CHAPTER XXIII.

DIRECT AND DEFINITE ACTION OF THE EXTERNAL CONDITIONS OF LIFE.

SLIGHT MODIFICATIONS IN PLANTS FROM THE DEFINITE ACTION OF CHANGED CONDITIONS, IN SIZE, COLOUR, CHEMICAL PROPERTIES, AND IN THE STATE OF THE TISSUES—LOCAL DISEASES—CONSPICUOUS MODIFICATIONS FROM CHANGED CLIMATE OR FOOD, ETC.—PLUMAGE OF BIRDS AFFECTED BY PECULIAR NUTRIMENT, AND BY THE INOCULATION OF POISON—LAND-SHELLS—MODIFICATIONS OF ORGANIC BEINGS IN A STATE OF NATURE THROUGH THE DEFINITE ACTION OF EXTERNAL CONDITIONS—COMPARISON OF AMERICAN AND EUROPEAN TREES — GALLS—EFFECTS OF PARASITIC FUNGI — CONSIDERATIONS OPPOSED TO THE BELIEF IN THE POTENT INFLUENCE OF CHANGED EXTERNAL CONDITIONS—PARALLEL SERIES OF VARIETIES—AMOUNT OF VARIATION DOES NOT CORRESPOND WITH THE DEGREE OF CHANGE IN THE CONDITIONS—BUD-VARIATION—MONSTROSITIES PRODUCED BY UNNATURAL TREATMENT—SUMMARY.

IF we ask ourselves why this or that character has been modified under domestication, we are, in most cases, lost in utter darkness. Many naturalists, especially of the French school, attribute every modification to the "monde ambiant," that is, to changed climate, with all its diversities of heat and cold, dampness and dryness, light and electricity, to the nature of the soil, and to varied kinds and amount of food. By the term definite action, as used in this chapter, I mean an action of such a nature that, when many individuals of the same variety are exposed during several generations to any particular change in their conditions of life, all, or nearly all the individuals, are modified in the same manner. The effects of habit, or of the increased use and disuse of various organs, might have been included under this head; but it will be convenient to discuss this subject in a separate chapter. By the term indefinite action I mean an action which causes one individual to vary in one way and another individual in another way, as we often see with plants and animals after they have been subjected for some generations to changed conditions of life. But we know far too little of the causes and laws of

variation to make a sound classification. The action of changed conditions, whether leading to definite or indefinite results, is a totally distinct consideration from the effects of selection; for selection depends on the preservation by man of certain individuals, or on their survival under various and complex natural circumstances, and has no relation whatever to the primary cause of each particular variation.

I will first give in detail all the facts which I have been able to collect, rendering it probable that climate, food, &c., have acted so definitely and powerfully on the organisation of our domesticated productions, that new sub-varieties or races have been thus formed without the aid of selection by man or nature. I will then give the facts and considerations opposed to this conclusion, and finally we will weigh, as fairly as we can, the evidence on both sides.

When we reflect that distinct races of almost all our domesticated animals exist in each kingdom of Europe, and formerly even in each district of England, we are at first strongly inclined to attribute their origin to the definite action of the physical conditions of each country; and this has been the conclusion of many authors. But we should bear in mind that man annually has to choose which animals shall be preserved for breeding, and which shall be slaughtered. We have also seen that both methodical and unconscious selection were formerly practised, and are now occasionally practised by the most barbarous races, to a much greater extent than might have been anticipated. Hence it is difficult to judge how far differences in the conditions between, for instance, the several districts in England, have sufficed to modify the breeds which have been reared in each. It may be argued that, as numerous wild animals and plants have ranged during many ages throughout Great Britain, and still retain the same character, the difference in conditions between the several districts could not have modified in a marked manner the various native races of cattle, sheep, pigs, and horses. The same difficulty of distinguishing between the effects of natural selection and the definite action of external conditions is encountered in a still higher degree when we compare closely allied species inhabiting two countries, such as North America

and Europe, which do not differ greatly in climate, nature of soil, &c., for in this case natural selection will inevitably and rigorously have acted during a long succession of ages.

Prof. Weismann has suggested[1] that when a variable species enters a new and isolated country, although the variations may be of the same general nature as before, yet it is improbable that they should occur in the same proportional numbers. After a longer or shorter period, the species will tend to become nearly uniform in character from the incessant crossing of the varying individuals; but owing to the proportion of the individuals varying in different ways not being the same in the two cases, the final result will be the production of two forms somewhat different from one another. In cases of this kind it would falsely appear as if the conditions had induced certain definite modifications, whereas they had only excited indefinite variability, but with the variations in slightly different proportional numbers. This view may throw some light on the fact that the domestic animals which formerly inhabited the several districts in Great Britain, and the half wild cattle lately kept in several British parks, differed slightly from one another; for these animals were prevented from wandering over the whole country and intercrossing, but would have crossed freely within each district or park.

From the difficulty of judging how far changed conditions have caused definite modifications of structure, it will be advisable to give as large a body of facts as possible, showing that extremely slight differences within the same country, or during different seasons, certainly produce an appreciable effect, at least on varieties which are already in an unstable condition. Ornamental flowers are good for this purpose, as they are highly variable, and are carefully observed. All floriculturists are unanimous that certain varieties are affected by very slight differences in the nature of the artificial compost in which they are grown, and by the natural soil of the district, as well as by the season. Thus, a skilful judge, in writing on Carnations and Picotees,[2] asks "where can Admiral Curzon be "seen possessing the colour, size, and strength which it has in "Derbyshire? Where can Flora's Garland be found equal to those "at Slough? Where do high-coloured flowers revel better than at

[1] 'Ueber den Einfluss der Isolirung auf die Artbildung,' 1872.

[2] 'Gardener's Chronicle,' 1853, p. 183.

"Woolwich and Birmingham? Yet in no two of these districts do "the same varieties attain an equal degree of excellence, although "each may be receiving the attention of the most skilful cultivators." The same writer then recommends every cultivator to keep five different kinds of soil and manure, "and to endeavour to suit the "respective appetites of the plants you are dealing with, for without "such attention all hope of general success will be vain." So it is with the Dahlia[3]: the Lady Cooper rarely succeeds near London, but does admirably in other districts; the reverse holds good with other varieties; and again, there are others which succeed equally well in various situations. A skilful gardener[4] states that he procured cuttings of an old and well-known variety (pulchella) of Verbena, which from having been propagated in a different situation presented a slightly different shade of colour; the two varieties were afterwards multiplied by cuttings, being carefully kept distinct; but in the second year they could hardly be distinguished, and in the third year no one could distinguish them.

