THE RELATIONS OF LIVING BEINGS TO ONE ANOTHER.

IN the preceding essays* we have considered the relations of living beings to space (as revealed to us by Palæontology) and to time—as shown us by organic geography. The inter-relations of living creatures, as enemies, as rivals, and as involuntary helpers, constitute a third department of Hexicology† not less interesting than the two others already treated of.

There is one very general inter-relation which has been already pointed out,‡ namely that between animals and plants, for animals cannot subsist without feeding directly or indirectly on plants, while plants are nourished by the carbonic acid which the animal world gives forth in breathing. The inter-relations which are to be here considered however are of the more active character just referred to and result from predatory habits, rivalry, or unintentional assistance. These relations may be grouped in twelve sets of inter-actions, seven of them favourable and five unfavourable.

1. Thus, in the first place, one kind of organism may benefit another by serving that other as its food.

2. One living creature may benefit another by destroying direct enemies of that other, which if not destroyed would prey upon it.

3. An organism may benefit another by destroying indirect enemies of that other—that is by destroying rivals which tend to stave out, though not directly to injure, the organism thus helped.

4. One living creature may benefit another by involuntarily carrying it about, and so serving it as a vehicle for change of place.

5. One animal sometimes benefits another organism by involuntarily feeding it in the process of feeding itself or otherwise.

* CONTEMPORARY REVIEW, for January and February, 1880.
† ἕξις, habit, state, or condition.
‡ See CONTEMPORARY REVIEW, July, 1879, pp. 713 and 714.

6. One organism may serve another species by carrying its eggs or seeds which thus become much more widely dispersed.

7. An organism of one kind may benefit another organism by accidentally aiding the reproductive processes of such other organism—as insects aid many plants by their visits to their flowers.

As to the unfavourable action of some living beings on other creatures:

8. One organism may injure another directly, by preying upon and devouring it.

9. It may injure it by continuously living with it as a parasite.

10. It may injure it by rivalry, by appropriating its food, and consequently by starvation.

11. It may injure another by benefiting accidentally the enemies or rivals of such other.

12. Lastly its one organism may injure another by hindering its reproductive processes.

In addition to these relations, living beings may either suffer or derive benefit from what is called *mimicry*—from being mistaken for creatures of another kind from that which they in reality are: a circumstance which, as we shall see, has relations with many striking peculiarities of form and colour.

From the foregoing relations it is plain that the greater or less abundance of any kind of animal or plant has a necessary influence on the abundance of some other kinds of animals or plants—as speaking generally, no one kind can greatly increase without diminishing the abundance of some other kind. Consequently if from whatever cause varieties arise better furnished than were their predecessors for the battle of life, and if such favourable characters are transmitted to their offspring, a numerical extension of such new forms will occur, with a corresponding numerical restriction of some other forms, and thus a relation becomes established between the modifications of certain species and the abundance or scarcity of others.

1. The first relation above enumerated in the foregoing lists is that by which one organism benefits another by serving that other as its food.

It is obvious that no organisms can exist save where they can obtain their needful nourishment.

Thus every carnivorous or insectivorous animal is doubly restricted in its range—1st, and directly, by the supply of animals fit for its food; and 2ndly, and indirectly, by the abundance of the supply of vegetable food needful for the existence of such animals. Therefore, if only for this reason, deserts must act as barriers to distribution.

The swallow-tailed butterfly is rapidly becoming extinct in England through the drainage of the fens, which process tends to exterminate plants which its larvæ need as their food.

The extent of the range of animals of different kinds is constantly enlarging or diminishing by means of such inter-relations, which are so obvious that no more on this head need be said.

But creatures may, as we shall shortly see, provide special food for others as our milk-yielding herds, or crops of grain, yield food to us.

2. Scarcely less obvious is the benefit bestowed by certain organisms on others through the destruction, by the former, of enemies of the latter.

Thus the abundance of cats (or other mice-eating animals) benefits certain humble bees, the nests of which are appropriated by mice to the detriment of the bees, with ulterior consequences to be noticed later. Thus, also, the destruction of small insectivorous birds, means the increase of insects.

