The Welsh language is still that of the peasantry and middle class, and the members of the Church of England are largely out-numbered by the Baptists, Calvinistic Methodists, and Independents.

Brecknockshire formed part of the territory of the Silures, and its occupation by the Romans could never have been very complete. After their expulsion the district (*Brycheiniog*) was ruled by native princes and was the scene of many a border struggle. Many of the castles which are scattered over its eastern border had their origin at this period; and some of them may be regarded as advanced posts erected by the English during the wars which preceded the formation of Offa's Dyke. Subsequently, when Bernard de Newmarch and his Norman followers obtained possession of the country, they were converted into regular fortresses, by which the neighbourhood was kept in awe, and the mountain passes defended. The district between Brecon and Builth was the scene of the last struggle between the English and Llewelyn in 1282, when the Welsh chieftain was defeated and slain. Since that date Breconshire has not been associated with any important historical events, unless we include among them the raids of Owen Glyndwr. It formed part of the Welsh Marches until their union with England in 1532. Among the eminent natives of the county may be mentioned Sir David Gam (Shakspeare's Fluellen), who lost his life at Agincourt while defending Henry V.; the ill-fated Henry Stafford, duke of Buckingham; John Penry ("Martin Marprelate"); Henry Vaughan, the poet; Dr Hugh Price, founder of Jesus College, Oxford; Thomas Howel, bishop of Bristol (less known than his brother, the letter writer); Theo. Jones, historian of the county; and Mrs Siddons.

Brecon, or Brecknock, the capital of the county of the same name, a market and borough town, 145 miles N. by W. from London, picturesquely situated in a fine open valley, at the confluence of the Honddu and Tarell with the Usk, and nearly in the centre of the county. It is supposed to occupy the site of the Roman station *Bannium*, but it is more probable that it was partly constructed with materials drawn from that spot, which lies to the W. of the present town, on the Via Julia Montana. There are three main streets, with several smaller ones. The houses are for the most part constructed of stone, and are generally well built. Brecon has a fine cruciform church (Early English in style), which has been restored by Sir Gilbert Scott. There are two other churches, and two Independent, two Baptist, and one Calvinistic Methodist chapel. The corporation consists of a mayor, recorder, four aldermen, and twelve councillors. The borough has returned one member to parliament since 1536. Constituency in 1875, 813. The assessed taxes yield annually £1259, and the annual value of real property paying income-tax is £24,941. There are weekly markets, and several fairs in the course of the year. The quarter sessions and assizes are held here. Brecon has a foundation called the College of Christ Church, of which the bishop of St David's is *ex officio* dean, but after the death of its present officers its revenues will devolve to the ecclesiastical commissioners and be appropriated to ecclesiastical uses. The ruins of the ancient castle are enclosed in the beautiful grounds of the Castle Hotel, and though unimportant in themselves, derive an interest from their connection with the Fitzwalters, de Braoses, de Bohuns, and Staffords, successive lords of Brecon. The principal fragment now remaining is Ely Tower, so called from its having formed the prison of Morton, bishop of Ely, where he concerted with his custodian, Henry Stafford, duke of Buckingham, the dethronement of Richard III., and the union of the houses of York and Lancaster. There are some fine Roman and other remains in the immediate vicinity. Population of municipality in 1871, 5845; inhabited houses, 1172.

BREDA, a town of Holland in the province of North Brabant, and capital of a circle, is situated in a marshy plain on the Merck, 24 miles S.W. of Bois-le-Duc, and 30 N.N.E. of Antwerp. It is strongly fortified and defended by a citadel (rebuilt by William III. of England), and the surrounding district may be laid under water when required. The town is well built, with wide and well-paved streets, is intersected by several canals, and has a fine quay, a town-hall, an arsenal, an observatory, an orphan asylum, a cathedral, and several Roman Catholic and Protestant churches, one of the latter having a spire 362 feet in height. It has also a Latin school and a military academy, and manufactures of linen and woollen goods, carpets, hats, beer, and musical instruments. Population (1869), 14,172.