The nature of the season has an especial influence on certain varieties of the Dahlia: in 1841 two varieties were pre-eminently good, and the next year these same two were pre-eminently bad. A famous amateur[5] asserts that in 1861 many varieties of the Rose came so untrue in character, "that it was hardly possible to recog-"nise them, and the thought was not seldom entertained that the "grower had lost his tally." The same amateur[6] states that in 1862 two-thirds of his Auriculas produced central trusses of flowers, and such trusses are liable not to keep true; and he adds that in some seasons certain varieties of this plant all prove good, and the next season all prove bad; whilst exactly the reverse happens with other varieties. In 1845 the editor of the 'Gardener's Chronicle'[7] remarked how singular it was that this year many Calceolarias tended to assume a tubular form. With Heartsease[8] the blotched sorts do not acquire their proper character until hot weather sets in; whilst other varieties lose their beautiful marks as soon as this occurs.

Analogous facts have been observed with leaves: Mr. Beaton asserts[9] that he raised at Shrubland, during six years, twenty thousand seedlings from the Punch Pelargonium, and not one had variegated leaves; but at Surbiton, in Surrey, one-third, or even a greater proportion, of the seedlings from this same variety were more or less variegated. The soil of another district in Surrey has a strong tendency to cause variegation, as appears from information given me by Sir F. Pollock. Verlot[10] states that the variegated strawberry

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[3] Mr. Wildman, 'Floricultural Soc.,' Feb. 7, 1843, reported in 'Gard. Chron.,' 1843, p. 86.

[4] Mr. Robson, in 'Journal of Horticulture,' Feb. 13th, 1866, p. 122.

[5] 'Journal of Horticulture,' 1861, p. 24.

[6] Ibid., 1862, p. 83.

[7] 'Gard. Chron.,' 1845, p. 660.

[8] Ibid., 1863, p. 628.

[9] 'Journal of Hort.,' 1861, pp. 64, 309.

[10] 'Des Variétés,' &c., p. 76.

retains its character as long as grown in a dryish soil, but soon loses it when planted in fresh and humid soil. Mr. Salter, who is well known for his success in cultivating variegated plants, informs me that rows of strawberries were planted in his garden in 1859, in the usual way; and at various distances in one row, several plants simultaneously became variegated; and what made the case more extraordinary, all were variegated in precisely the same manner. These plants were removed, but during the three succeeding years other plants in the same row became variegated, and in no instance were the plants in any adjoining row affected.

The chemical qualities, odours, and tissues of plants are often modified by a change which seems to us slight. The Hemlock is said not to yield conicine in Scotland. The root of the *Aconitum napellus* becomes innocuous in frigid climates. The medicinal properties of the Digitalis are easily affected by culture. As the *Pistacia lentiscus* grows abundantly in the South of France, the climate must suit it, but it yields no mastic. The *Laurus sassafras* in Europe loses the odour proper to it in North America.[11] Many similar facts could be given, and they are remarkable because it might have been thought that definite chemical compounds would have been little liable to change either in quality or quantity.

The wood of the American Locust-tree (*Robinia*) when grown in England is nearly worthless, as is that of the Oak-tree when grown at the Cape of Good Hope.[12] Hemp and flax, as I hear from Dr. Falconer, flourish and yield plenty of seed on the plains of India, but their fibres are brittle and useless. Hemp, on the other hand, fails to produce in England that resinous matter which is so largely used in India as an intoxicating drug.

The fruit of the Melon is greatly influenced by slight differences in culture and climate. Hence it is generally a better plan, according to Naudin, to improve an old kind than to introduce a new one into any locality. The seed of the Persian Melon produces near Paris fruit inferior to the poorest market kinds, but at Bordeaux yields delicious fruit.[13] Seed is annually brought from Thibet to Kashmir,[14] and produces fruit weighing from four to ten pounds, but plants raised next year from seed saved in Kashmir give fruit weighing only from two to three pounds. It is well known that American varieties of the Apple produce in their native land magnificent and brightly-coloured fruit, but these in England are of poor quality and a dull colour. In Hungary there are many

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[11] Engel, 'Sur les Propr. Médicales des Plantes,' 1860, pp. 10, 25. On changes in the odours of plants, *see* Dalibert's Experiments, quoted by Beckman, 'Inventions,' vol. ii. p. 344; and Nees, in Ferussac, 'Bull. des Sc. Nat.,' 1824, tom. i. p. 60. With respect to the rhubarb, &c., *see* also 'Gardener's Chronicle,' 1849, p. 355; 1862, p. 1123.

[12] Hooker, 'Flora Indica,' p. 32.

[13] Naudin, 'Annales des Sc. Nat.,' 4th series, Bot., tom. xi., 1859, p. 81. 'Gardener's Chronicle,' 1859, p. 464.

[14] Moorcroft's 'Travels,' &c., vol ii p. 143.

varieties of the kidney-bean, remarkable for the beauty of their seeds, but the Rev. M. J. Berkeley[15] found that their beauty could hardly ever be preserved in England, and in some cases the colour was greatly changed. We have seen in the ninth chapter, with respect to wheat, what a remarkable effect transportal from the north to the south of France, and conversely, produced on the weight of the grain.

When man can perceive no change in plants or animals which have been exposed to a new climate or to different treatment, insects can sometimes perceive a marked change. A cactus has been imported into India from Canton, Manilla Mauritius, and from the hot-houses of Kew, and there is likewise a so-called native kind which was formerly introduced from South America; all these plants belong to the same species and are alike in appearance, but the cochineal insect flourishes only on the native kind, on which it thrives prodigiously.[16] Humboldt remarks[17] that white men "born in the torrid zone walk barefoot with impunity in the same apartment where a European, recently landed, is exposed to the attacks of the *Pulex penetrans*." This insect, the too well-known chigoe, must therefore be able to perceive what the most delicate chemical analysis fails to discover, namely, a difference between the blood or tissues of a European and those of a white man born in the tropics. But the discernment of the chigoe is not so surprising as it at first appears; for according to Liebig[18] the blood of men with different complexions, though inhabiting the same country, emits a different odour.