Again, certain plants are benefited by ants, which are not only inimical to caterpillars and slugs, or to other kinds of ants, which would destroy the foliage of such plants, but are even, by their numbers, voracity, and powers of biting and stinging, capable of protecting them from large animals, such as cattle, or even from man. For this purpose, certain plants (*e.g.*, the Bull's Horn acacia,* and some others) maintain standing armies of these active insects, being provided with special cavities which serve them for barracks and with special nutritive growths, which supply the rations for the army and can be eaten without detriment to the plant.

Plants of the genus *Triplaris* have not only their trunks, but their smallest branches and twigs hollow, serving as the habitations of brown ants, which rush out in multitudes if the tree be touched or shaken, and bite furiously.

Again, the Trumpet-tree (*Cecropia peltata*) has a hollow stem, which is divided into cells by transverse partitions. The ants gain access to a cell by making a hole from the outside, and then burrow through the partitions, thus getting the run of the whole stem. Some cells they devote to the reception of eggs, others to grubs, and others to pupæ; while a queen ant will inhabit a cell by herself. If the tree be shaken, the ants rush out in myriads and search about for the molester.† But these ants do not live on any natural product of the tree directly; but, strange to say, they bring into it a herd of insect-cattle (scale-insects, like the cochineal insect), which they, as it were, milk, while the cattle, safely stabled in the cells, live by sucking the juices of the tree, which thus not only shelters, but also indirectly nourishes, its defensive army of ants. The milk of the scale-insects is a certain honey-like fluid which they secrete, which exudes from them, and which the ants greedily devour. This habit of cattle-keeping is not peculiar to these tree-inhabiting ants, but is practised by some other kinds which keep domesticated aphides in their nests.

But ants are not only provided with free quarters by some plants, but also, as before said, with rations. In the Bull's Horn acacia just mentioned, the ants are both securely housed and also furnished with a bountiful

* So called from its opposite diverging thorns, which are shaped like those of a bull.
† See Belt's "Naturalist in Nicaragua," p. 222.

supply of food, and to secure the attendance of the garrison at the right time and place, this food is so arranged and distributed as to effect that object with wonderful perfection. The leaves are bi-pinnate. At the base of each pair of leaflets, on the mid-rib, is a crater-shaped gland, which, when the leaves are young, secretes a honey-like liquid. Of this the ants are very fond; and they are constantly running about from one gland to another to sip up the honey as it is secreted. But this is not all; there is a still more wonderful provision of more solid food. At the end of each of the small divisions of the compound leaflet there is, when the leaf first unfolds, a little yellow fruit-like body united by a point at its base to the end of the pinnule. Examined through a microscope, this little appendage looks like a golden pear. When the leaf first unfolds, the little pears are not quite ripe, and the ants are continually employed going from one to another, examining them. When an ant finds one sufficiently advanced, it bites the small point of attachment; then, bending down the fruit-like body, it breaks it off and bears it away in triumph to its nest. All the fruit-like bodies do not ripen at once, but successively, so that the ants are kept about the young leaf for some time after it unfolds. Thus the young leaf is always guarded by ants; and no caterpillar or larger animal could attempt to injure it, without being attacked by the little warriors.*

We have a still more remarkable plant in the *Myrmecodia tuberosa*, which has a large, irregular, tuber-like stem, resembling a wasp's nest, growing on trees, and bearing fleshy leaves and small flowers. This structure is riddled with galleries formed by ants which inhabit it, and these excavations not only do not seem to injure it, but are said to be necessary to enable it to flourish. Its seed is somewhat like that of the mistletoe, and germinates on any suitable branch upon which it may have fallen. It then grows to a certain extent, but if not perforated by the ant, fails (as we hear) to develope itself further and dies. The beneficial action of the ant is by no means yet understood.

3. But an organism may benefit another by destroying the indirect enemies or rivals of the latter. It is thus that around herdsmen's huts in the Alps, we find species of aconite, dock, chenopodium, and different plants, which have gained an extensive footing through the destruction of other vegetation by the grazing herds, which find the aconite and other plants referred to, unpalatable, and so, by constantly sparing them, unintentionally extend their range.

4. As to the benefit† which an organism may receive by being involuntarily carried about by another, we have examples in the sessile barnacles which fix themselves on the whelk-shells made use of by hermit crabs as their artificial defensive armour, and on the skin of the whale, and being thus carried about, get a more plentiful supply of food.