Breda obtained municipal rights in 1252 from Henry, but was not surrounded with walls till 1534. The old castle, which had been built in 1350 by Jan Van Polanen, was restored about the same time. In 1696 William Prince of Orange and king of England caused the erection of the new castle, which was regarded as one of the finest buildings of the period. It was afterwards the residence of Charles II. in his exile, and is now the seat of the military academy. The town was captured by the Spaniards in 1581, by Maurice of Orange in 1590; again by the Spaniards, under Spinola, in 1625; and by Henry of Orange in 1637. It was finally ceded to Holland by the treaty of Westphalia in 1648. During the wars of the French Revolution it was taken by Dumouriez in 1793, and again by Pichegru in 1795. Much of its celebrity is due to the various political congresses of which it has been the scene. In 1566 the nobles of the Netherlands formed there the league known as the Compromise; in 1575 a conference was held between the ambassadors of Spain and those of the United Provinces; in 1667 a peace was signed between England, Holland, France, and Denmark; and in 1746–7 the representatives of the same powers met in the town to discuss the terms of another treaty.

BREDA, Jan Van, a Dutch painter, was the son of Alexander Van Breda, an artist of considerable merit, and was born at Antwerp in 1683. He imitated the style of Wouvermans and Breughel with such dexterity, that even connoisseurs are often unable to distinguish his copies of their pictures from the originals. He visited England, where he was so well employed, that in a few years he was able to retire to his native country with a competency. The earl of Derwentwater was one of his chief patrons. He died at Antwerp in 1750.

BREDOW, Gabriel Gottfried, a German historian and professor in the university of Breslau, was born at Berlin in 1773. He is known in England by his *Manual of Ancient History*, which was translated into English in 1827; *Researches on History, Geography, and Chronology;* and his valuable *Historical Tables*, which come down to 1811. This last work was translated into English by Major J. Bell, who continued the tables down to 1820, and produced a popular and very useful work. Bredow died in 1814.

BREEDS AND BREEDING.[1] The word breeds is usually applied to the varieties of domesticated *animals* only, but since the phenomena presented under cultivation by all classes of organisms are entirely similar in character, and since, moreover, much of our knowledge on the subject has been gained from botany and horticulture, we shall include, under the one term breeds, the varieties of domestic animals and of cultivated plants. The natural and simple definition of breeding would be the art by which breeds are produced. But here the objection arises, that in this definition too much is assumed. It may be argued that our domesticated animals and plants are each

[1] Many of the facts and arguments contained in the present article are taken from Mr Darwin's work, *The Variation of Animals and Plants under Domestication*, 1868, and 2d. ed. 1876; and in most instances it has not been considered necessary to give the references.

identical with a wild prototype either living or extinct, and that man has merely deprived them of liberty and regulated their environment and propagation in the manner most advantageous to each kind. At the present day, when the whole range of biological thought is so largely permeated by the principles of the doctrine of evolution, this objection will probably not be advanced. Yet, when it is remembered that such an authority as Col. Hamilton Smith held the belief that each breed of dog had its wild prototype, it appears necessary to modify the definition above given. Let it be said that the art of breeding consists in changing the conditions of life and regulating the reproduction of animals and plants.

Since a breed is a domestic variety, it implies the existence of a group of individuals marked off from their congeners by the possession of certain characters which are transmitted to their offspring. It is this *transmission* of peculiarities which is the essential characteristic of a breed; for any collection of domesticated organisms could be divided into groups of individuals distinguished by certain points, but such groups would not necessarily form breeds. It is evident, then, that the law of heredity which asserts that "like begets like" must hold good, or the existence of breeds will be an impossibility. Again, if it were absolutely true that like begets like, that is, if the offspring were in all cases identical with the parent, it is evident that neither by man's interference, nor by the operation of nature, could a breed or race arise. It seems, then, that were it not in the nature of all organic beings to reproduce their kind in the manner formulated in the principle of heredity, and were it not for the continuous slight infringement of it expressed by the principle of variability, breeds could not have arisen. It is therefore necessary to examine these two principles as part of the subject under consideration.

Whatever views we may entertain respecting the origin of our domestic animals and plants, there can be no doubt as to the matter of fact that breeders have always proceeded on one principle,—*select the best individuals in each generation and pair them.* Now we have found that the qualities of organic beings (forming in a certain sense the material on which the breeder has to work) can be generalized under two principles—heredity and variability. And in the same way the art of breeding is itself capable of a kind of generalization under the principle of selection. There are thus three great principles or laws—heredity, variability, and selection,—the last relating to the art of man, the other two to those qualities of organic beings which render the art practicable.