Diseases peculiar to certain localities, heights, or climates, may be here briefly noticed, as showing the influence of external circumstances on the human body. Diseases confined to certain races of man do not concern us, for the constitution of the race may play the more important part, and this may have been determined by unknown causes. The Plica Polonica stands, in this respect, in a

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[15] 'Gardener's Chronicle,' 1861, p. 1113.

[16] Royle, 'Productive Resources of India,' p. 59.

[17] 'Personal Narrative,' Eng. translat., vol. v. p. 101. This statement has been confirmed by Karsten ('Beitrag zur Kenntniss der Rhynchoprion:' Moscow, 1864, s. 39), and by others.

[18] 'Organic Chemistry,' Eng. translat., 1st edit., p. 369.

nearly intermediate position; for it rarely affects Germans, who inhabit the neighbourhood of the Vistula, where so many Poles are grievously affected; neither does it affect Russians, who are said to belong to the same original stock as the Poles.[19] The elevation of a district often governs the appearance of diseases; in Mexico the yellow fever does not extend above 924 metres; and in Peru, people are affected with the *verugas* only between 600 and 1600 metres above the sea; many other such cases could be given. A peculiar cutaneous complaint, called the *Bouton d'Alep*, affects in Aleppo and some neighbouring districts almost every native infant, and some few strangers; and it seems fairly well established that this singular complaint depends on drinking certain waters. In the healthy little island of St. Helena the scarlet-fever is dreaded like the Plague; analogous facts have been observed in Chili and Mexico.[20] Even in the different departments of France it is found that the various infirmities which render the conscript unfit for serving in the army, prevail with remarkable inequality, revealing, as Boudin observes, that many of them are endemic, which otherwise would never have been suspected.[21] Any one who will study the distribution of disease will be struck with surprise at what slight differences in the surrounding circumstances govern the nature and severity of the complaints by which man is at least temporarily affected.

The modifications as yet referred to are extremely slight, and in most cases have been caused, as far as we can judge, by equally slight differences in the conditions. But such conditions acting during a series of generations would perhaps produce a marked effect.

With plants, a considerable change of climate sometimes produces a conspicuous result. I have given in the ninth chapter the most remarkable case known to me, namely, that of varieties of maize, which were greatly modified in the course of only two or three generations when taken from a tropical country to a cooler one, or conversely. Dr. Falconer informs me that he has seen the English Ribston-pippin apple, a Himalayan oak, Prunus and Pyrus, all assume in the hotter parts of India a fastigate or pyramidal habit; and this fact is the more interesting, as a Chinese tropical species of Pyrus naturally grows thus. Although in these cases the changed manner of growth seems to have been directly caused by the great heat, we know that many fastigate trees have originated in their temperate homes. In the Botanic Gardens of Ceylon the apple-tree[22] "sends out numerous runners under ground, which continually rise into small stems, and form a growth around the parent-tree." The varieties of the cabbage which produce heads in Europe fail to do so

[19] Prichard, 'Phys. Hist. of Mankind,' 1851, vol. i. p. 155.

[20] Darwin, 'Journal of Researches,' 1845, p. 434.

[21] These statements on disease are taken from Dr. Boudin's 'Géographie et Statistique Médicale,' 1857, tom. i. pp. xliv. and lii.; tom. ii. p. 315.

[22] 'Ceylon,' by Sir J. E. Tennent, vol. i., 1859, p. 89.

in certain tropical countries.[23] The *Rhododendron ciliatum* produced at Kew flowers so much larger and paler-coloured than those which it bears on its native Himalayan mountain, that Dr. Hooker[24] would hardly have recognised the species by the flowers alone. Many similar facts with respect to the colour and size of flowers could be given.

The experiments of Vilmorin and Buckman on carrots and parsnips prove that abundant nutriment produces a definite and inheritable effect on the roots, with scarcely any change in other parts of the plant. Alum directly influences the colour of the flowers of the Hydrangea.[25] Dryness seems generally to favour the hairiness or villosity of plants. Gärtner found that hybrid Verbascums became extremely woolly when grown in pots. Mr. Masters, on the other hand, states that the *Opuntia leucotricha* "is "well clothed with beautiful white hairs when grown in a damp "heat, but in a dry heat exhibits none of this peculiarity."[26] Slight variations of many kinds, not worth specifying in detail, are retained only as long as plants are grown in certain soils, of which Sageret[27] gives some instances from his own experience. Odart, who insists strongly on the permanence of the varieties of the grape, admits[28] that some varieties, when grown under a different climate or treated differently, vary in a slight degree, as in the tint of the fruit and in the period of ripening. Some authors have denied that grafting causes even the slightest difference in the scion; but there is sufficient evidence that the fruit is sometimes slightly affected in size and flavour, the leaves in duration, and the flowers in appearance.[29]

There can be no doubt, from the facts given in the first chapter, that European dogs deteriorate in India, not only in their instincts but in structure; but the changes which they undergo are of such a nature, that they may be partly due to reversion to a primitive form, as in the case of feral animals. In parts of India the turkey becomes reduced in size, "with the pendulous appendage over the beak enormously developed."[30] We have seen how soon the wild duck, when domesticated, loses its true character, from the effects of abundant or changed food, or from taking little exercise. From the direct action of a humid climate and poor pasture the horse rapidly decreases in size in the Falkland Islands. From information which

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[23] Godron, 'De l'Espèce,' tom. ii. p. 52.

[24] 'Journal of Horticultural Soc.,' vol. vii., 1852, p. 117.

[25] 'Journal of Hort. Soc.,' vol. i. p. 160.

[26] *See* Lecoq, on the Villosity of Plants, 'Géograph. Bot.,' tom. iii. pp. 287, 291; Gärtner, 'Bastarderz.,' s. 261; Mr. Masters, on the Opuntia, in 'Gard. Chronicle,' 1846, p. 444.

[27] 'Pom. Phys.,' p. 136.

[28] 'Ampélographie,' 1849, p. 19.

[29] Gärtner, 'Bastarderz.,' s. 606, has collected nearly all recorded facts. Andrew Knight (in 'Transact. Hort. Soc.,' vol. ii. p. 160) goes so far as to maintain that few varieties are absolutely permanent in character when propagated by buds or grafts.