* Op. cit., p. 219.

† For a multitude of interesting facts connected with the whole of this subject, see "Animal Parasites and Messmates," by Professor Van Beneden, 1876.

It is very problematical whether the sucking fish or Remora (which does not suck in the sense of extracting juice from the animal to which it attaches itself, but only adheres by "suckers") similarly benefits by its adhesion to foreign bodies. This curious animal was made use of in ancient love-philters, and is said to be now used by fishers for turtle, the fish being let go with a cord attached to its tail, so that it may be able to be drawn in again together with any turtle to which it may have adhered; this, however, is a fable.

5. An animal may benefit others, not only by carrying them about but also by involuntarily feeding them with a portion of its own food, or otherwise.

Thus lobsters, in the midst of the eggs which load their abdomen at certain seasons, often carry about with them a sort of leech, which feeds on such eggs as may die.

More singular is the habit of a worm of the Philippine Islands, which inhabits the intestines of a fish, its head projecting from the fish's anal aperture, and feeds (while thus carried about) upon small creatures which may be attracted by the fish's excreta.

Similarly, a small muræna may inhabit the branchial sack of the angler (*Lophius*); and another small fish may dwell within the interior of a sea anemone or of a starfish. Indeed, small fishes may live inside the mouths of larger ones, nourishing themselves on morsels of the latter's food.

But the guest may sometimes feed its host, as seems to be the case with the small crabs (called Pinnotheres), which live within the valves of mussels, and which latter profit by the fragments of food which the active crabs acquire.

One of the most curious instances of two organisms harmoniously and habitually living together, is that presented by the group of lichens. All lichens were, until of late, supposed to be a distinct kind of plant, parallel with the fern-kind, the alga-kind, or the fungi; but it now appears that every lichen is a compound being, made up of two kinds of plants growing in constant and intimate association. Every lichen is, in fact, composed of an alga and a fungus, which live together, and are mutually beneficial each to the other.

The structure of a lichen is as follows:—

Lichens are perennial organisms, which grow upon stones, the bark or leaves of other plants, and on other lichens. They are grey, yellow, or greenish-yellow, and their body, or Thallus, is a flattened scale-like encrusting body, or a leafy expansion, or a branching structure, or a shrubby tuft. They are long-lived, with intermittent growth. Each consists of certain layers; an external (epidermal or cortical layer), an interior or medullary layer, and a deeper layer, or hypothallus, from which root-like prolongations extend into the supporting body. Certain discs (which may be enclosed or open) are formed on the lichen, and each is called an Apothecium. It contains a number of vertical cases, or

Sporangia, within which Spores are developed. All that is hitherto described is of the nature of fungus. But scattered in the substance of the Thallus, and often forming a separate layer, are certain green cells called *Gonidia.* These are Algæ. They multiply, and their progeny, called *hymenial gonidia,* come to lie about the walls of the Sporangia. When ripe, the Sporangia burst and cast forth their spores, and with them, some of the hymenial gonidia. Then from the spores, hyphæ grow forth and invest the gonidia which have adhered to the spore, and the gonidia thus invested are thereby somehow benefited and increase much in size and greenness. The hyphæ multiply and the structure grows again into a lichen. If gonidia are sown without the fungus, they merely divide and multiply as small algæ, and the fungus sown without gonidia will germinate and grow for a time, but soon withers and dies.

We have thus, in a Lichen, a wonderful organism, composed of two kinds of plants which naturally live and grow as conjoined vegetable messmates and cannot flourish one without the other.

Instances of beneficial cohabitation have been given in the insect-herd-keeping ants. But some ants are benefited by other ants of a different species, which the former take captive when young, and which, when full grown in the nests of their captors, turn to and do the domestic work of the community. So great is in some instances this dependence of certain kinds of warrior-ants on their slaves, that they are habitually carried on their journeys by the latter, and will perish though surrounded by food, unless their slaves are at hand to feed them.

6. But some organisms may aid others by involuntarily disseminating the eggs or seeds of the latter.

Thus it is notorious that plants are carried to distant lands by birds which have swallowed seeds and have voided them while the seeds are still alive and capable of germination.

