CHAPTER XXIV.

LAWS OF VARIATION—USE AND DISUSE, ETC.

NISUS FORMATIVUS, OR THE CO-ORDINATING POWER OF THE ORGANISATION—ON THE EFFECTS OF THE INCREASED USE AND DISUSE OF ORGANS—CHANGED HABITS OF LIFE—ACCLIMATISATION WITH ANIMALS AND PLANTS—VARIOUS METHODS BY WHICH THIS CAN BE EFFECTED—ARRESTS OF DEVELOPMENT—RUDIMENTARY ORGANS.

IN this and the two following chapters I shall discuss, as well as the difficulty of the subject permits, the several laws which govern Variability. These may be grouped under the effects of use and disuse, including changed habits and acclimatisation—arrest of development—correlated variation—the cohesion of homologous parts—the variability of multiple parts—compensation of growth—the position of buds with respect to the axis of the plant—and lastly, analogous variation. These several subjects so graduate into one another that their distinction is often arbitrary.

It may be convenient first briefly to discuss that co-ordinating and reparative power which is common, in a higher or lower degree, to all organic beings, and which was formerly designated by physiologists as *nisus formativus*.

Blumenbach and others[1] have insisted that the principle which permits a Hydra, when cut into fragments, to develop itself into two or more perfect animals, is the same with that which causes a wound in the higher animals to heal by a cicatrice. Such cases as that of the Hydra are evidently analogous to the spontaneous division or fissiparous generation of the lowest animals, and likewise to the budding of plants. Between these extreme cases and that of a mere cicatrice we have every gradation. Spallanzani,[2] by cutting off the legs and tail of a Salamander, got in the course of three months six crops of these members; so that 687 perfect bones were reproduced by one animal during one season. At whatever point

[1] 'An Essay on Generation,' Eng. translat., p. 18; Paget, 'Lectures on Surgical Pathology,' 1853, vol. i. p. 209.

[2] 'An Essay on Animal Reproduction,' Eng. translat., 1769, p. 79.

the limb was cut off, the deficient part, and no more, was exactly reproduced. When a diseased bone has been removed, a new one sometimes "gradually assumes the regular form, and all the attachments of muscles, ligaments, &c., become as complete as before."[3]

This power of re-growth does not, however, always act perfectly; the reproduced tail of a lizard differs in the form of the scales from the normal tail: with certain Orthopterous insects the large hind legs are reproduced of smaller size:[4] the white cicatrice which in the higher animals unites the edges of a deep wound is not formed of perfect skin, for elastic tissue is not produced till long afterwards.[5] "The activity of the *nisus formativus*," says Blumenbach, "is in an inverse ratio to the age of the organised body." Its power is also greater with animals, the lower they stand in the scale of organisation; and animals low in the scale correspond with the embryos of higher animals belonging to the same class. Newport's observations[6] afford a good illustration of this fact, for he found that "myriapods, whose highest development scarcely carries them beyond the larvæ of perfect insects, can regenerate limbs and antennæ up to the time of their last moult;" and so can the larvæ of true insects, but, except in one order, not in the mature insect. Salamanders correspond in development with the tadpoles or larvæ of the tailless Batrachians, and both possess to a large extent the power of re-growth; but not so the mature tailless Batrachians.

Absorption often plays an important part in the repair of injuries. When a bone is broken and does not unite, the ends are absorbed and rounded, so that a false joint is formed; or if the ends unite, but overlap, the projecting parts are removed.[7] A dislocated bone will form for itself a new socket. Displaced tendons and varicose veins excavate new channels in the bones against which they press. But absorption comes into action, as Virchow remarks, during the normal growth of bones; parts which are solid during youth become hollowed out for the medullary tissue as the bone increases in size. In trying to understand the many well-adapted cases of re-growth when aided by absorption, we should remember that almost all parts of the organisation, even whilst retaining the same form, undergo constant renewal; so that a part which is not renewed would be liable to absorption.

Some cases, usually classed under the so-called *nisus formativus*, at first appear to come under a distinct head; for not only are old structures reproduced, but new structures are formed. Thus, after inflammation "false membranes," furnished with blood-vessels, lymphatics, and nerves, are developed; or a fœtus escapes from the

[3] Carpenter's 'Principles of Comp. Physiology,' 1854, p. 479.

[4] Charlesworth's 'Mag. of Nat. Hist.,' vol. i., 1837, p. 145.

[5] Paget, 'Lectures on Surgical Pathology,' vol. i. p. 239.

[6] Quoted by Carpenter, 'Comp. Phys.,' p. 479.

[7] Prof. Marey's discussion on the power of co-adaptation in all parts of the organisation is excellent. 'La Machine Animale,' 1873, chap. ix. *See* also Paget, 'Lectures,' &c., p. 257.

Fallopian tubes, and falls into the abdomen, "nature pours out a "quantity of plastic lymph, which forms itself into organised mem-"brane, richly supplied with blood-vessels," and the fœtus is nourished for a time. In certain cases of hydrocephalus the open and dangerous spaces in the skull are filled up with new bones, which interlock by perfect serrated sutures.[8] But most physiologists, especially on the Continent, have now given up the belief in plastic lymph or blastema, and Virchow[9] maintains that every structure, new or old, is formed by the proliferation of pre-existing cells. On this view false membranes, like cancerous or other tumours, are merely abnormal developments of normal growths; and we can thus understand how it is that they resemble adjoining structures; for instance, that a "false membrane in the serous "cavities acquires a covering of epithelium exactly like that which "covers the original serous membrane; adhesions of the iris may "become black apparently from the production of pigment-cells like "those of the uvea."[10]

No doubt the power of reparation, though not always perfect, is an admirable provision, ready for various emergencies, even for such as occur only at long intervals of time.[11] Yet this power is not more wonderful than the growth and development of every single creature, more especially of those which are propagated by fissiparous generation. This subject has been here noticed, because we may infer that, when any part or organ is either greatly increased in size or wholly suppressed through variation and continued selection, the co-ordinating power of the organisation will continually tend to bring again all the parts into harmony with one another.

On the Effects of the Increased Use and Disuse of Organs.

It is notorious, and we shall immediately adduce proofs, that increased use or action strengthens muscles, glands, sense-organs, &c.; and that disuse, on the other hand, weakens them. It has been experimentally proved by Ranke[12] that the flow of blood is greatly increased towards any part which is performing work, and sinks again when the part is at rest. Consequently, if the work is frequent, the vessels increase in size and the part is better nourished. Paget[13] also accounts for the long, thick, dark-coloured hairs which occasionally

[8] These cases are given by Blumenbach in his 'Essay on Generation,' pp. 52, 54.

[9] 'Cellular Pathology,' trans. by Dr. Chance, 1860, pp. 27, 441.

[10] Paget, 'Lectures on Pathology,' vol. i., 1853, p. 357.

[11] Paget, ibid., p. 150.

[12] 'Die Blutvertheilung, &c. der Organe,' 1871, as quoted by Jaeger, 'In Sachen Darwin's,' 1874, p. 48. *See* also H. Spencer, 'The Principles of Biology,' vol. ii. 1866, chap. 3–5.

