produce obvious results in the short space of fifty years. And if such changes may occur unnoticed under the supervision of men keenly alive to the possibilities of change, a far greater field for this kind of modification must have been offered before any such knowledge was general. An unperceived divergence of character will arise whenever men, actuated by some vague belief in heredity, begin to select the best individuals, roughly speaking, for reproductive purposes. Each man will unconsciously take a standard of excellence slightly different from his neighbours, and thus his strain will imperceptibly begin to differ from theirs. Now there can be no doubt that an amount of selection sufficient for this purpose must have been practised from a very remote period. Youatt, after an examination of the passages in the Old Testament bearing on the subject, asserts that some of the best principles of breeding were then understood. The antiquity of breeding is also proved by certain passages in ancient Chinese encyclopædias.

The ancestors of nations at present civilized must have passed through stages in which they resembled the savages of the present day; therefore it may fairly be assumed that customs which are found among lowly developed savages are of great antiquity. Now few races are more barbarous than the Australians, yet even they take pains in the breeding of their dogs, matching the finest together and providing good food for the mother in order that the young may be well nurtured. From a large body of similar evidence there can be no doubt that a degree of selection sufficient for the development of unperceived divergence has been

[1] Low, p. 304. [2] *Jour. Roy. Agri. Soc.*, xiv., 1853, p. 214.
[3] See Mr Spooner's excellent paper on "Cross-Breeding" in the *Jour. Roy. Agri. Soc.*, vol. xx. pt. ii.

[4] *The Sheep*, p. 315.

practised from exceedingly ancient times. The results produced by prolonged selection of this kind may be estimated in various ways. For instance, although it is certain that the pointer originally came from Spain, no such breed exists there at the present day. So far as is known no efforts have ever been made to modify the pointer; but every one has wished to possess as good dogs as possible, and by an unconscious consensus of opinion, the desire for improvement has resulted in a slow progressive change in a certain direction. But the amount of divergence produced by long-continued selection may be illustrated more forcibly by general considerations than by special instances. The fact that the progenitors of many cultivated plants and domestic animals cannot with certainty be determined points out the great divergence from the wild parent form that has been effected under domestication. The genus *Auchenia* may serve as an illustration. There are four forms in this genus—the guanaco and vicuña, found wild, and undoubtedly distinct species, and the llama and alpaca, known only in a domesticated condition. Most professed naturalists have looked on all four forms as specifically distinct, and have made the assumption that the wild llama and alpaca have become extinct. But Mr Ledger appears to have proved conclusively[1] that the llama is the domesticated descendant of the guanaco, and the alpaca that of the vicuña,—so that a large amount of divergence must have been effected in this case. And as we know that careful selection was anciently applied to these animals, there is nothing inconceivable in such a transformation having been effected. The power of long-continued selection is well shown by the fact that, in domestic animals and plants, the parts or qualities valued by man have been most modified; thus the sheep has been prized during many ages for its fleece, the horse for its strength and fleetness, and, accordingly, we do not find breeds of sheep differing from each other in strength and fleetness, or breeds of horses distinguished by the properties of their hair, but on the contrary both animals have produced races characterized by differences in the qualities for which they are valued. The same law is even more clearly demonstrated by plants under cultivation. In the radish, which has been esteemed exclusively for its root, it is the latter that differs in the several varieties, while the flowers, seed, and foliage are almost identical in all. Again, the varieties of the gooseberry differ much in their fruit, but hardly perceptibly in their flowers and organs of reproduction. In some cases structures neglected by man have varied by correlation; but allowing for this exception, they may be said to have escaped the effects of selection, and accordingly to have remained stationary, while the selected qualities have gradually improved.

In attempting to frame an answer to the question—How much has man actually effected? it will be well first to estimate the amount of modification which may be claimed as his work, and then to measure the efficiency of the agents by which these results are believed to have been effected.

(1.) Organic beings resemble each other in descending degrees, so that they can be classed in groups under groups,—classes, orders, genera, &c. The doctrine of evolution gives life to this arrangement and makes it truly a "natural" classification,—the idea of different degrees of community of descent being added to that of arbitrary classification by community of characteristics. Thus it happens that the number and distinctness of the genera contained in a natural family become to a certain extent a gauge of the amount of divergence which the modifying causes of nature have produced, since the time when all the genera were united in the parent form of their family. And by a similar method we may estimate the amount of divergence that man has effected. For instance, there can be no doubt that all the varieties of the domestic pigeon are the descendants of the rock pigeon, and have sprung up under the care of man during the long period of time that has elapsed since their wild ancestor was first domesticated. These varieties amount to more than 150 in number; and there can be no question that, supposing them to be found wild, they would be grouped under at least five distinct genera,—so great are differences existing among them. This instance gives some idea of the marvellous amount of modification that may arise under domestication.

(2.) Are the powers which man possesses of producing modification sufficient for the work assigned to them? It will be well to set down the assumptions which may fairly be made in connection with this point.

First, the labours of the great breeders teach us what enormous changes can be effected in the short space of one man's life; and we know that the essential principles involved in the process were anciently known and followed.

Secondly, we may feel certain that great divergence of character is unconsciously produced during long continued selection of any kind; and we know that some kind of selection must have existed from remote periods. Logically considered, therefore, the possibility of almost any degree of divergence having been effected turns in great measure on the question of the antiquity of selection.

It is therefore important to note that an indirect kind of selection must almost necessarily be coeval with domestication. For this can be shown to be the case with tame animals possessed by the rudest savage, who does not regulate their increase in accordance with even the vaguest belief in heredity. In each litter of puppies, for instance, some would necessarily be destroyed, for their master would be unable to preserve all the young ones which were produced. He would certainly not save those which were small, feeble, or deficient in any valuable quality. The finest in each generation would then be preserved, merely because it was believed that they, individually, would be useful, and not with any idea of "breeding." Nevertheless, it would indirectly follow that the superior individuals in each generation would, as a rule, form the progenitors of the next one; that is, a kind of indirect selection would arise. If then we can be sure that domestication, in some form, has existed from remote times, we may feel tolerably certain that the above-described rude form of selection must be of nearly equal antiquity. Apart from the direct proofs on this head which we possess in the remains of the prehistoric period, there is a high antecedent probability in favour of the extreme antiquity of domestication; for it is certain that tame animals are of great use to savages, and the wild progenitors of many of our domestic creatures are rendered tame with ease. This is the case with wild dogs, pigs, cattle, ducks, &c. In the case of vegetables, it appears that, in times of scarcity, savages devour almost any berries or leaves which they can obtain, often suffering terribly in consequence; and in this way plants at all superior in nutritious qualities would assuredly be discovered. We may, therefore, conclude—(1), that the domestication of animals and the culture of plants date from exceedingly remote antiquity; (2), that a certain amount of selection must have been nearly coeval with domestication; (3), that some degree of divergence of character must almost necessarily have accompanied selection; and (4), that, consequently, the large amount of modification claimed to have been produced by man is a conceivable and credible result. (F. D.)

BREGENTZ, the ancient *Brigantia*, capital of the circle of Vorarlberg, in Tyrol, stands on a hill at the S.E. end of the Lake of Constance. It has an old castle, two convents, and an orphanage. Silk and cotton are manufac-

[1] *Bull. de la Soc. d'Acclimat.*, tom. vii., 1860, p. 457.