To this very end (*i.e.*, that they may be swallowed) many seeds are enclosed in soft, juicy, pleasantly-tasting envelopes. And such fruits again assume when ripe colours which more or less strongly contrast with that of the foliage leaves, and so more readily attract the attention of the animals which eat them.

Birds also sometimes disseminate seeds by carrying them enclosed in the mud which may adhere to their feet. Wading and swimming birds frequently thus carry away with them the seeds of plants, the eggs of aquatic insects and those of snail-like animals. "Fresh water molluscs just hatched were found to attach themselves to a duck's foot suspended in an aquarium; and they would thus be easily carried from one lake or river to another, and by the help of different species of aquatic birds, might soon spread all over the globe. Even a water-beetle has been caught with a small living shell (*Anchylus*) attached to it; and these fly long distances and are liable to be blown out to sea."*

* Wallace, "Geographical Distribution," vol. i. p. 31.

Similarly many plants, like the common golden rod, have their fruits or seeds so provided with hooked processes that they adhere to the fur coats of every passing beast, and so get their range extended, as has been before pointed out.*

Parasites also are habitually dispersed far and wide both on land and in water, by the excreta of their numerous and varied hosts, as will shortly appear when parasitism is treated of.

7. The aid which some organisms give to the reproductive purposes of other organisms, is confined to that aid which is given to the fertilization of plants by the visits of insects or small birds. But the aid thus given is immense both as regards the total result and the great number of species thus affected.

Most flowering plants bear more seed when fertilized by pollen from another flower or from another plant, and are sometimes even sterile, when fertilized by their own pollen. Hence the common need of insect visitors and the relation thus established between animals and plants, the former involuntarily aiding the reproductive processes of the latter. As we shall shortly see, flowers are often so shaped as to favour the visits of useful insects, and similarly the legs and mouths of insects are appropriately formed to enable them to visit, profitably to the plants, their nectar-bearing flowers.

Most plants which are fertilized by insects, and some plants which are not so fertilized, have flowers conspicuous by colour or by odour, or by both these attracting qualities, of which qualities the attraction of insects often seems to be one of the main ends. But insects visit the flowers neither for the sake of one nor the other of these qualities, but for the practical purpose of eating the sweet secretion or nectar which such flowers produce generally in their deeper recesses. Different flowers are, in the most varied and ingenious ways, so constructed that the visiting insect may go away from one flower well dusted with pollen grains, and may leave some of these grains adhering to the stigma of the flower next visited.

Flowers, the anthers and stigmas of which ripen simultaneously, are generally so arranged that the pollen cannot get at the stigma of its own flower, but has to be carried to that of another flower; while in many flowers, the arrangement of the parts is such that self-fertilization would seem to be inevitable, yet such action is avoided by the simple contrivance of asynchronism in the ripening of the pollen and stigma—the one ripening first in some, the other in others. In the Arum, the pistils mature before the anthers, and there are within the spathe numerous hairs so arranged as freely to admit insects to its depths, but to oppose their egress. Thus, if they come in after having been dusted with pollen from other flowers, they, while imprisoned, if not even while entering, impregnate the stigmas. But if they come in fresh to the flower, the hairs imprison them, and they, while buzzing about, get

* See CONTEMPORARY REVIEW, October, 1879, p. 322.

themselves well dusted with pollen from the ripe anthers. After a time the hairs shrivel, and the dusted insects so escape to visit profitably another Arum. Similarly in Aristolochia, insects are imprisoned for a time with like results. In the dead nettle (*Lamium*) the pistil projects beyond the anthers, and so is fertilized by an incoming, pollen-dusted bee.