[13] 'Lectures on Pathology,' 1853, vol. i. p. 71.

grow, even in young children, near old-standing inflamed surfaces or fractured bones by an increased flow of blood to the part. When Hunter inserted the spur of a cock into the comb, which is well supplied with blood-vessels, it grew in one case spirally to a length of six inches, and in another case forward, like a horn, so that the bird could not touch the ground with its beak. According to the interesting observations of M. Sedillot,[14] when a portion of one of the bones of the leg of an animal is removed, the associated bone enlarges till it attains a bulk equal to that of the two bones, of which it has to perform the functions. This is best exhibited in dogs in which the tibia has been removed; the companion bone, which is naturally almost filiform and not one-fifth the size of the other, soon acquires a size equal to or greater than that of the tibia. Now, it is at first difficult to believe that increased weight acting on a straight bone could, by alternately increasing and diminishing the pressure, cause the blood to flow more freely in the vessels which permeate the periosteum and thus supply more nutriment to the bone. Nevertheless the observations adduced by Mr. Spencer,[15] on the strengthening of the bowed bones of rickety children, along their concave sides, leads to the belief that this is possible.

The rocking of the stem of a tree increases in a marked manner the growth of the woody tissue in the parts which are strained. Prof. Sachs believes, from reasons which he assigns, that this is due to the pressure of the bark being relaxed in such parts, and not as Knight and H. Spencer maintain, to an increased flow of sap caused by the movement of the trunk.[16] But hard woody tissue may be developed without the aid of any movement, as we see with ivy closely attached to an old wall. In all such cases, it is very difficult to distinguish between the effects of long-continued selection and those which follow from the increased action of the part, or directly from some other cause. Mr. H. Spencer[17] acknowledges this difficulty, and gives as an instance the thorns on trees

[14] 'Comptes Rendus,' Sept. 26th, 1864, p. 539.

[15] H. Spencer, 'The Principles of Biology,' vol. ii. p. 243.

[16] Ibid., vol. ii. p. 269. Sachs, 'Text-book of Botany,' 1875, p. 734.

[17] Ibid., vol. ii. p. 273.

and the shells of nuts. Here we have extremely hard woody tissue without the possibility of any movement, and without, as far as we can see, any other directly exciting cause; and as the hardness of these parts is of manifest service to the plant, we may look at the result as probably due to the selection of so-called spontaneous variations. Every one knows that hard work thickens the epidermis on the hands; and when we hear that with infants, long before birth, the epidermis is thicker on the palms and soles of the feet than on any other part of the body, as was observed with admiration by Albinus,[18] we are naturally inclined to attribute this to the inherited effects of long-continued use or pressure. We are tempted to extend the same view even to the hoofs of quadrupeds; but who will pretend to determine how far natural selection may have aided in the formation of structures of such obvious importance to the animal?

That use strengthens the muscles may be seen in the limbs of artisans who follow different trades; and when a muscle is strengthened, the tendons, and the crests of bone to which they are attached, become enlarged; and this must likewise be the case with the blood-vessels and nerves. On the other hand, when a limb is not used, as by Eastern fanatics, or when the nerve supplying it with nervous power is effectually destroyed, the muscles wither. So again, when the eye is destroyed the optic nerve becomes atrophied, sometimes even in the course of a few months.[19] The Proteus is furnished with branchiæ as well as with lungs: and Schreibers[20] found that when the animal was compelled to live in deep water, the branchiæ were developed to thrice their ordinary size, and the lungs were partially atrophied. When, on the other hand, the animal was compelled to live in shallow water, the lungs became larger and more vascular, whilst the branchiæ disappeared in a more or less complete degree. Such modifications as these are, however, of comparatively little value for us, as we do not actually know that they tend to be inherited.

In many cases there is reason to believe that the lessened use of various organs has affected the corresponding parts in the offspring. But there is no good evidence that this ever follows in the course of a single generation. It appears, as in the case of general or in-

[18] Paget, 'Lectures on Pathology,' vol. ii. p. 209.

[19] Müller's 'Phys.,' Eng. translat., pp. 54, 791. Prof. Reed has given ('Physiological and Anat. Researches,' p. 10) a curious account of the atrophy of the limbs of rabbits after the destruction of the nerve.

[20] Quoted by Lecoq, in 'Géograph. Bot.,' tom. i., 1854, p. 182.

definite variability, that several generations must be subjected to changed habits for any appreciable result. Our domestic fowls, ducks, and geese have almost lost, not only in the individual but in the race, their power of flight; for we do not see a young fowl, when frightened, take flight like a young pheasant. Hence I was led carefully to compare the limb-bones of fowls, ducks, pigeons, and rabbits, with the same bones in the wild parent-species. As the measurements and weights were fully given in the earlier chapters I need here only recapitulate the results. With domestic pigeons, the length of the sternum, the prominence of its crest, the length of the scapulæ and furculum, the length of the wings as measured from tip to tip of the radii, are all reduced relatively to the same parts in the wild pigeon. The wing and tail feathers, however, are increased in length, but this may have as little connection with the use of the wings or tail, as the lengthened hair on a dog with the amount of exercise which it has habitually taken. The feet of pigeons, except in the long-beaked races, are reduced in size. With fowls the crest of the sternum is less prominent, and is often distorted or monstrous; the wing-bones have become lighter relatively to the leg-bones, and are apparently a little shorter in comparison with those of the parent-form, the *Gallus bankiva*. With ducks, the crest of the sternum is affected in the same manner as in the foregoing cases: the furculum, coracoids, and scapulæ are all reduced in weight relatively to the whole skeleton: the bones of the wings are shorter and lighter, and the bones of the legs longer and heavier, relatively to each other, and relatively to the whole skeleton, in comparison with the same bones in the wild-duck. The decreased weight and size of the bones, in the foregoing cases, is probably the indirect result of the reaction of the weakened muscles on the bones. I failed to compare the feathers of the wings of the tame and wild duck; but Gloger[21] asserts that in the wild duck the tips of the wing-feathers reach almost to the end of the tail, whilst in the domestic duck they often hardly reach to its base. He remarks also on the greater thickness of the legs, and says that the swimming membrane between the toes is reduced; but I was not able to detect this latter difference.

With the domesticated rabbit the body, together with the whole skeleton, is generally larger and heavier than in the wild animal, and the leg-bones are heavier in due proportion; but whatever standard of comparison be taken, neither the leg-bones nor the scapulæ have increased in length proportionally with the increased dimensions of the rest of the skeleton. The skull has become in a marked manner narrower, and, from the measurements of its capacity formerly given, we may conclude, that this narrowness results from the decreased size of the brain, consequent on the mentally inactive life led by these closely-confined animals.

We have seen in the eighth chapter that silk-moths, which have

[21] 'Das Abändern der Vögel,' 1833, s. 74.

been kept during many centuries closely confined, emerge from their cocoons with their wings distorted, incapable of flight, often greatly reduced in size, or even, according to Quatrefages, quite rudimentary. This condition of the wings may be largely owing to the same kind of monstrosity which often affects wild Lepidoptera when artificially reared from the cocoon; or it may be in part due to an inherent tendency, which is common to the females of many Bombycidæ, to have their wings in a more or less rudimentary state; but part of the effect may be attributed to long-continued disuse.

From the foregoing facts there can be no doubt that with our anciently domesticated animals, certain bones have increased or decreased in size and weight owing to increased or decreased use; but they have not been modified, as shown in the earlier chapters, in shape or structure. With animals living a free life and occasionally exposed to severe competition the reduction would tend to be greater, as it would be an advantage to them to have the development of every superfluous part saved. With highly-fed domesticated animals, on the other hand, there seems to be no economy of growth, nor any tendency to the elimination of superfluous details. But to this subject I shall recur.