Heredity.—The simplest form of heredity is found amongst those organisms which reproduce their kind by division into two parts similar to each other. This process is illustrated by the fission of a Moneron. The next advance in complexity of reproduction occurs when the two portions into which the organism divides are dissimilar to one another; here the process by which both portions ultimately assume the form of the parent is not one of simple nutrition, *i.e.*, of formation of tissue like that already formed. The process by which man propagates some of his cultivated plants is one of artificial reproduction by fission. For instance, a cutting or part of a shoot, or even a leaf (as with Begonia), if placed in suitable soil, will reproduce the original plant in all its minute details. We are here face to face with the mystery of reproduction; for we have the ever wonderful fact that in a few cells lies dormant the vital impetus which enables them to produce from inorganic pabulum a most complicated structure, which in its totality is utterly unlike themselves. And this example shows us, moreover, how essentially the same are sexual and asexual reproduction; for there is no intrinsic difference between reproduction from a small part artificially separated from a simple foliar organ (a leaf) and the same sequence of growth originating in a small portion naturally segregated from a transformed foliar organ (the ovary). The conditions of growth are not the same in the two cases, and there all essential difference ends; for the broad distinction which the congress of two individuals in one case appears to make is swept away by the facts of Parthenogenesis. In the lowest of living things we have seen that growth and reproduction are almost identical aspects of life. And this connection is not less close among higher organisms; as Mr Herbert Spencer observes,—"When in place of its lost claw a lobster puts forth from the same spot a cellular mass, which, while increasing in bulk, assumes the form and structure of the original claw, we can have no hesitation in ascribing this result to a play of forces like that which moulds the materials contained in a piece of Begonia leaf into the shape of a young Begonia. In the one case as in the other the vitalized molecules composing the tissues show their proclivity towards a particular arrangement; and whether such proclivity is exhibited in reproducing the entire form or in completing it when rendered imperfect matters not."[1] The main fact of inheritance is so obvious that it is apt to be forgotten. Mr Darwin remarks,—"It is hardly possible, within a moderate compass, to impress on those who have not attended to the subject the full conviction of the force of inheritance, which is slowly acquired by rearing animals, by studying the various treatises which have been published on the various domestic animals, and by conversing with breeders."[2] Certain peculiarities have appeared only once or twice in the history of the world, but have reappeared in children or grandchildren of the individuals so characterized. Thus Lambert "the porcupine man," whose skin was covered with warty projections, which were periodically moulted, had all his six children and two grandsons similarly affected. The most striking cases of inheritance have, as in this instance, been observed in man; but the very existence of the numerous breeds of domestic animals is clear evidence of the possibility of the transmission of every kind of peculiarity. For instance, it is believed that the varieties of the domestic pigeon amount to at least 150, and these races differ from each other in many ways, and all breed true to their kind. Some very curious peculiarities have been perpetuated. A race of cattle called "Dutch buttocked" was formed in Yorkshire by selecting in each generation the animals with the largest hinder-quarters. When the breed began to be established it was found that the large size of the calves' hind-quarters increased the dangers of parturition to a considerable extent. This case is interesting as showing that hurtful peculiarities may be inherited just as readily as those which are beneficial, and as bearing witness to the improbability of the view that there is an innate tendency to vary in the right direction. The terrible strength of inheritance exhibited by disease is a fact which is only too well established in the case of man; and in the maladies of domestic animals the same law holds good. It appears that nearly all the diseases to which the horse is subject are hereditary,—for instance, contracted feet, curbs, splints, spavin, founder, and weakness of the fore legs, roaring or broken and thick wind, melanosis, specific ophthalmia, and blindness, and even such habits as crib-biting and jibbing, are all plainly hereditary. The fact that any, even the most complex combinations of qualities are capable of hereditary transmission, is, perhaps, more forcibly brought home by considering the monetary aspect of the art of breeding, than by the fullest collection of special instances. As Mr Herbert Spencer remarks:—"Excluding those inductions