In some plants different individual flowers will vary in two or three correlated ways, the better to ensure cross-fertilization, as in the primrose, in which one flower will have the stamens long and the pistil short (so that the insects visiting it get dusted with pollen), while another will have the pistil long and stamens short, so that the dusty insect visiting it may more surely fertilize it. In some plants, as *e.g.* in Salvia, the stamens have their anthers set as on a swivel, so that an incoming insect, by pushing (as it necessarily does) against the lower barren part, brings the pollen-bearing part down on its back. In no plants are the arrangements for insect fertilization so curious and complex as in the orchids. Their flowers have their nectar stored in a spur projecting backwards from the labellum. Insects, in trying to reach it, necessarily come in contact with the rostellum, and the pollinia become attached to the insect's head. The insects then fly away with the pollinia inclined backwards, and were they then to enter another flower no fertilization would be effected, for the pollinia would be inclined right away from the stigmatic surface of the next flower visited. But the candicle of each detached pollinium has a most remarkable power of one-sided contraction, the result of which is that the pollinia bend more and more forwards till they are inclined at right angles to their original inclination. The result of this change is that when they visit the next flower the pollinia necessarily strike against the stigma to the adhesive surface of which some pollen grains at least are left adhering.

Since flowers are so generally fertilized through the visits of suitable insects which are in search of nectar, it is obviously very desirable for plants that their flowers should be protected from the visits of insects or other animals which (from their minute size or wingless condition, or from some peculiarity of organization) are unsuitable for effecting the fertilizing process. Accordingly we find that flowers are thus protected by a variety of contrivances.

In the first place it has been suggested that the so-called "sleep" of flowers is a closure of the blossom which takes place in order to hinder the visits of useless or hurtful insects, which are active at the time of such "sleep," whilst the opening takes place while suitable insects are on the wing. Such action is *e.g.* said to be found in certain plants of the Pink order, which expose their blossoms and give forth their perfume only in the evening and at night.

But the phenomena of plant movement referred to, is too general to be accounted for by such a cause, which could have no effect on the folding of the leaflets of foliage leaves, as in clover, and movements plainly take place in many flowers in obedience to quite other influences—such *e.g.* as the light of the sun—as in the Pimpernel. Still, the daily closing of flowers does no doubt serve, in many cases, to exclude undesirable insect visitors, while their opening is, of course, a necessary condition for the admission of desirable ones.

But the visits of undesirable and especially of wingless insects and other small creeping animals is specially guarded against in many plants by a variety of complex and ingenious contrivances.*

Thus, snails, slugs, and caterpillars may be kept from flowers by means merely of a group of prickles placed on every part of the plant which has to be traversed to reach the flower. Such creatures would carefully avoid bringing their soft and delicate bodies in contact with such defences.

Flowers (and indeed the foliage of many plants) are protected by the unpleasant tastes of the alkaloids (resins or oils) which they possess, or by the leaves below the flower-stalk being in some cases so formed as to hold a quantity of dew, so that the flower rises from the midst of a small pond which ants, &c., cannot traverse. They may be also protected by viscid secretions interposed in the wingless insects' path, or by the curious action of milky juice, as Dr. Kerner thus shows:—

> "I placed various kinds of ants upon sundry plants that were full of milky juice, and was not a little surprised to see the ants soon glued down by it. No sooner had the ants reached the uppermost leaves, or the peduncles and the involucral bracts, then at each movement the terminal hooks of their feet cut through the epiderm, and from the little clefts thus made, milky juice immediately begun to flow. Not only the feet of the ants, but the hinder parts of their body were soon bedrabbled with the white fluid; and if the ants, as was frequently the case, bit into the tissues of the epiderm in self-defence, their organs of mastication also at once became coated over with the milky juice. By this the ants were much impeded in their movements, and in order to rid themselves of the annoyance to which they were subjected, drew their feet through their mouths, and tried also to clear the hinder part of their body from the juice with which it was smeared. The movements, however, which accompanied their efforts simply resulted in the production of new fissures in the epiderm and fresh discharges of milky juice, so that the position of the ants became each moment worse and worse. Many of them now tried to escape by getting as best they might to the edge of the leaf, and letting themselves fall from thence to the ground. Some succeeded, but others tried this method of escape too late; for the air soon hardened the milky juice into a tough brown substance; and after this all the struggling of the ants to free themselves from the viscid matter was in vain. Their movements became gradually fewer and weaker, until finally they ceased altogether, and the dead animals were left adhering to the involucre or the uppermost leaves."†

Again, both the access of unwelcome visitors, and the guidance of welcome visitors, along paths most useful for the plant's fertilization, are sometimes aided by tangles of hair-like processes which may grow within the flower and acts as path-pointers.