Turning now to more general observations, Nathusius has shown that with the improved races of the pig, the shortened legs and snout, the form of the articular condyles of the occiput, and the position of the jaws with the upper canine teeth projecting in a most anomalous manner in front of the lower canines, may be attributed to these parts not having been fully exercised. For the highly-cultivated races do not travel in search of food, nor root up the ground with their ringed muzzles.[22] These modifications of structure, which are all strictly inherited, characterise several improved breeds, so that they cannot have been derived from any single domestic stock. With respect to cattle, Professor Tanner has remarked that the lungs and liver in the improved breeds "are found to be considerably reduced in size when compared "with those possessed by animals having perfect liberty;"[23]

[22] Nathusius, 'Die Racen des Schweines,' 1860, s. 53, 57; 'Vorstudien .... Schweineschädel,' 1864, s. 103, 130, 133. Prof. Lucae supports and extends the conclusions of Von Nathusius: 'Der Schädel des Maskenschweines,' 1870.

[23] 'Journal of Agriculture of Highland Soc.,' July, 1860, p. 321.

and the reduction of these organs affects the general shape of the body. The cause of the reduced lungs in highly-bred animals which take little exercise is obvious; and perhaps the liver may be affected by the nutritious and artificial food on which they largely subsist. Again, Dr. Wilckens asserts [24] that various parts of the body certainly differ in Alpine and lowland breeds of several domesticated animals, owing to their different habits of life; for instance, the neck and fore-legs in length, and the hoofs in shape.

It is well known that, when an artery is tied, the anastomosing branches, from being forced to transmit more blood, increase in diameter; and this increase cannot be accounted for by mere extension, as their coats gain in strength. With respect to glands, Sir J. Paget observes that "when one kidney is destroyed the other "often becomes much larger, and does double work." [25] If we compare the size of the udders and their power of secretion in cows which have been long domesticated, and in certain breeds of the goat in which the udders nearly touch the ground, with these organs in wild or half-domesticated animals, the difference is great. A good cow with us daily yields more than five gallons, or forty pints of milk, whilst a first-rate animal, kept, for instance, by the Damaras of South Africa,[26] "rarely gives more than two or three pints of milk "daily, and, should her calf be taken from her, she absolutely "refuses to give any." We may attribute the excellence of our cows and of certain goats, partly to the continued selection of the best milking animals, and partly to the inherited effects of the increased action, through man's art, of the secreting glands.

It is notorious that short-sight is inherited; and we have seen in the twelfth chapter from the statistical researches of M. Giraud-Teulon, that the habit of viewing near objects gives a tendency to short-sight. Veterinarians are unanimous that horses are affected with spavins, splints, ringbones, &c., from being shod and from travelling on hard roads, and they are almost equally unanimous that a tendency to these malformations is transmitted. Formerly horses were not shod in North Carolina, and it has been asserted that they did not then suffer from these diseases of the legs and feet.[27]

Our domesticated quadrupeds are all descended, as far as is known, from species having erect ears; yet few kinds can be named, of which at least one race has not drooping ears.

[24] 'Landwirth. Wochenblatt,' No. 10.

[25] 'Lectures on Surgical Pathology,' 1853, vol. i. p. 27.

[26] Andersson, 'Travels in South Africa,' p. 318. For analogous cases in South America, *see* Aug. St.-Hilaire, 'Voyage dans la Province de Goyaz,' tom. i. p. 71.

[27] Brickell's 'Nat. Hist. of North Carolina,' 1739, p. 53.

Cats in China, horses in parts of Russia, sheep in Italy and elsewhere, the guinea-pig formerly in Germany, goats and cattle in India, rabbits, pigs, and dogs in all long-civilised countries have dependent ears. With wild animals, which constantly use their ears like funnels to catch every passing sound, and especially to ascertain the direction whence it comes, there is not, as Mr. Blyth has remarked, any species with drooping ears except the elephant. Hence the incapacity to erect the ears is certainly in some manner the result of domestication; and this incapacity has been attributed by various authors [28] to disuse, for animals protected by man are not compelled habitually to use their ears. Col. Hamilton Smith[29] states that in ancient effigies of the dog, "with the exception of one "Egyptian instance, no sculpture of the earlier Grecian era "produces representations of hounds with completely drooping "ears; those with them half pendulous are missing in the "most ancient; and this character increases, by degrees, in "the works of the Roman period." Godron also has remarked "that the pigs of the ancient Egyptians had not their ears "enlarged and pendent."[30] But it is remarkable that the drooping of the ear is not accompanied by any decrease in size; on the contrary, animals so different as fancy rabbits, certain Indian breeds of the goat, our petted spaniels, bloodhounds, and other dogs, have enormously elongated ears, so that it would appear as if their weight had caused them to droop, aided perhaps by disuse. With rabbits, the drooping of the much elongated ears has affected even the structure of the skull.

The tail of no wild animal, as remarked to me by Mr. Blyth, is curled; whereas pigs and some races of dogs have their tails much curled. This deformity, therefore, appears to be the result of domestication, but whether in any way connected with the lessened use of the tail is doubtful.

[28] Livingstone, quoted by Youatt on Sheep, p. 142. Hodgson, in 'Journal of Asiatic Soc. of Bengal,' vol. xvi., 1847, p. 1006, &c. &c. On the other hand, Dr. Wilckens argues strongly against the belief that the drooping of the ears is the result of disuse: 'Jahrbuch der deutschen Viehzucht,' 1866.

[29] 'Naturalist's Library,' Dogs, vol. ii., 1840, p. 104.

[30] 'De l'Espèce,' tom. i., 1859, p. 367.

The epidermis on our hands is easily thickened, as every one knows, by hard work. In a district of Ceylon the sheep have "horny callosities that defend their knees, and which "arise from their habit of kneeling down to crop the short "herbage, and this distinguishes the Jaffna flocks from those "of other portions of the island;" but it is not stated whether this peculiarity is inherited.[31]

The mucous membrane which lines the stomach is continuous with the external skin of the body; therefore it is not surprising that its texture should be affected by the nature of the food consumed, but other and more interesting changes likewise follow. Hunter long ago observed that the muscular coat of the stomach of a gull (*Larus tridactylus*) which had been fed for a year chiefly on grain was thickened; and, according to Dr. Edmondston, a similar change periodically occurs in the Shetland Islands in the stomach of the *Larus argentatus*, which in the spring frequents the cornfields and feeds on the seed. The same careful observer has noticed a great change in the stomach of a raven which had been long fed on vegetable food. In the case of an owl (*Strix grallaria*), similarly treated, Menetries states that the form of the stomach was changed, the inner coat became leathery, and the liver increased in size. Whether these modifications in the digestive organs would in the course of generations become inherited is not known.[32]

The increased or diminished length of the intestines, which apparently results from changed diet, is a more remarkable case, because it is characteristic of certain animals in their domesticated condition, and therefore must be inherited. The complex absorbent system, the blood-vessels, nerves, and muscles, are necessarily all modified together with the intestines. According to Daubenton, the intestines of the domestic cat are one-third longer than those of the wild cat of Europe; and although this species is not the parent-stock of the domestic animal, yet, as Isidore Geoffroy has remarked,

[31] 'Ceylon,' by Sir J. E. Tennent, 1859, vol. ii. p. 531.