[1] *Principles of Biology*, London, 1863, p. 181.
[2] *Op. cit.*, vol. ii. p. 4.

that have been so fully verified as to rank with exact science, there are no inductions so trustworthy as those which have undergone the mercantile test. When we have thousands of men whose profit or loss depends on the truth of the inferences they draw from simple and perpetually repeated observations; and when we find that the inferences arrived at and handed down from generation to generation of these deeply interested observers has become an unshakeable conviction, we may accept it without hesitation. In breeders of animals we have such a class, led by such experiences and entertaining such a conviction—the conviction that minor peculiarities are inherited as well as major peculiarities. Hence the immense prices paid for successful racers, bulls of superior form, sheep that have certain desired peculiarities."[1] Not only are slight and gradual changes inherited, but in some cases sudden and well-marked variations are strongly transmitted. The case of the Niata cattle is now well known; a similar case is recorded of a rabbit born with only one ear, from which a breed was formed which steadily produced one-eared rabbits. These remarkable cases of sudden and large variation being inherited are closely allied to the still more curious phenomenon of the inheritance of mutilations. The most striking cases on record are those of Brown-Séquard.[2] In his experiments on the inheritance of artificially produced epilepsy he found that guinea pigs, after having undergone section of the sciatic nerve, often nibbled off portions of their hind legs in consequence of the anæsthesia of those parts. Now the offspring of these self-mutilated animals were in thirteen cases born without toes. To appreciate the true value of this case it must be noted that Dr Brown-Séquard has for thirty years kept guinea pigs, and has had many thousands under observation, and *not a single case* of congenitally toeless animals has occurred excepting among the offspring of mutilated parents. In spite of the universal tendency towards the transmission of the form and qualities of the parents to the offspring, there occur capricious and inexplicable lapses in inheritance. It is not possible logically to distinguish a want of inheritance from a case of variation; but when the difference between the offspring and the parent consists merely in the absence in the former of a quality possessed by the parent, it may be more conveniently classed as a want of inheritance than as an instance of variation. Although a weeping or pendulous habit in trees is in some cases strongly inherited, in other instances the want of inheritance is equally well marked. Mr Rivers sowed above 20,000 seeds of the weeping ash, and not a single seedling was in the least degree pendulous. M. Borchmeyer has also observed the same fact in Germany. In all cases it must be remembered that the form and qualities which the offspring of an animal or plant will assume when fully developed are not solely dependent on the nature of the hereditary impetus with which it starts; the initial tendency is as it were calculated so as to impart under certain conditions a certain form to the organism. If the conditions change, the initial tendency will not lead to the proper result; and it is to be noted that the apparent amount of alteration in the conditions is no measure of the amount of effect produced on the organism. For instance, none of the English breeds of sheep can be kept pure in France, the lambs of even the first generation lose vigour as the heat of the summer comes on, and the breed becomes absolutely degenerate. It is extremely curious that the force of inheritance which seems all powerful in England should give way so utterly under such a slight change of circumstances.

The method by which a breed was formed, combining the valuable qualities of the English sheep with a constitution fitted for the French conditions of life, is most instructive, and is a triumph of thoughtful and scientific breeding. The successful attainment of this end is due to M. Malingié-Nouel. He found that the offspring of a cross between a pure English ram and a French ewe inherit the desirable form of the sire, but, unfortunately, also his undesirable constitution. He accordingly paired a ewe taken from a border district, and therefore intermediate between two breeds, with a similar intermediate ram. He thus produced a sheep "combining the four races—Berry, Sologne, Merino, and Touraine . . . without decided character, without fixity, . . . but possessing the merit of being used to our climate and management."[3] It was now found that the lambs born of this mongrel ewe by purely-bred New Kent rams combined the English form with the French constitution, and transmitted this desirable combination to their offspring, and in this way the "Charmoise" breed was produced.