* See "Flowers and their Unbidden Guests," by Dr. A. Kerner. Translated by Dr. Ogle. C. Kegan Paul & Co. 1878.

† Op. cit., p. 68.

The protection of the attracting nectar is often effected by the curving, dilating, or crowding together of parts of the flower so as either to completely enclose it or only to allow the passage of an insect's sucking proboscis. As an example of the first mode may be mentioned the snapdragon, in which the nectar is so enclosed that an insect cannot get at it without forcibly pushing open the mouth of the corolla. The second mode may be seen in *Ænothera grandiflora* by a contraction of the calyx reducing the opening leading to the nectar so much as only to admit a slender proboscis. Again in *Scutellaria albida*, the two lateral petals greatly bulge. The consequence of this is that insects, in "entering into the flower, push these two bulging parts asunder; and the consequence is that the loose pollen which has been discharged from the anthers under the upper lip, and has been deposited on the cushion-like upper surface of the arched bulgings, is displaced from this position and showered down on the back of the insect. The insect in its further roving soon carries it to some other flower. Supposing these bulging parts not to exist, then no insect would rub against the pollen, unless that part of its body which has to be introduced into the tube were at least 4^{mm} in thickness; but as it is, insects of only half these dimensions can push apart the two bulgings, and in so doing will get besprinkled with pollen, and will therefore be just as useful as larger insects in promoting intercrossing."* Again, a calyx may (as in many *Sileneæ*) be so inflated that a bee's proboscis is not long enough to traverse the space from its exterior to the nectary, a condition which will save such flowers from being gnawed through laterally by bees, as flowers sometimes are. Other plants, as *Impatiens tricoruis*, have nectaries at the base of the foliage leaves and so divert creeping insects from visiting the flowers and rifling them of their nectar. Even the form of pollen varies in harmony with its mode of distribution, being smooth or even winged in wind-fertilized plants, while that of others is often covered with spiny projections to adapt it to insect conveyance.

As to the attractions of colour and scent, it is evident that these will be increased by the aggregation of flowers into masses or heads of Inflorescence, as in Umbellifers, Lilacs, &c.; and similarly their attractive action at a distance is increased by their being massed together in large quantities. It is thus that Mr. Wallace explains the beauty of Alpine plants. He tells us† their beauty and massing may be traced to the comparative scarcity of winged insects in the higher regions, and to the necessity of attracting them from a distance. Similarly he explains the overwhelming preponderance of Ferns in such places as Tahiti, and the absence of conspicuous flowers in the flowering plants of the islands of the Galapagos Archipelago, by the paucity of insects in such places. Nevertheless this must be also due, and perhaps greatly due, to the humidity of the air. In Juan Fernandez, though insects are very scarce, yet showy flowers are by no means deficient; the circumstance is sup-

* *L. c.* p. 117.

† "Tropical Nature," p. 232.

posed to be due to an extraordinary abundance of humming birds, which, in their visits to flowers, perform the same fertilizing action as that performed by insects. There are many other birds, such as the brush-tongued lories and the honey-eaters of the Australian region, which act like insects in fertilizing flowers.

Another interesting fact is noted by Mr. Wallace.* He says:—"Among the minor but not unimportant peculiarities that characterise the lofty tropical forests, is the curious way in which many of the smaller trees have their flowers situated on the main trunk or longer branches instead of on the upper part of the tree. The cacao-tree is a well-known example. . . . . Another (in Borneo) belonging to the family of custard-apples, has its slender trunk, about 15 or 20 feet high, completely covered with star-shaped flowers, three inches across, of a rich orange-red colour, making the trees look as if they had been artificially decorated with brilliant garlands. Bees and butterflies are the greatest flower haunters. Now bees 'love the sun,' and frequent open grounds or the flowery tops of the lofty forest-trees, fully exposed to the sun and air. The forest shades, on the other hand, are frequented by thousands of butterflies, but these mostly keep near the ground, where they have a free passage among the tree-trunks, and visit the flowering shrubs and herbaceous plants. To attract these it is necessary that flowers should be low down and conspicuous. If they grew in the usual way, on the tops of these smaller trees, overshadowed by the dense canopy above them, they would be out of sight of both groups of insects; but, being placed openly on the stems, and in the greatest profusion, they cannot fail to attract the attention of the wandering butterflies."