[32] For the foregoing statements, *see* Hunter's 'Essays and Observations,' 1861, vol. ii. p. 329; Dr. Edmondston, as quoted in Macgillivray's 'British Birds,' vol. v. p. 550: Menetries, as quoted in Bronn's 'Geschichte der Natur,' B. ii. s. 110.

the several species of cats are so closely allied that the comparison is probably a fair one. The increased length appears to be due to the domestic cat being less strictly carnivorous in its diet than any wild feline species; for instance, I have seen a French kitten eating vegetables as readily as meat. According to Cuvier, the intestines of the domesticated pig exceed greatly in proportionate length those of the wild boar. In the tame and wild rabbit the change is of an opposite nature, and probably results from the nutritious food given to the tame rabbit.[33]

Changed and inherited Habits of Life.—This subject, as far as the mental powers of animals are concerned, so blends into instinct, that I will here only remind the reader of such cases as the tameness of our domesticated animals—the pointing or retrieving of dogs—their not attacking the smaller animals kept by man—and so forth. How much of these changes ought to be attributed to mere habit, and how much to the selection of individuals which have varied in the desired manner, irrespectively of the special circumstances under which they have been kept, can seldom be told.

We have already seen that animals may be habituated to a changed diet; but some additional instances may be given. In the Polynesian Islands and in China the dog is fed exclusively on vegetable matter, and the taste for this kind of food is to a certain extent inherited.[34] Our sporting dogs will not touch the bones of game birds, whilst most other dogs devour them with greediness. In some parts of the world sheep have been largely fed on fish. The domestic hog is fond of barley, the wild boar is said to disdain it; and the disdain is partially inherited, for some young wild pigs bred in captivity showed an aversion for this grain, whilst others of the same brood relished it.[35] One of my relations bred some young pigs from a Chinese sow by a wild Alpine boar; they lived free in the park, and were so tame that they came to the house to

[33] These statements on the intestines are taken from Isidore Geoffroy Saint-Hilaire, 'Hist. Nat. Gén.,' tom. iii. pp. 427, 441.

[34] Gilbert White 'Nat. Hist. Selborne,' 1825, vol. ii. p. 121.

[35] Burdach, 'Traité de Phys.,' tom. ii. p. 267, as quoted by Dr. P. Lucas, 'L'Héréd. Nat.,' tom. i. p. 388.

be fed; but they would not touch swill, which was devoured by the other pigs. An animal when once accustomed to an unnatural diet, which can generally be effected only during youth, dislikes its proper food, as Spallanzani found to be the case with a pigeon which had been long fed on meat. Individuals of the same species take to new food with different degrees of readiness; one horse, it is stated, soon learned to eat meat, whilst another would have perished from hunger rather than have partaken of it.[36] The caterpillars of the *Bombyx hesperus* feed in a state of nature on the leaves of the *Café diable*, but, after having been reared on the Ailanthus, they would not touch the *Café diable*, and actually died of hunger.[37]

It has been found possible to accustom marine fish to live in fresh water; but as such changes in fish and other marine animals have been chiefly observed in a state of nature, they do not properly belong to our present subject. The period of gestation and of maturity, as shown in the earlier chapters, —the season and the frequency of the act of breeding,—have all been greatly modified under domestication. With the Egyptian goose the rate of change with respect to the season has been recorded.[38] The wild drake pairs with one female, the domestic drake is polygamous. Certain breeds of fowls have lost the habit of incubation. The paces of the horse, and the manner of flight of certain breeds of the pigeon, have been modified and are inherited. Cattle, horses, and pigs have learnt to browse under water in the St. John's River, East Florida, where the Vallisneria has been largely naturalised. The cows were observed by Prof. Wyman to keep their heads immersed for "a period varying from fifteen to thirty-five seconds."[39] The voice differs much in certain kinds of fowls and pigeons. Some varieties are clamorous and others silent, as the Call and common duck, or the Spitz and pointer dog. Every one knows how the breeds of the dog differ from

[36] This and several other cases are given by Colin, 'Physiologie Comp. des Animaux Dom.,' 1854, tom. i. p. 426.

[37] M. Michely de Cayenne, in 'Bull. Soc. d'Acclimat.,' tom. viii., 1861, p. 563.

[38] Quatrefages, 'Unité de l'Espèce Humaine,' 1861, p. 79.

[39] 'The American Naturalist,' Ap. 1874, p. 237.

one another in their manner of hunting, and in their ardour after different kinds of game or vermin.

With plants the period of vegetation is easily changed and is inherited, as in the case of summer and winter wheat, barley, and vetches; but to this subject we shall immediately return under acclimatisation. Annual plants sometimes become perennial under a new climate, as I hear from Dr. Hooker is the case with the stock and mignonette in Tasmania. On the other hand, perennials sometimes become annuals, as with the Ricinus in England, and as, according to Captain Mangles, with many varieties of the heartsease. Von Berg [40] raised from seed of *Verbascum phœniceum*, which is usually a biennial, both annual and perennial varieties. Some deciduous bushes become evergreen in hot countries.[41] Rice requires much water, but there is one variety in India which can be grown without irrigation.[42] Certain varieties of the oat and of our other cereals are best fitted for certain soils.[43] Endless similar facts could be given in the animal and vegetable kingdoms. They are noticed here because they illustrate analogous differences in closely allied natural species, and because such changed habits of life, whether due to habit, or to the direct action of external conditions, or to so-called spontaneous variability, would be apt to lead to modifications of structure.

Acclimatisation. — From the previous remarks we are naturally led to the much disputed subject of acclimatisation. There are two distinct questions: Do varieties descended from the same species differ in their power of living under different climates? And secondly, if they so differ, how have they become thus adapted? We have seen that European dogs do not succeed well in India, and it is asserted,[44] that no one has there succeeded in keeping the Newfoundland long alive; but then it may be argued, and probably with truth, that these

[40] 'Flora,' 1835, B. ii. p. 504.

[41] Alph. de Candolle, 'Géograph. Bot.,' tom. ii. p. 1078.

[42] Royle, 'Illustrations of the Botany of the Himalaya,' p. 19.

[43] 'Gardener's Chronicle,' 1850, pp. 204, 219.

[44] Rev. R. Everest, 'Journal As. Soc. of Bengal,' vol. iii. p. 19.

northern breeds are specifically distinct from the native dogs which flourish in India. The same remark may be made with respect to different breeds of sheep, of which, according to Youatt,[45] not one brought "from a torrid climate lasts out "the second year," in the Zoological Gardens. But sheep are capable of some degree of acclimatisation, for Merino sheep bred at the Cape of Good Hope have been found far better adapted for India than those imported from England.[46] It is almost certain that all the breeds of the fowl are descended from one species; but the Spanish breed, which there is good reason to believe originated near the Mediterranean,[47] though so fine and vigorous in England, suffers more from frost than any other breed. The Arrindy silk moth introduced from Bengal, and the Ailanthus moth from the temperate province of Shan Tung, in China, belong to the same species, as we may infer from their identity in the caterpillar, cocoon, and mature states;[48] yet they differ much in constitution: the Indian form "will flourish only in warm latitudes," the other is quite hardy and withstands cold and rain.

Plants are more strictly adapted to climate than are animals. The latter when domesticated withstand such great diversities of climate, that we find nearly the same species in tropical and temperate countries; whilst the cultivated plants are widely dissimilar. Hence a larger field is open for inquiry in regard to the acclimatisation of plants than of animals. It is no exaggeration to say that with almost every plant which has long been cultivated, varieties exist which are endowed with constitutions fitted for very different climates; I will select only a few of the more striking cases, as it would be tedious to give all. In North America numerous fruit-trees have been raised, and in horticultural publications,—for instance, in that by Downing,—lists are given of the varieties which are best able to withstand the severe climate of the northern States and Canada. Many American varieties of the pear, plum, and peach are excellent in their own country, but until recently, hardly one was known that succeeded in England; and with apples,[49] not one succeeds. Though the American varieties can withstand a severer winter than ours, the

[45] Youatt on Sheep, 1838, p. 491.