In this instance it seems as if the tendencies supplied by the ewe formed so discordant a combination that no strong tendency resulted for any of the French forms to appear, so that the form of the English ram was strongly impressed on the offspring. On the other hand, the *constitutional* tendencies coming from the mother's side were not discordant, but united in impressing the French constitution on the offspring. This case is instructive as establishing the possibility of an important kind of acclimatization, and as bearing on a somewhat exceptional phenomenon of heredity, namely, that when *both* parents exhibit a given character strongly, the offspring do not inherit it so surely as when one parent only is especially well characterized. Thus a successful breeder of laced Sebright bantams says,—"I am confident that those that are best laced frequently produce offspring very far from perfect in their markings, whilst those exhibited by myself which have so often proved successful were bred from the union of heavily laced birds with those that were scarcely sufficiently laced."[4] The class of cases just noticed is, moreover, of great interest as bearing on a form of inheritance which has been named "prepotency of transmission." When the offspring, instead of being intermediate between the parents, strongly resemble one of them, the latter is said to be prepotent in transmitting its likeness. The famous bull Favourite is believed to have had a prepotent influence on the short-horn race. It has also been observed with English race horses that certain mares have generally transmitted their own character, while other mares of equally pure blood have allowed the character of the sire to prevail.

In other cases a remarkable weakness of transmission of character is found to exist. A striking instance is given by Mr Brent.[5] It must be premised that the breed of pigeons known as "trumpeters" is characterized by a tuft of feathers over the beak, by a crest on the head, and by a most peculiar coo. Mr Brent crossed a trumpeter with another breed, and then recrossed the mongrels with trumpeters. But it was only at the fourth generation, when the birds had $\frac{15}{16}$ trumpeter blood in their veins, that the characteristic tuft appeared, and even then the peculiar trumpeting coo was absent.

It is frequently asserted that the male is prepotent over the female in transmitting certain characters. It has been shown,[6] however, that such rules do not hold good except

[1] *Principles of Biology*, 1864, No. 10, p. 242.
[2] *Proc. Roy. Soc.*, No. 297; *Brit. Assoc.*, 1870; *Lancet*, Jan. 1875, p. 7.
[3] *Jour. Roy. Agri. Soc.*, xiv. 1853, p. 214, translated by Mr Pusey.
[4] *The Poultry Book*, by W. Tegetmeier, 1866, p. 245.
[5] *The Pigeon Book*, p. 46.
[6] Prosper Lucas, *L'Hérêd. Nat.*, tom. ii. l. ii. ch. i., and Gärtner, *Bastarderzeugung*, s. 264–266.

to a very limited extent, and in certain groups only. It frequently happens that a character existing in one of the parents is transmitted more powerfully to the offspring of the sex to which that parent belongs than to the opposite sex. The large and important subject of secondary sexual characters hinges entirely on this phenomenon. The resemblance between prepotency and sexual limitation becomes clear when we remember that where the offspring are of one sex it may be impossible to distinguish between these forms of heredity. The most interesting point connected with secondary sexual peculiarities in relation to the subject of breeds is, that they are sometimes found in domesticated animals whose nearest wild congeners show no such limitation of character. Thus in the sheep, the males of certain races differ greatly from the females in the shape of their horns, in the development of fat in the tail (in certain fat-tailed breeds), and in the outline of the forehead. These differences are interesting because, so far as we know, similar secondary sexual differences are not found in the nearest allied wild species of sheep. On the other hand, secondary peculiarities which originally distinguished the sexes are in some cases diminished or removed by domestication. Thus our improved breeds of pigs have to a large extent lost the formidable tusks of the wild boar. The existence of secondary sexual characters gives a striking illustration of another important law of inheritance. This law asserts that the age at which any character first shows itself in the offspring is the same as that at which it appeared in the parent. Now, secondary sexual characters—those, for instance, presented by the male sex—have apparently been developed by sexual selection, and this force can only be brought to bear on variations occurring in adult animals. If, then, the male offspring do not develop the selected peculiarities until they arrive at puberty, the age at which it appeared in their male parent, it is clear that they cannot differ from the female until the age of puberty arrives. And this is well known to be the case, for at an early age the sexes are usually undistinguishable by any secondary characters. (See *Descent of Man*, vol. i. chap. viii.)