[30] Mr. Blyth, in 'Annals and Mag of Nat. Hist.,' vol. xx., 1847, p. 391.

I have received, this seems likewise to be the case to a certain extent with sheep in Australia.

Climate definitely influences the hairy covering of animals; in the West Indies a great change is produced in the fleece of sheep, in about three generations. Dr. Falconer states[31] that the Thibet mastiff and goat, when brought down from the Himalaya to Kashmir, lose their fine wool. At Angora not only goats, but shepherd-dogs and cats, have fine fleecy hair, and Mr. Ainsworth[32] attributes the thickness of the fleece to the severe winters, and its silky lustre to the hot summers. Burnes states positively[33] that the Karakool sheep lose their peculiar black curled fleeces when removed into any other country. Even within the limits of England, I have been assured that the wool of two breeds of sheep was slightly changed by the flocks being pastured in different localities.[34] It has been asserted on good authority [35] that horses kept during several years in the deep coal-mines of Belgium become covered with velvety hair, almost like that on the mole. These cases probably stand in close relation to the natural change of coat in winter and summer. Naked varieties of several domestic animals have occasionally appeared; but there is no reason to believe that this is in any way related to the nature of the climate to which they have been exposed.[36]

It appears at first sight probable that the increased size, the tendency to fatten, the early maturity and altered forms of our improved cattle, sheep, and pigs, have directly resulted from their abundant supply of food. This is the opinion of many competent judges, and probably is to a great extent true. But as far as form is concerned, we must not overlook the more potent influence of lessened use on the limbs and lungs. We see, moreover, as far as size is concerned, that selection is apparently a more powerful agent than a large supply of food, for we can thus only account for the existence, as remarked to me by Mr. Blyth, of the largest and smallest breeds of sheep in the same country, of Cochin-China fowls and Bantams, of small Tumbler and large Runt pigeons, all kept together and supplied with abundant nourishment. Nevertheless there can be little doubt that our domesticated animals have been modified, independently of the increased or lessened use of parts, by the conditions to which they have been subjected, without the aid of selection. For instance, Prof. Rütimeyer[37] shows that the bones of

[31] 'Natural History Review,' 1862, p. 113.

[32] 'Journal of Roy. Geographical Soc.,' vol. ix., 1839, p. 275.

[33] 'Travels in Bokhara,' vol. iii. p. 151.

[34] *See* also, on the influence of marshy pastures on the wool, Godron, 'L'Espèce,' tom. ii. p. 22.

[35] Isidore Geoffroy Saint-Hilaire, 'Hist. Nat. Gén.,' tom. iii. p. 438.

[36] Azara has made some good remarks on this subject, 'Quadrupèdes du Paraguay,' tom. ii. p. 337. *See* an account of a family of naked mice produced in England, 'Proc. Zoolog. Soc.,' 1856, p. 38.

[37] 'Die Fauna der Pfahlbauten, 1861, s. 15.

domesticated quadrupeds can be distinguished from those of wild animals by the state of their surface and general appearance. It is scarcely possible to read Nathusius's excellent 'Vorstudien,'[38] and doubt that, with the highly improved races of the pig, abundant food has produced a conspicuous effect on the general form of the body, on the breadth of the head and face, and even on the teeth. Nathusius rests much on the case of a purely bred Berkshire pig, which when two months old became diseased in its digestive organs, and was preserved for observation until nineteen months old; at this age it had lost several characteristic features of the breed, and had acquired a long, narrow head, of large size relatively to its small body, and elongated legs. But in this case and in some others we ought not to assume that, because certain characters are lost, perhaps through reversion, under one course of treatment, therefore that they were at first directly produced by an opposite treatment.

In the case of the rabbit, which has become feral on the island of Porto Santo, we are at first strongly tempted to attribute the whole change—the greatly reduced size, the altered tints of the fur, and the loss of certain characteristic marks—to the definite action of the new conditions to which it has been exposed. But in all such cases we have to consider in addition the tendency to reversion to progenitors more or less remote, and the natural selection of the finest shades of difference.

The nature of the food sometimes either definitely induces certain peculiarities, or stands in some close relation with them. Pallas long ago asserted that the fat-tailed sheep of Siberia degenerate and lose their enormous tails when removed from certain saline pastures; and recently Erman[39] states that this occurs with the Kirgisian sheep when brought to Orenburgh.

It is well known that hemp-seed causes bullfinches and certain other birds to become black. Mr. Wallace has communicated to me some much more remarkable facts of the same nature. The natives of the Amazonian region feed the common green parrot (*Chrysotis festiva*, Linn.) with the fat of large Siluroid fishes, and the birds thus treated become beautifully variegated with red and yellow feathers. In the Malayan archipelago, the natives of Gilolo alter in an analogous manner the colours of another parrot, namely, the *Lorius garrulus*, Linn., and thus produce the *Lori rajah* or King-Lory. These parrots in the Malay Islands and South America, when fed by the natives on natural vegetable food, such as rice and plaintains, retain their proper colours. Mr. Wallace has, also, recorded[40] a still more singular fact. "The Indians (of S. America) "have a curious art by which they change the colours of the feathers "of many birds. They pluck out those from the part they wish to "paint, and inoculate the fresh wound with the milky secretion "from the skin of a small toad. The feathers grow of a brilliant

[38] 'Schweineschädel,' 1864, s. 99.

[39] 'Travels in Siberia,' Eng. translat., vol. i. p. 228.

[40] A. R. Wallace, 'Travels on the Amazon and Rio Negro,' p. 294.

"yellow colour, and on being plucked out, it is said, grow again of "the same colour without any fresh operation."

Bechstein[41] does not entertain any doubt that seclusion from light affects, at least temporarily, the colours of cage-birds.