[46] Royle, 'Prod. Resources of India,' p. 153.

[47] Tegetmeier, 'Poultry Book,' 1866, p. 102.

[48] Dr. R. Paterson, in a paper communicated to Bot. Soc. of Canada, quoted in the 'Reader,' 1863, Nov. 13th.

[49] *See* remarks by Editor in 'Gard. Chronicle,' 1848, p. 5.

summer here is not hot enough. Fruit-trees have also originated in Europe with different constitutions, but they are not much noticed, because nurserymen here do not supply wide areas. The Forelle pear flowers early, and when the flowers have just set, and this is the critical period, they have been observed, both in France and England, to withstand with complete impunity a frost of 18° and even 14° Fahr., which killed the flowers, whether fully expanded or in bud, of all other kinds of pears.[50] This power in the flower of resisting cold and afterwards producing fruit does not invariably depend, as we know on good authority,[51] on general constitutional vigour. In proceeding northward, the number of varieties which are found capable of resisting the climate rapidly decreases, as may be seen in the list of the varieties of the cherry, apple, and pear, which can be cultivated in the neighbourhood of Stockholm.[52] Near Moscow, Prince Troubetzkoy planted for experiment in the open ground several varieties of the pear, but one alone, the *Poire sans Pepins*, withstood the cold of winter.[53] We thus see that our fruit-trees, like distinct species of the same genus, certainly differ from each other in their constitutional adaptation to different climates.

With the varieties of many plants, the adaptation to climate is often very close. Thus it has been proved by repeated trials "that "few if any of the English varieties of wheat are adapted for culti- "vation in Scotland;"[54] but the failure in this case is at first only in the quantity, though ultimately in the quality, of the grain produced. The Rev. M. J. Berkeley sowed wheat-seed from India, and got "the most meagre ears," on land which would certainly have yielded a good crop from English wheat.[55] In these cases varieties have been carried from a warmer to a cooler climate; in the reverse case, as "when wheat was imported directly from France "into the West Indian Islands, it produced either wholly barren "spikes or furnished with only two or three miserable seeds, while "West Indian seed by its side yielded an enormous harvest."[56] Here is another case of close adaptation to a slightly cooler climate; a kind of wheat which in England may be used indifferently either as a winter or summer variety, when sown under the warmer climate of Grignan, in France, behaved exactly as if it had been a true winter wheat.[57]

Botanists believe that all the varieties of maize belong to the same species; and we have seen that in North America, in proceeding northward, the varieties cultivated in each zone produce their

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[50] 'Gard. Chronicle,' 1860, p. 938. Remarks by Editor and quotation from Decaisne.

[51] J. de Jonghe, of Brussels, in 'Gard. Chronicle,' 1857, p. 612.

[52] Ch. Martius, 'Voyage Bot. Côtes Sept. de la Norvège,' p. 26.

[53] 'Journal de l'Acad. Hort. de Gand,' quoted in 'Gard. Chron.,' 1859, p. 7.

[54] 'Gard. Chronicle,' 1851, p. 396.

[55] Ibid., 1862, p. 235.

[56] On the authority of Labat, quoted in 'Gard. Chron.,' 1862, p. 235.

[57] MM. Edwards and Colin, 'Annal. des Sc. Nat.,' 2nd series, Bot., tom. v. p. 22.

flowers and ripen their seed within shorter and shorter periods. So that the tall, slowly maturing southern varieties do not succeed in New England, and the New English varieties do not succeed in Canada. I have not met with any statement that the southern varieties are actually injured or killed by a degree of cold which the northern varieties can withstand with impunity, though this is probable; but the production of early flowering and early seeding varieties deserves to be considered as one form of acclimatisation. Hence it has been found possible, according to Kalm, to cultivate maize further and further northwards in America. In Europe, also, as we learn from the evidence given by Alph. de Candolle, the culture of maize has extended since the end of the last century thirty leagues north of its former boundary.[58] On the authority of Linnæus,[59] I may quote an analogous case, namely, that in Sweden tobacco raised from home-grown seed ripens its seed a month sooner and is less liable to miscarry than plants raised from foreign seed.

With the Vine, differently from the maize, the line of practical culture has retreated a little southward since the middle ages;[60] but this seems due to commerce being now easier, so that it is better to import wine from the south than to make it in northern districts. Nevertheless the fact of the vine not having spread northward shows that acclimatisation has made no progress during several centuries. There is, however, a marked difference in the constitution of the several varieties,—some being hardy, whilst others, like the muscat of Alexandria, require a very high temperature to come to perfection. According to Labat,[61] vines taken from France to the West Indies succeed with extreme difficulty, whilst those imported from Madeira or the Canary Islands thrive admirably.

Gallesio gives a curious account of the naturalisation of the Orange in Italy. During many centuries the sweet orange was propagated exclusively by grafts, and so often suffered from frosts, that it required protection. After the severe frost of 1709, and more especially after that of 1763, so many trees were destroyed, that seedlings from the sweet orange were raised, and, to the surprise of the inhabitants, their fruit was found to be sweet. The trees thus raised were larger, more productive, and hardier than the old kinds; and seedlings are now continually raised. Hence Gallesio concludes that much more was effected for the naturalisation of the orange in Italy by the accidental production of new kinds during a period of about sixty years, than had been effected by grafting old varieties during many ages.[62] I may add that Risso[63] describes some Portuguese varieties

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[58] 'Géograph. Bot.,' p. 337.

[59] 'Swedish Acts,' Eng. translat., 1739–40, vol. i. Kalm, in his 'Travels,' vol. ii. p. 166, gives an analogous case with cotton-plants raised in New Jersey from Carolina seed.

[60] De Candolle, 'Géograph. Bot.,' p. 339.

[61] 'Gard. Chronicle,' 1862, p. 235.

[62] Gallesio, 'Teoria della Riproduzione Veg.,' 1816, p. 125; and 'Traité du Citrus,' 1811, p. 359.

[63] 'Essai sur l'Hist. des Orangers,' 1813, p. 20, &c.

of the orange as extremely sensitive to cold, and as much tenderer than certain other varieties.

The peach was known to Theophrastus, 322 B.C.[64] According to the authorities quoted by Dr. F. Rolle,[65] it was tender when first introduced into Greece, and even in the island of Rhodes only occasionally bore fruit. If this be correct, the peach, in spreading during the last two thousand years over the middle parts of Europe, must have become much hardier. At the present day different varieties differ much in hardiness: some French varieties will not succeed in England; and near Paris, the *Pavie de Bonneuil* does not ripen its fruit till very late in the season, even when grown on a wall; "it is, therefore, only fit for a very hot southern climate."[66]

I will briefly give a few other cases. A variety of *Magnolia grandiflora*, raised by M. Roy, withstands a temperature several degrees lower than that which any other variety can resist. With camellias there is much difference in hardiness. One particular variety of the Noisette rose withstood the severe frost of 1860 " un- " touched and hale amidst a universal destruction of other Noisettes." In New York the "Irish yew is quite hardy, but the common yew " is liable to be cut down." I may add that there are varieties of the sweet potato (*Convolvulus batatas*) which are suited for warmer, as well as for colder, climates.[67]

The plants as yet mentioned have been found capable of resisting an unusual degree of cold or heat, when fully grown. The following cases refer to plants whilst young. In a large bed of young Araucarias of the same age, growing close together and equally exposed, it was observed,[68] after the unusually severe winter of 1860–61, that, "in the midst of " the dying, numerous individuals remained on which the " frost had absolutely made no kind of impression." Dr. Lindley, after alluding to this and other similar cases, remarks, "Among the lessons which the late formidable " winter has taught us, is that, even in their power of " resisting cold, individuals of the same species of plants are " remarkably different." Near Salisbury, there was a sharp frost on the night of May 24th, 1836, and all the French

[64] Alph. de Candolle, 'Géograph. Bot.,' p. 882.