The interesting form of inheritance exemplified by the transmission through the female line of diseases necessarily confined to the male sex has been already alluded to. This latency of male characters is clearly illustrated by what frequently occurs to old hens. It is well known that a large number of female birds, when old or diseased, partly assume the secondary male characters of their species. Waterton (*Essays on Nat. Hist.*) gives a curious instance of a hen which had ceased laying, and had assumed the plumage, voice, spurs, and warlike disposition of the cock. The opposite case of the assumption by the male of female characters is illustrated by the fact that capons sometimes acquire the sitting instinct of the hen.

The possibility of characters existing in a latent condition is of the utmost moment to the breeder, since upon it depends the possibility of reversion or atavism. Reversion is a matter of extreme importance to the breeder, for it is one of the serious hindrances to the progress of his art. Since the time of the famous Bakewell during last century, Leicester sheep have been bred with the most scrupulous care, yet grey-faced, black-spotted, or wholly black lambs occasionally appear. In this case the most careful selection has been necessary to battle against the tendency of the original colouring of the sheep to reappear. And in all cases of selection it is this tendency that has to be struggled against by the breeder. On this principle the gardener looks over his beds and weeds out the "rogues." Even from seeds gathered from the finest cultivated varieties of the heart's-ease (*Viola tricolor*), plants perfectly wild both in flowers and foliage are frequently produced. The proximate cause of any particular case of reversion is utterly obscure; but some of the general causes may be set down. It is frequently asserted that domestic animals or cultivated plants, when allowed to run wild, always revert to the original parent form of the species. This assertion appears to rest on insufficient evidence, and to be an exaggerated statement of what is known on the subject. Nevertheless some weight must be allowed to it. Pigs have run wild in various parts of the world, and have everywhere acquired the general characters of the wild pig, and the young have re-acquired the longitudinal stripes. This last character is interesting, since it is not in any way a direct result of the changed conditions of life, as the thicker bristles and increased size of the tusks might be supposed to be. Another well-established cause of reversion is *crossing*. The case is exceedingly striking when the offspring of a cross do not resemble any near progenitor, but throw back to very remote ancestors. In illustration may be mentioned the experiments on pigeons detailed in the *Variation of Animals and Plants under Domestication* (vol. i. p. 200). There can be but little doubt that all our domestic races of pigeons have descended from *Columba livia*, the wild rock pigeon; the common dovecot pigeons exhibit the coloration of the parent form, and the most purely-bred fancy breeds, when of a blue colour, often show these characteristic marks. One of the above-mentioned experiments consisted in pairing a "mongrel female barb fantail with a mongrel male barb spot, neither of which mongrels had the least blue about them." It appears that blue barbs are exceedingly rare, that the spot has been known as a pure breed for nearly 200 years, and that a white fantail throwing any other colour is almost an unknown occurrence; nevertheless the offspring from the above two mongrels were of exactly the same blue tint over the whole back and wings as that of the wild rock pigeon from the Shetland Islands. Moreover, every characteristic mark of the wild pigeon was repeated in their mongrel offspring. This experiment demonstrates in the most striking way the tendency of a cross to produce reversion. The same result was also obtained by pairing black Spanish cocks with hens of various white breeds. In this case the offspring reverted to the red colouring of *Gallus bankiva*, which may be safely ranked as the parent form of our domestic fowls. In these instances the offspring revert to a character originally possessed by the ancestors of both parents, and here the cross is in no way essential to the reversion; it merely acts as a disturbing cause (although, probably, no other equally strong disturbing power could be named). In these cases reversion to a character of any degree of antiquity may occur. In the other class of cases where the character to which the offspring revert is one given by a single cross with a distinct variety, the tendency to reversion becomes weaker in each generation removed from the cross, and may ultimately be obliterated. The length of time requisite to effect obliteration has formed a subject of discussion. The question can hardly be answered, but the fact that it has been asked shows at least that obliteration may in some cases be effected in a practically finite period. In other cases even characters gained in this way by a single cross seem incapable of extermination. Fowls have been known to exhibit a Malay character, due to a cross with that breed forty years previously.

Variability.—When in any case we find the offspring differing from the parent, we set it down at first sight as an instance of variability. But on the discovery being made that the peculiarities characterizing the offspring are derived from a remote ancestor, it can no longer be so considered, and must be attributed to reversion. Many cases of apparent variation are due to this cause. Thus Gärtner declares, and his experience is of the highest value

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 nccessarily 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.