It is well known that the shells of land-mollusca are affected by the abundance of lime in different districts. Isidore Geoffroy Saint-Hilaire[42] gives the case of *Helix lactea*, which has recently been carried from Spain to the South of France and to the Rio Plata, and in both countries now presents a distinct appearance, but whether this has resulted from food or climate is not known. With respect to the common oyster, Mr. F. Buckland informs me that he can generally distinguish the shells from different districts; young oysters brought from Wales and laid down in beds where "*natives*" are indigenous, in the short space of two months begin to assume the "native" character. M. Costa[43] has recorded a much more remarkable case of the same nature, namely, that young shells taken from the shores of England and placed in the Mediterranean, at once altered their manner of growth and formed prominent diverging rays, like those on the shells of the proper Mediterranean oyster. The same individual shell, showing both forms of growth, was exhibited before a society in Paris. Lastly, it is well known that caterpillars fed on different food sometimes either themselves acquire a different colour or produce moths differing in colour.[44]

It would be travelling beyond my proper limits here to discuss how far organic beings in a state of nature are definitely modified by changed conditions. In my 'Origin of Species' I have given a brief abstract of the facts bearing on this point, and have shown the influence of light on the colours of birds, and of residence near the sea on the lurid tints of insects, and on the succulency of plants. Mr. Herbert Spencer[45] has recently discussed with much ability this whole subject on general grounds. He argues, for instance, that with all animals the external and internal tissues are differently acted on by the surrounding conditions, and they invariably differ in intimate structure. So again the upper and lower surfaces of true leaves, as well as of stems and petioles, when these assume

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[41] 'Naturgeschichte der Stubenvögel,' 1840, s. 262, 308.

[42] 'Hist. Nat Gén.,' tom. iii. p. 402.

[43] 'Bull. de la Soc. Imp. d'Acclimat.,' tom. viii. p. 351.

[44] *See* an account of Mr. Gregson's experiments on the *Abraxus grossulariata*, 'Proc. Entomolog. Soc.,' Jan. 6th, 1862: these experiments have been confirmed by Mr. Greening, in 'Proc. of the Northern Entomolog. Soc.,' July 28th, 1862. For the effects of food on caterpillars, *see* a curious account by M. Michely, in 'Bull. de la Soc. Imp. d'Acclimat.,' tom. viii. p. 563. For analogous facts from Dahlbom on Hymenoptera, *see* Westwood's 'Modern Class. of Insects,' vol. ii. p. 98. *See* also Dr. L. Moller, 'Die Abhängigkeit der Insecten,' 1867, s. 70.

[45] 'The Principles of Biology,' vol. ii., 1866. The present chapters were written before I had read Mr. Herbert Spencer's work, so that I have not been able to make so much use of it as I should otherwise probably have done.

the function and occupy the position of leaves, are differently circumstanced with respect to light, &c., and apparently in consequence differ in structure. But, as Mr. Herbert Spencer admits, it is most difficult in all such cases to distinguish between the effects of the definite action of physical conditions and the accumulation through natural selection of inherited variations which are serviceable to the organism, and which have arisen independently of the definite action of these conditions.

Although we are not here concerned with the definite action of the conditions of life on organisms in a state of nature, I may state that much evidence has been gained during the last few years on this subject. In the United States, for instance, it has been clearly proved, more especially by Mr. J. A. Allen, that, with birds, many species differ in tint, size of body and of beak, and in length of tail, in proceeding from the North to the South; and it appears that these differences must be attributed to the direct action of temperature.[46] With respect to plants I will give a somewhat analogous case: Mr. Meehan,[47] has compared twenty-nine kinds of American trees with their nearest European allies, all grown in close proximity and under as nearly as possible the same conditions. In the American species he finds, with the rarest exceptions, that the leaves fall earlier in the season, and assume before their fall a brighter tint; that they are less deeply toothed or serrated; that the buds are smaller; that the trees are more diffuse in growth and have fewer branchlets; and, lastly, that the seeds are smaller—all in comparison with the corresponding European species. Now considering that these corresponding trees belong to several distinct orders, and that they are adapted to widely different stations, it can hardly be supposed that their differences are of any special service to them in the New and Old worlds; and if so such differences cannot have been gained through natural selection, and must be attributed to the long continued action of a different climate.

[46] Professor Weismann comes to the same conclusion with respect to certain European butterflies in his valuable essay, 'Ueber den Saison-Dimorphismus,' 1875. I might also refer to the recent works of several other authors on the present subject; for instance, to Kerner's 'Gute und schlechte Arten,' 1866.

[47] 'Proc. Acad. Nat. Soc. of Philadelphia,' Jan. 28th, 1862.

Galls.—Another class of facts, not relating to cultivated plants, deserves attention. I allude to the production of galls. Every one knows the curious, bright-red, hairy productions on the wild rose-tree, and the various different galls produced by the oak. Some of the latter resemble fruit, with one face as rosy as the rosiest apple. These bright colours can be of no service either to the gall-forming insect or to the tree, and probably are the direct result of the action of the light, in the same manner as the apples of Nova Scotia or Canada are brighter coloured than English apples. According to Osten Sacken's latest revision, no less than fifty-eight kinds of galls are produced on the several species of oak, by Cynips with its sub-genera; and Mr. B. D. Walsh[48] states that he can add many others to the list. One American species of willow, the *Salix humilis*, bears ten distinct kinds of galls. The leaves which spring from the galls of various English willows differ completely in shape from the natural leaves. The young shoots of junipers and firs, when punctured by certain insects, yield monstrous growths resembling flowers and fir-cones; and the flowers of some plants become from the same cause wholly changed in appearance. Galls are produced in every quarter of the world; of several sent to me by Mr. Thwaites from Ceylon, some were as symmetrical as a composite flower when in bud, others smooth and spherical like a berry; some protected by long spines, others clothed with yellow wool formed of long cellular hairs, others with regularly tufted hairs. In some galls the internal structure is simple, but in others it is highly complex; thus M. Lacaze-Duthiers[49] has figured in the common ink-gall no less than seven concentric layers, composed of distinct tissue, namely, the epidermic, sub-epidermic, spongy, intermediate, and the hard protective layer formed of curiously thickened woody cells, and, lastly, the central mass, abounding with starch-granules on which the larvæ feed.

Galls are produced by insects of various orders, but the

[48] *See* Mr. B. D. Walsh's excellent papers in 'Proc. Entomolog. Soc. Philadelphia,' Dec. 1866, p. 284. With respect to the willow, *see* ibid., 1864, p. 546.