[65] 'Ch. Darwin's Lehre von der Entstehung,' &c., 1862, s. 87.

[66] Decaisne, quoted in 'Gard. Chronicle,' 1865, p. 271.

[67] For the magnolia, *see* Loudon's 'Gard. Mag.,' vol. xiii., 1837, p. 21. For camellias and roses, *see* 'Gard. Chron.,' 1860, p. 384. For the yew, 'Journal of Hort.,' March 3rd, 1863, p 174. For sweet potatoes, *see* Col. von Siebold, in 'Gard. Chron.,' 1855, p. 822.

[68] The Editor, 'Gard. Chron.,' 1861, p. 239.

beans (*Phaseolus vulgaris*) in a bed were killed except about one in thirty, which completely escaped.[69] On the same day of the month, but in the year 1864, there was a severe frost in Kent, and two rows of scarlet-runners (*P. multiflorus*) in my garden, containing 390 plants of the same age and equally exposed, were all blackened and killed except about a dozen plants. In an adjoining row of "Fulmer's dwarf bean" (*P. vulgaris*), one single plant escaped. A still more severe frost occurred four days afterwards, and of the dozen plants which had previously escaped only three survived; these were not taller or more vigorous than the other young plants, but they escaped completely, with not even the tips of their leaves browned. It was impossible to behold these three plants, with their blackened, withered, and dead brethren all around, and not see at a glance that they differed widely in constitutional power of resisting frost.

This work is not the proper place to show that wild plants of the same species, naturally growing at different altitudes or under different latitudes, become to a certain extent acclimatised, as is proved by the different behaviour of their seedlings when raised in another country. In my 'Origin of Species' I have alluded to some cases, and I could add many others. One instance must suffice: Mr. Grigor, of Forres,[70] states that seedlings of the Scotch fir (*Pinus sylvestris*), raised from seed from the Continent and from the forests of Scotland, differ much. "The difference is perceptible in one-year-old, "and more so in two-year-old seedlings; but the effects of "the winter on the second year's growth almost uniformly "make those from the Continent quite brown, and so damaged, "that by the month of March they are quite unsaleable, "while the plants from the native Scotch pine, under the "same treatment, and standing alongside, although consider-"ably shorter, are rather stouter and quite green, so that the

[69] Loudon's 'Gard. Mag.,' vol. xii., 1836, p. 378.

[70] 'Gardener's Chron.,' 1865, p. 699. Mr. G. Maw gives ('Gard. Chron.' 1870, p. 895) a number of striking cases; he brought home from southern Spain and northern Africa several plants, which he cultivated in England alongside specimens from northern districts; and he found a great difference not only in their hardiness during the winter, but in the behaviour of some of them during the summer.

"beds of the one can be known from the other when seen "from the distance of a mile." Closely similar facts have been observed with seedling larches.

Hardy varieties would alone be valued or noticed in Europe; whilst tender varieties, requiring more warmth, would generally be neglected; but such occasionally arise. Thus Loudon[71] describes a Cornish variety of the elm which is almost an evergreen, and of which the shoots are often killed by the autumnal frosts, so that its timber is of little value. Horticulturists know that some varieties are much more tender than others: thus all the varieties of the broccoli are more tender than cabbages; but there is much difference in this respect in the sub-varieties of the broccoli; the pink and purple kinds are a little hardier than the white Cape broccoli, "but "they are not to be depended on after the thermometer falls below "24° Fahr.;" the Walcheren broccoli is less tender than the Cape, and there are several varieties which will stand much severer cold than the Walcheren.[72] Cauliflowers seed more freely in India than cabbages.[73] To give one instance with flowers: eleven plants raised from a hollyhock, called the *Queen of the Whites*,[74] were found to be much more tender than various other seedlings. It may be presumed that all tender varieties would succeed better under a climate warmer than ours. With fruit-trees, it is well known that certain varieties, for instance of the peach, stand forcing in a hot-house better than others; and this shows either pliability of organisation or some constitutional difference. The same individual cherry-tree, when forced, has been observed during successive years gradually to change its period of vegetation.[75] Few pelargoniums can resist the heat of a stove, but *Alba Multiflora* will, as a most skilful gardener asserts, "stand pine-apple top and bottom heat the whole winter; "without looking any more drawn than if it had stood in a common "greenhouse; and *Blanche Fleur* seems as if it had been made on "purpose for growing in winter, like many bulbs, and to rest all "summer."[76] There can hardly be a doubt that the *Alba Multiflora* pelargonium must have a widely different constitution from that of most other varieties of this plant; it would probably withstand even an equatorial climate.

We have seen that according to Labat the vine and wheat require acclimatisation in order to succeed in the West Indies. Similar facts have been observed at Madras: "two parcels of mignonette-

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[71] 'Arboretum et Fruticetum,' vol. iii. p. 1376.

[72] Mr. Robson, in 'Journal of Horticulture,' 1861, p. 23.

[73] Dr. Bonavia, 'Report of the Agri.-Hort. Soc. of Oudh,' 1866.

[74] 'Cottage Gardener,' 1860, April 24th, p. 57.

[75] 'Gardener's Chronicle,' 1841, p. 291.

[76] Mr. Beaton, in 'Cottage Gardener,' March 20th, 1860, p. 377. Queen Mab will also stand stove heat. *See* 'Gardener's Chronicle,' 1845, p. 226.

"seed, one direct from Europe, the other saved at Bangalore (of "which the mean temperature is much below that of Madras), were "sown at the same time: they both vegetated equally favourably, "but the former all died off a few days after they appeared above "ground; the latter still survive, and are vigorous, healthy plants." "So again, turnip and carrot seed saved at Hyderabad are found to "answer better at Madras than seed from Europe or from the Cape "of Good Hope."[77] Mr. J. Scott of the Calcutta Botanic Gardens, informs me that seeds of the sweet-pea (*Lathyrus odoratus*) imported from England produce plants, with thick, rigid stems and small leaves, which rarely blossom and never yield seed; plants raised from French seed blossom sparingly, but all the flowers are sterile; on the other hand, plants raised from sweet-peas grown near Darjeeling in Upper India, but originally derived from England, can be successfully cultivated on the plains of India; for they flower and seed profusely, and their stems are lax and scandent. In some of the foregoing cases, as Dr. Hooker has remarked to me, the greater success may perhaps be attributed to the seeds having been more fully ripened under a more favourable climate; but this view can hardly be extended to so many cases, including plants, which, from being cultivated under a climate hotter than their native one, become fitted for a still hotter climate. We may therefore safely conclude that plants can to a certain extent become accustomed to a climate either hotter or colder than their own; although the latter cases have been more frequently observed.