[49] *See* his admirable 'Histoire des Galles,' in 'Annal. des Sc. Nat. Bot.,' 3rd series, tom. xix., 1853, p. 273.

greater number by species of Cynips. It is impossible to read M. Lacaze-Duthiers' discussion and doubt that the poisonous secretion of the insect causes the growth of the gall; and every one knows how virulent is the poison secreted by wasps and bees, which belong to the same group with Cynips. Galls grow with extraordinary rapidity, and it is said that they attain their full size in a few days;[50] it is certain that they are almost completely developed before the larvæ are hatched. Considering that many gall-insects are extremely small, the drop of secreted poison must be excessively minute; it probably acts on one or two cells alone, which, being abnormally stimulated, rapidly increase by a process of self-division. Galls, as Mr. Walsh[51] remarks, afford good, constant, and definite characters, each kind keeping as true to form as does any independent organic being. This fact becomes still more remarkable when we hear that, for instance, seven out of the ten different kinds of galls produced on *Salix humilis* are formed by gall-gnats (*Cecidomyidæ*) which "though essentially dis-"tinct species, yet resemble one another so closely that in "almost all cases it is difficult, and in most cases impossible, "to distinguish the full-grown insects one from the other."[52] For in accordance with a wide-spread analogy we may safely infer that the poison secreted by insects so closely allied would not differ much in nature; yet this slight difference is sufficient to induce widely different results. In some few cases the same species of gall-gnat produces on distinct species of willows galls which cannot be distinguished; the *Cynips fecundatrix*, also, has been known to produce on the Turkish oak, to which it is not properly attached, exactly the same kind of gall as on the European oak.[53] These latter facts apparently prove that the nature of the poison is a more powerful agent in determining the form of the gall than the specific character of the tree which is acted on.

As the poisonous secretion of insects belonging to various orders has the special power of affecting the growth of various

[50] Kirby and Spence's 'Entomology,' 1818, vol. i. p. 450; Lacaze-Duthiers, ibid., p. 284.

[51] 'Proc. Entomolog. Soc. Philadelphia,' 1864, p. 558.

[52] Mr. B. D. Walsh, ibid., p. 633, and Dec. 1866, p. 275.

[53] Mr. B. D. Walsh, ibid., 1864, pp 545, 411, 495; and Dec. 1866, p. 278 *See* also Lacaze-Duthiers.

plants; as a slight difference in the nature of the poison suffices to produce widely different results; and lastly, as we know that the chemical compounds secreted by plants are eminently liable to be modified by changed conditions of life, we may believe it possible that various parts of a plant might be modified through the agency of its own altered secretions. Compare, for instance, the mossy and viscid calyx of a moss-rose, which suddenly appears through bud-variation on a Provence-rose, with the gall of red moss growing from the inoculated leaf of a wild rose, with each filament symmetrically branched like a microscopical spruce-fir, bearing a glandular tip and secreting odoriferous gummy matter.[54] Or compare, on the one hand, the fruit of the peach, with its hairy skin, fleshy covering, hard shell and kernel, and on the other hand one of the more complex galls with its epidermic, spongy, and woody layers, surrounding tissue loaded with starch granules. These normal and abnormal structures manifestly present a certain degree of resemblance. Or, again, reflect on the cases above given of parrots which have had their plumage brightly decorated through some change in their blood, caused by having been fed on certain fishes, or locally inoculated with the poison of a toad. I am far from wishing to maintain that the moss-rose or the hard shell of the peach-stone or the bright colours of birds are actually due to any chemical change in the sap or blood; but these cases of galls and of parrots are excellently adapted to show us how powerfully and singularly external agencies may affect structure. With such facts before us, we need feel no surprise at the appearance of any modification in any organic being.

I may, also, here allude to the remarkable effects which parasitic fungi sometimes produce on plants. Reissek[55] has described a Thesium, affected by an Œcidium, which was greatly modified, and assumed some of the characteristic features of certain allied species, or even genera. Suppose, says Reissek, "the condition originally "caused by the fungus to become constant in the course of time, "the plant would, if found growing wild, be considered as a distinct "species or even as belonging to a new genus." I quote this

[54] Lacaze-Duthiers, ibid., pp. 325, 328.

[55] 'Linnæa,' vol. xvii., 1843; quoted by Dr. M. T. Masters, Royal Institution, March 16th, 1860.

remark to show how profoundly, yet in how natural a manner, this plant must have been modified by the parasitic fungus. Mr. Meehan[56] also states that three species of Euphorbia and *Portulaca olereacea*, which naturally grow prostrate, become erect when they are attacked by the Œcidium. *Euphorbia maculata* in this case also becomes nodose, with the branchlets comparatively smooth and the leaves modified in shape, approaching in these respects to a distinct species, namely, the *E. hypericifolia*.

Facts and Considerations opposed to the belief that the Conditions of Life act in a potent manner in causing definite Modifications of Structure.

I have alluded to the slight differences in species naturally living in distinct countries under different conditions; and such differences we feel at first inclined to attribute, probably often with justice, to the definite action of the surrounding conditions. But it must be borne in mind that there exist many animals and plants which range widely and have been exposed to great diversities of climate, yet remain uniform in character. Some authors, as previously remarked, account for the varieties of our culinary and agricultural plants by the definite action of the conditions to which they have been exposed in the different parts of Great Britain; but there are about 200 plants[57] which are found in every single English county; and these plants must have been exposed for an immense period to considerable differences of climate and soil, yet do not differ. So, again, some animals and plants range over a large portion of the world, yet retain the same character.

Notwithstanding the facts previously given on the occurrence of highly peculiar local diseases and on the strange modifications of structure in plants caused by the inoculated poison of insects, and other analogous cases; still there are a multitude of variations—such as the modified skull of the niata ox and bulldog, the long horns of Caffre cattle, the conjoined toes of the solid-hoofed swine, the immense crest and protuberant skull of Polish fowls, the crop of the pouter-pigeon, and a host of other such cases—which we can hardly attribute to the definite action, in the sense before specified, of the external conditions of life. No doubt in every case there must have been some exciting cause; but as we see innumerable

[56] 'Proc. Acad. Nat. Sc., Philadelphia,' June 16, 1874, and July 23, 1875.

[57] Hewett C. Watson, 'Cybele Britannica,' vol. i., 1847, p. 11.

individuals exposed to nearly the same conditions, and one alone is affected, we may conclude that the constitution of the individual is of far higher importance than the conditions to which it has been exposed. It seems, indeed, to be a general rule that conspicuous variations occur rarely, and in one individual alone out of millions, though all may have been exposed, as far as we can judge, to nearly the same conditions. As the most strongly marked variations graduate insensibly into the most trifling, we are led by the same train of thought to attribute each slight variation much more to innate differences of constitution, however caused, than to the definite action of the surrounding conditions.