We will now consider the means by which acclimatisation may be effected, namely, through the appearance of varieties having a different constitution, and through the effects of habit. In regard to new varieties, there is no evidence that a change in the constitution of the offspring necessarily stands in any direct relation with the nature of the climate inhabited by the parents. On the contrary, it is certain that hardy and tender varieties of the same species appear in the same country. New varieties thus spontaneously arising become fitted to slightly different climates in two different ways; firstly, they may have the power, either as seedlings or when full-grown, of resisting intense cold, as with the Moscow pear, or of resisting intense heat, as with some kinds of Pelargonium, or the flowers may withstand severe frost, as with the Forelle pear. Secondly, plants may become adapted to climates widely different from their own, from flowering and fruiting either earlier or later in the season. In both

[77] 'Gardener's Chronicle,' 1841, p. 439.

these cases the power of acclimatisation by man consists simply in the selection and preservation of new varieties. But without any direct intention on his part of securing a hardier variety, acclimatisation may be unconsciously effected by merely raising tender plants from seed, and by occasionally attempting their cultivation further and further northwards, as in the case of maize, the orange and the peach.

How much influence ought to be attributed to inherited habit or custom in the acclimatisation of animals and plants is a much more difficult question. In many cases natural selection can hardly have failed to have come into play and complicated the result. It is notorious that mountain sheep resist severe weather and storms of snow which would destroy lowland breeds; but then mountain sheep have been thus exposed from time immemorial, and all delicate individuals will have been destroyed, and the hardiest preserved. So with the Arrindy silk-moths of China and India; who can tell how far natural selection may have taken a share in the formation of the two races, which are now fitted for such widely different climates? It seems at first probable that the many fruit-trees which are so well fitted for the hot summers and cold winters of North America, in contrast with their poor success under our climate, have become adapted through habit; but when we reflect on the multitude of seedlings annually raised in that country, and that none would succeed unless born with a fitting constitution, it is possible that mere habit may have done nothing towards their acclimatisation. On the other hand, when we hear that Merino sheep, bred during no great number of generations at the Cape of Good Hope—that some European plants raised during only a few generations in the cooler parts of India, withstand the hotter parts of that country much better than the sheep or seeds imported directly from England, we must attribute some influence to habit. We are led to the same conclusion when we hear from Naudin [78] that the races of melons, squashes, and gourds, which have long been cultivated

[78] Quoted by Asa Gray, in 'Am. Journ. of Sci.,' 2nd series, Jan. 1865, p. 106.

in Northern Europe, are comparatively more precocious, and need much less heat for maturing their fruit, than the varieties of the same species recently brought from tropical regions. In the reciprocal conversion of summer and winter wheat, barley, and vetches into each other, habit produces a marked effect in the course of a very few generations. The same thing apparently occurs with the varieties of maize, which, when carried from the Southern States of America, or into Germany, soon became accustomed to their new homes. With vine-plants taken to the West Indies from Madeira, which are said to succeed better than plants brought directly from France, we have some degree of acclimatisation in the individual, independently of the production of new varieties by seed.

The common experience of agriculturists is of some value, and they often advise persons to be cautious in trying the productions of one country in another. The ancient agricultural writers of China recommend the preservation and cultivation of the varieties peculiar to each country. During the classical period, Columella wrote, "Vernaculum pecus "peregrino longe præstantius est."[79]

I am aware that the attempt to acclimatise either animals or plants has been called a vain chimera. No doubt the attempt in most cases deserves to be thus called, if made independently of the production of new varieties endowed with a different constitution. With plants propagated by buds, habit rarely produces any effect; it apparently acts only through successive seminal generations. The laurel, bay, laurestinus, &c., and the Jerusalem artichoke, which are propagated by cuttings or tubers, are probably now as tender in England as when first introduced; and this appears to be the case with the potato, which until recently was seldom multiplied by seed. With plants propagated by seed, and with animals, there will be little or no acclimatisation unless the hardier individuals are either intentionally or unconsciously preserved. The kidney-bean has often been advanced as an

[79] For China, *see* 'Mémoire sur les Chinois,' tom. xi., 1786, p. 60. Columella is quoted by Carlier, in 'Journal de Physique,' tom. xxiv., 1784.

instance of a plant which has not become hardier since its first introduction into Britain. We hear, however, on excellent authority,[80] that some very fine seed, imported from abroad, produced plants "which blossomed most profusely, but were "nearly all but abortive, whilst plants grown alongside from "English seed podded abundantly;" and this apparently shows some degree of acclimatisation in our English plants. We have also seen that seedlings of the kidney-bean occasionally appear with a marked power of resisting frost; but no one, as far as I can hear, has ever separated such hardy seedlings, so as to prevent accidental crossing, and then gathered their seed, and repeated the process year after year. It may, however, be objected with truth that natural selection ought to have had a decided effect on the hardiness of our kidney-beans; for the tenderest individuals must have been killed during every severe spring, and the hardier preserved. But it should be borne in mind that the result of increased hardiness would simply be that gardeners, who are always anxious for as early a crop as possible, would sow their seed a few days earlier than formerly. Now, as the period of sowing depends much on the soil and elevation of each district, and varies with the season; and as new varieties have often been imported from abroad, can we feel sure that our kidney-beans are not somewhat hardier? I have not been able, by searching old horticultural works, to answer this question satisfactorily.

On the whole the facts now given show that, though habit does something towards acclimatisation, yet that the appearance of constitutionally different individuals is a far more effective agent. As no single instance has been recorded either with animals or plants of hardier individuals having been long and steadily selected, though such selection is admitted to be indispensable for the improvement of any other character, it is not surprising that man has done little in the acclimatisation of domesticated animals and cultivated plants. We need not, however, doubt that under nature new races and new species would become adapted to widely different climates, by variation, aided by habit, and regulated by natural selection.

[80] Messrs. Hardy and Son, in 'Gard. Chronicle,' 1856, p. 589.

Arrests of Development: Rudimentary and Aborted Organs.

Modifications of structure from arrested development, so great or so serious as to deserve to be called monstrosities, are not infrequent with domesticated animals, but, as they differ much from any normal structure, they require only a passing notice. Thus the whole head may be represented by a soft nipple-like projection, and the limbs by mere papillæ. These rudiments of limbs are sometimes inherited, as has been observed in a dog.[81]

Many lesser anomalies appear to be due to arrested development. What the cause of the arrest may be, we seldom know, except in the case of direct injury to the embryo. That the cause does not generally act at an extremely early embryonic period we may infer from the affected organ seldom being wholly aborted,—a rudiment being generally preserved. The external ears are represented by mere vestiges in a Chinese breed of sheep; and in another breed, the tail is reduced "to a little button, suffocated in a manner, by fat."[82] In tailless dogs and cats a stump is left. In certain breeds of fowls the comb and wattles are reduced to rudiments; in the Cochin-China breed scarcely more than rudiments of spurs exist. With polled Suffolk cattle, "rudiments of horns can often be felt at an "early age;"[83] and with species in a state of nature, the relatively great development of rudimentary organs at an early period of life is highly characteristic of such organs. With hornless breeds of cattle and sheep, another and singular kind of rudiment has been observed, namely, minute dangling horns attached to the skin alone, and which are often shed and grow again. With hornless goats, according to Desmarest,[84] the bony protuberance which properly supports the horn exists as a mere rudiment.

With cultivated plants it is far from rare to find the petals, stamens, and pistils represented by rudiments, like those observed in natural species. So it is with the whole seed in many fruits; thus, near Astrakhan there is a grape with mere traces of seeds, "so "small and lying so near the stalk that they are not perceived in "eating the grape."[85] In certain varieties of the gourd, the tendrils, according to Naudin, are represented by rudiments or by various monstrous growths. In the broccoli and cauliflower the greater number of the flowers are incapable of expansion, and include rudimentary organs. In the Feather hyacinth (*Muscari comosum*) in its natural state the upper and central flowers are brightly coloured but rudimentary; under cultivation the tendency to

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[81] Isid. Geoffroy Saint-Hilaire, 'Hist. Nat. des Anomalies,' 1836, tom. ii. pp. 210, 223, 224, 395; 'Philosoph. Transact.,' 1775, p. 313.

[82] Pallas, quoted by Youatt on Sheep, p. 25.

[83] Youatt on Cattle, 1834, p. 174.

[84] 'Encyclop. Méthod.,' 1820, p. 483: *see* p. 500, on the Indian zebu casting its horns. Similar cases in European cattle were given in the third chapter.

[85] Pallas, 'Travels,' Eng. Translat., vol. i. p. 243.

abortion travels downwards and outwards, and all the flowers become rudimentary; but the abortive stamens and pistils are not so small in the lower as in the upper flowers. In the *Viburnum opulus*, on the other hand, the outer flowers naturally have their organs of fructification in a rudimentary state, and the corolla is of large size; under cultivation, the change spreads to the centre, and all the flowers become affected. In the compositæ, the so-called doubling of the flowers consists in the greater development of the corolla of the central florets, generally accompanied with some degree of sterility; and it has been observed [86] that the progressive doubling invariably spreads from the circumference to the centre,—that is, from the ray florets, which so often include rudimentary organs, to those of the disc. I may add, as bearing on this subject, that with Asters, seeds taken from the florets of the circumference have been found to yield the greatest number of double flowers.[87] In the above cases we have a natural tendency in certain parts to be rudimentary, and this under culture spreads either to, or from, the axis of the plant. It deserves notice, as showing how the same laws govern the changes which natural species and artificial varieties undergo, that in the species of Carthamus, one of the Compositæ, a tendency to the abortion of the pappus may be traced extending from the circumference to the centre of the disc as in the so-called doubling of the flowers in the members of the same family. Thus, according to A. de Jussieu,[88] the abortion is only partial in *Carthamus creticus*, but more extended in *C. lanatus*; for in this species only two or three of the central seeds are furnished with a pappus, the surrounding seeds being either quite naked or furnished with a few hairs; and lastly in *C. tinctorius*, even the central seeds are destitute of pappus, and the abortion is complete.

With animals and plants under domestication, when an organ disappears, leaving only a rudiment, the loss has generally been sudden, as with hornless and tailless breeds; and such cases may be ranked as inherited monstrosities. But in some few cases the loss has been gradual, and has been effected partly by selection, as with the rudimentary combs and wattles of certain fowls. We have also seen that the wings of some domesticated birds have been slightly reduced by disuse, and the great reduction of the wings in certain silk-moths, with mere rudiments left, has probably been aided by disuse.

With species in a state of nature, rudimentary organs are extremely common. Such organs are generally variable, as several naturalists have observed; for, being useless, they are not regulated by natural selection, and they are more or less liable to reversion. The same rule certainly holds good with

[86] Mr. Beaton, in 'Journal of Horticulture,' May 21, 1861, p. 133.

[87] Lecoq, 'De la Fécondation,' 1862, p. 233.

[88] 'Annales du Muséum,' tom. vi p. 319.

parts which have become rudimentary under domestication. We do not know through what steps under nature rudimentary organs have passed in being reduced to their present condition; but we so incessantly see in species of the same group the finest gradations between an organ in a rudimentary and perfect state, that we are led to believe that the passage must have been extremely gradual. It may be doubted whether a change of structure so abrupt as the sudden loss of an organ would ever be of service to a species in a state of nature; for the conditions to which all organisms are closely adapted usually change very slowly. Even if an organ did suddenly disappear in some one individual by an arrest of development, intercrossing with the other individuals of the same species would tend to cause its partial reappearance; so that its final reduction could only be effected by some other means. The most probable view is, that a part which is now rudimentary, was formerly, owing to changed habits of life, used less and less, being at the same time reduced in size by disuse, until at last it became quite useless and superfluous. But as most parts or organs are not brought into action during an early period of life, disuse or decreased action will not lead to their reduction until the organism arrives at a somewhat advanced age; and from the principle of inheritance at corresponding ages the reduction will be transmitted to the offspring at the same advanced stage of growth. The part or organ will thus retain its full size in the embryo, as we know to be the case with most rudiments. As soon as a part becomes useless, another principle, that of economy of growth, will come into play, as it would be an advantage to an organism exposed to severe competition to save the development of any useless part; and individuals having the part less developed will have a slight advantage over others. But, as Mr. Mivart has justly remarked, as soon as a part is much reduced, the saving from its further reduction will be utterly insignificant; so that this cannot be effected by natural selection. This manifestly holds good if the part be formed of mere cellular tissue, entailing little expenditure of nutriment. How then can the further reduction of an already somewhat reduced part be effected? That this has occurred

repeatedly under Nature is shown by the many gradations which exist between organs in a perfect state and the merest vestiges of them. Mr. Romanes [89] has, I think, thrown much light on this difficult problem. His view, as far as it can be given in a few words, is as follows: all parts are somewhat variable and fluctuate in size round an average point. Now, when a part has already begun from any cause to decrease, it is very improbable that the variations should be as great in the direction of increase as of diminution; for its previous reduction shows that circumstances have not been favourable for its development; whilst there is nothing to check variations in the opposite direction. If this be so, the long continued crossing of many individuals furnished with an organ which fluctuates in a greater degree towards decrease than towards increase, will slowly but steadily lead to its diminution. With respect to the complete and absolute abortion of a part, a distinct principle, which will be discussed in the chapter on pangenesis, probably comes into action.

With animals and plants reared by man there is no severe or recurrent struggle for existence, and the principle of economy will not come into action, so that the reduction of an organ will not thus be aided. So far, indeed, is this from being the case, that in some few instances organs, which are naturally rudimentary in the parent-species, become partially redeveloped in the domesticated descendants. Thus cows, like most other ruminants, properly have four active and two rudimentary mammæ; but in our domesticated animals, the latter occasionally become considerably developed and yield milk. The atrophied mammæ, which, in male domesticated animals, including man, have in some rare cases grown to full size and secreted milk, perhaps offer an analogous case. The hind feet of dogs naturally include rudiments of a fifth toe, and in certain large breeds these toes, though still rudimentary,

[89] I suggested in 'Nature' (vol. viii. pp. 432, 505) that with organisms subjected to unfavourable conditions all the parts would tend towards reduction, and that under such circumstances any part which was not kept up to its standard size by natural selection would, owing to intercrossing, slowly but steadily decrease. In three subsequent communications to 'Nature' (March 12, April 9, and July 2, 1874), Mr. Romanes gives his improved view.

become considerably developed and are furnished with claws. In the common Hen, the spurs and comb are rudimentary, but in certain breeds these become, independently of age or disease of the ovaria, well developed. The stallion has canine teeth, but the mare has only traces of the alveoli, which, as I am informed by the eminent veterinarian Mr. G. T. Brown, frequently contain minute irregular nodules of bone. These nodules, however, sometimes become developed into imperfect teeth, protruding through the gums and coated with enamel; and occasionally they grow to a fourth or even a third of the length of the canines in the stallion. With plants I do not know whether the redevelopment of rudimentary organs occurs more frequently under culture than under nature. Perhaps the pear-tree may be a case in point, for when wild it bears thorns, which consist of branches in a rudimentary condition and serve as a protection, but, when the tree is cultivated, they are reconverted into branches.