We are led to the same conclusion by considering the cases, formerly alluded to, of fowls and pigeons, which have varied and will no doubt go on varying in directly opposite ways, though kept during many generations under nearly the same conditions. Some, for instance, are born with their beaks, wings, tails, legs, &c., a little longer, and others with these same parts a little shorter. By the long-continued selection of such slight individual differences which occur in birds kept in the same aviary, widely different races could certainly be formed; and long-continued selection, important as is the result, does nothing but preserve the variations which arise, as it appears to us, spontaneously.

In these cases we see that domesticated animals vary in an indefinite number of particulars, though treated as uniformly as is possible. On the other hand, there are instances of animals and plants, which, though they have been exposed to very different conditions, both under nature and domestication, have varied in nearly the same manner. Mr. Layard informs me that he has observed amongst the Caffres of South Africa a dog singularly like an arctic Esquimaux dog. Pigeons in India present nearly the same wide diversities of colour as in Europe; and I have seen chequered and simply barred pigeons, and pigeons with blue and white loins, from Sierra Leone, Madeira, England, and India. New varieties of flowers are continually raised in different parts of Great Britain, but many of these are found by the judges at our exhibitions to be almost identical with old varieties. A vast number of new fruit-trees and culinary vegetables have been produced in North America: these differ from European varieties in the same general manner as the several varieties raised in Europe differ from one another; and no one has ever pretended that the climate of America has given to the many American varieties any general character by which they can be recognised. Nevertheless, from the facts previously advanced on the authority of Mr. Meehan with respect to American and European forest-trees it would be rash to affirm that varieties raised in the two countries would not in the course of ages assume a distinctive character. Dr. M. Masters has recorded a striking fact[58] bearing on this subject: he raised numerous plants

[58] 'Gardener's Chronicle,' 1857, p. 629.

of *Hybiscus syriacus* from seed collected in South Carolina and the Holy Land, where the parent-plants must have been exposed to considerably different conditions; yet the seedlings from both localities broke into two similar strains, one with obtuse leaves and purple or crimson flowers, and the other with elongated leaves and more or less pink flowers.

We may, also, infer the prepotent influence of the constitution of the organism over the definite action of the conditions of life, from the several cases given in the earlier chapters of parallel series of varieties,—an important subject, hereafter to be more fully discussed. Sub-varieties of the several kinds of wheat, gourds, peaches, and other plants, and to a limited extent sub-varieties of the fowl, pigeon, and dog, have been shown either to resemble or to differ from one another in a closely corresponding or parallel manner. In other cases, a variety of one species resembles a distinct species; or the varieties of two distinct species resemble one another. Although these parallel resemblances no doubt often result from reversion to the former characters of a common progenitor; yet in other cases, when new characters first appear, the resemblance must be attributed to the inheritance of a similar constitution, and consequently to a tendency to vary in the same manner. We see something of a similar kind in the same monstrosity appearing and reappearing many times in the same species of animal, and, as Dr. Maxwell Masters has remarked to me, in the same species of plant.

We may at least conclude, that the amount of modification which animals and plants have undergone under domestication does not correspond with the degree to which they have been subjected to changed circumstances. As we know the parentage of domesticated birds far better than of most quadrupeds, we will glance through the list. The pigeon has varied in Europe more than almost any other bird; yet it is a native species, and has not been exposed to any extraordinary change of conditions. The fowl has varied equally, or almost equally, with the pigeon, and is a native of the hot jungles of India. Neither the peacock, a native of the same country, nor the guinea-fowl, an inhabitant of the dry deserts of Africa, has varied at all, or only in colour. The turkey, from Mexico, has varied but little. The duck, on the other hand, a native of Europe, has yielded some well-marked races; and as this is an aquatic bird, it must have been subjected to a far more serious change in its habits than the pigeon or even the fowl, which nevertheless have varied in a much higher degree. The goose, a native of Europe and aquatic like the duck, has

varied less than any other domesticated bird, except the peacock.

Bud-variation is, also, important under our present point of view. In some few cases, as when all the eyes on the same tuber of the potato, or all the fruit on the same plum-tree, or all the flowers on the same plant, have suddenly varied in the same manner, it might be argued that the variation had been definitely caused by some change in the conditions to which the plants had been exposed; yet, in other cases, such an admission is extremely difficult. As new characters sometimes appear by bud-variation, which do not occur in the parent-species or in any allied species, we may reject, at least in these cases, the idea that they are due to reversion. Now it is well worth while to reflect maturely on some striking case of bud-variation, for instance that of the peach. This tree has been cultivated by the million in various parts of the world, has been treated differently, grown on its own roots and grafted on various stocks, planted as a standard, trained against a wall, or under glass; yet each bud of each sub-variety keeps true to its kind. But occasionally, at long intervals of time, a tree in England, or under the widely different climate of Virginia, produces a single bud, and this yields a branch which ever afterwards bears nectarines. Nectarines differ, as every one knows, from peaches in their smoothness, size, and flavour; and the difference is so great that some botanists have maintained that they are specifically distinct. So permanent are the characters thus suddenly acquired, that a nectarine produced by bud-variation has propagated itself by seed. To guard against the supposition that there is some fundamental distinction between bud and seminal variation, it is well to bear in mind that nectarines have likewise been produced from the stone of the peach; and, reversely, peaches from the stone of the nectarine. Now is it possible to conceive external conditions more closely alike than those to which the buds on the same tree are exposed? Yet one bud alone, out of the many thousands borne by the same tree, has suddenly, without any apparent cause, produced a nectarine. But the case is even stronger than this, for the same flower-bud has yielded a fruit, one-

half or one-quarter a nectarine, and the other half or three-quarters a peach. Again, seven or eight varieties of the peach have yielded by bud-variation nectarines: the nectarines thus produced, no doubt, differ a little from one another; but still they are nectarines. Of course there must be some cause, internal or external, to excite the peach-bud to change its nature; but I cannot imagine a class of facts better adapted to force on our minds the conviction that what we call the external conditions of life are in many cases quite insignificant in relation to any particular variation, in comparison with the organisation or constitution of the being which varies.

It is known from the labours of Geoffroy Saint-Hilaire, and recently from those of Dareste and others, that eggs of the fowl, if shaken, placed upright, perforated, covered in part with varnish, &c., produce monstrous chickens. Now these monstrosities may be said to be directly caused by such unnatural conditions, but the modifications thus induced are not of a definite nature. An excellent observer, M. Camille Dareste,[59] remarks "that the various species of monstrosities "are not determined by specific causes; the external agencies "which modify the development of the embryo act solely in "causing a perturbation—a perversion in the normal course of "development." He compares the result to what we see in illness: a sudden chill, for instance, affects one individual alone out of many, causing either a cold, or sore-throat, rheumatism, or inflammation of the lungs or pleura. Contagious matter acts in an analogous manner.[60] We may take a still more specific instance: seven pigeons were struck by rattle-snakes:[61] some suffered from convulsions; some had their blood coagulated, in others it was perfectly fluid; some showed ecchymosed spots on the heart, others on the intestines, &c.; others again showed no visible lesion in any organ. It is well known that excess in drinking causes different diseases

[59] 'Mémoire sur la Production Artificielle des Monstruosités,' 1862, pp. 8–12; 'Recherches sur les Conditions, &c., chez les Monstres,' 1863, p. 6. An abstract is given of Geoffroy's Experiments by his son, in his 'Vie, Travaux,' &c., 1847, p. 290.

[60] Paget, 'Lectures on Surgical Pathology,' 1853, vol. i. p. 483.

[61] 'Researches upon the Venom of the Rattle-snake,' Jan. 1861, by Dr. Mitchell, p. 67.

in different men; but in the tropics the effects of intemperance differ from those caused in a cold climate;[62] and in this case we see the definite influence of opposite conditions. The foregoing facts apparently give us as good an idea as we are likely for a long time to obtain, how in many cases external conditions act directly, though not definitely, in causing modifications of structure.

Summary.—There can be no doubt, from the facts given in this chapter, that extremely slight changes in the conditions of life sometimes, probably often, act in a definite manner on our domesticated productions; and, as the action of changed conditions in causing indefinite variability is accumulative, so it may be with their definite action. Hence considerable and definite modifications of structure probably follow from altered conditions acting during a long series of generations. In some few instances a marked effect has been produced quickly on all, or nearly all, the individuals which have been exposed to a marked change of climate, food, or other circumstance. This has occurred with European men in the United States, with European dogs in India, with horses in the Falkland Islands, apparently with various animals at Angora, with foreign oysters in the Mediterranean, and with maize transported from one climate to another. We have seen that the chemical compounds of some plants and the state of their tissues are readily affected by changed conditions. A relation apparently exists between certain characters and certain conditions, so that if the latter be changed the character is lost—as with the colours of flowers, the state of some culinary plants, the fruit of the melon, the tail of fat-tailed sheep, and the peculiar fleeces of other sheep.

The production of galls, and the change of plumage in parrots when fed on peculiar food or when inoculated by the poison of a toad, prove to us what great and mysterious changes in structure and colour, may be the definite result of chemical changes in the nutrient fluids or tissues.

We now almost certainly know that organic beings in a

[62] Mr. Sedgwick, in 'British and Foreign Medico-Chirurg. Review,' July 1863, p. 175.

state of nature may be modified in various definite ways by the conditions to which they have been long exposed, as in the case of the birds and other animals in the northern and southern United States, and of American trees in comparison with their representatives in Europe. But in many cases it is most difficult to distinguish between the definite result of changed conditions, and the accumulation through natural selection of indefinite variations which have prove serviceable. If it profited a plant to inhabit a humid instead of an arid station, a fitting change in its constitution might possibly result from the direct action of the environment, though we have no grounds for believing that variations of the right kind would occur more frequently with plants inhabiting a station a little more humid than usual, than with other plants. Whether the station was unusually dry or humid, variations adapting the plant in a slight degree for directly opposite habits of life would occasionally arise, as we have good reason to believe from what we actually see in other cases.

The organisation or constitution of the being which is acted on, is generally a much more important element than the nature of the changed conditions, in determining the nature of the variation. We have evidence of this in the appearance of nearly similar modifications under different conditions, and of different modifications under apparently nearly the same conditions. We have still better evidence of this in closely parallel varieties being frequently produced from distinct races, or even distinct species; and in the frequent recurrence of the same monstrosity in the same species. We have also seen that the degree to which domesticated birds have varied, does not stand in any close relation with the amount of change to which they have been subjected.

To recur once again to bud-variations. When we reflect on the millions of buds which many trees have produced, before some one bud has varied, we are lost in wonder as to what the precise cause of each variation can be. Let us recall the case given by Andrew Knight of the forty-year-old tree of the yellow magnum bonum plum, an old variety which has been propagated by grafts on various stocks for a very long period

throughout Europe and North America, and on which a single bud suddenly produced the red magnum bonum. We should also bear in mind that distinct varieties, and even distinct species,—as in the case of peaches, nectarines, and apricots,—of certain roses and camellias,—although separated by a vast number of generations from any progenitor in common, and although cultivated under diversified conditions, have yielded by bud-variation closely analogous varieties. When we reflect on these facts we become deeply impressed with the conviction that in such cases the nature of the variation depends but little on the conditions to which the plant has been exposed, and not in any especial manner on its individual character, but much more on the inherited nature or constitution of the whole group of allied beings to which the plant in question belongs. We are thus driven to conclude that in most cases the conditions of life play a subordinate part in causing any particular modification; like that which a spark plays, when a mass of combustibles bursts into flame—the nature of the flame depending on the combustible matter, and not on the spark.[63]

No doubt each slight variation must have its efficient cause; but it is as hopeless an attempt to discover the cause of each, as to say why a chill or a poison affects one man differently from another. Even with modifications resulting from the definite action of the conditions of life, when all or nearly all the individuals, which have been similarly exposed, are similarly affected, we can rarely see the precise relation between cause and effect. In the next chapter it will be shown that the increased use or disuse of various organs produces an inherited effect. It will further be seen that certain variations are bound together by correlation as well as by other laws. Beyond this we cannot at present explain either the causes or nature of the variability of organic beings.

[63] *Professor Weismann argues* strongly in favour of this view in his *'Saison-Dimorphismus der Schmetterlinge,'* 1875, pp. 40–43.