Such are some of the curious inter-relations which exist between very different orders of living beings, with respect to the involuntary assistance afforded by one set to the reproductive processes of the other set. In spite, however, of the manifest inter-relations between the forms of insects and the forms and colours of flowers, a sufficient number of instances are to be found† in which shapes and colours do not answer any purpose of the kind above referred to, to shew that such explanations of floral beauty are after all fundamentally inadequate.

We may now turn to consider the various kinds of prejudicial action, by which one kind of organism can affect another.

8. As to the various ways in which living beings may be related one to another injuriously, the first and most obvious is the direct injury which one kind inflicts on another by preying upon it, as lions destroy antelopes, or as fishes devour one another. And hereby the range and abundance of one kind of organism is being constantly affected by the presence of others in ways not always apparent at the first glance.

* *L. c.*, p. 34.

† See Henslow, "On Self-Fertilization," "Trans. Linn. Soc.," Second Series, Botany vol. i. The reader may also profitably refer to the Hon. Justice Fry's article on this subject in the CONTEMPORARY REVIEW, for December, 1879.

Thus, with respect to pigeons, Mr. Wallace has remarked* that they are especially abundant and varied in tropical archipelagoes; so that, if we take the Malay and Pacific Islands, the Madagascar group, and the Antilles or West Indian Islands, we find that they possess between them more different kinds of pigeons than all the continental tropics combined. Yet further, that portion of the Malay Archipelago east of Borneo, together with the Pacific Islands, is exceptionally rich in pigeons; and the reason seems to be that monkeys and all other arboreal mammals that devour eggs, are entirely absent from this region. Even in South America, pigeons are scarce where monkeys are abundant, and *vice versâ*. But this must be due in part (and perhaps largely) to monkeys not only eating their eggs (for they eat the eggs of other birds also) but to their eating much fruit, and so helping to starve out the pigeons.

All animals are, as has been before said more than once, directly or indirectly supported by plants, and the range of plants and the very existence of species is often wonderfully affected by the appearance on the scene of even one new kind of animal. Thus a great grazing district at the Cape, called "the Midlands," was, in Burchell's time, covered with luxuriant greensward, with a few trees and bushes, with willows and acacias along the sides of its streams. The introduction of sheep first destroyed the grass and then most of the shrubs, a change which affected the rainfall, so that this region has been invaded by the hardy plants of the adjacent Karroo desert, and is fast becoming an extension of the desert itself.

St. Helena, when discovered by the Portuguese in the year 1502, was entirely covered with forests (the trees drooping over its high precipices over-hanging the sea), with a rich flora of absolutely peculiar plants. In 1513 some goats were introduced, and in fifty years had multiplied into thousands. Yet in 1709 trees still abounded, and the peculiar native ebony tree was still so abundant that it was used to burn lime with. In another hundred years (1810), the goats had entirely destroyed the great forests, yet so rich was the soil that it was hoped, with the destruction of the goats (and they then were destroyed) the island would regain its wood by a quarter of a century. But this was not to be, for the Government of that day most unhappily planted the island with trees and shrubs from other countries, which have so grown and spread that now the old indigenous flora is almost confined to a few patches on the central ridge of the island, at a height of 2700 feet. What we have lost may be judged from the fact that of the forty-five kinds of flowering plants and twenty-three species of ferns which yet survive, no less than forty of the former and thirteen of the latter are absolutely peculiar to the island.

Although plants are thus the food of animals, animals are also occasionally the food of plants. This we have seen to be the case with respect to Drosera and Venus's fly trap. It has also been ascertained that the fluid secreted by the leaves of these plants really digests

* *L. c.*, p. 103.

the insects caught, as also that the plants so fed are greatly benefited by their animal diet, increasing in size and weight, and in the number and perfection of the seeds they produce. Similar powers seem to be exercised by the curious pitchers of *Nepenthes* and *Sarracenia*.

9. But one organism may injure another by living upon it continuously, and slowly appropriating a portion of its substance as nutriment. In other words, some creatures may be parasites, and injure their hosts by their parasitism. Many plants may appear, to the superficial observer, to be parasites on other plants, when they are really nothing of the kind. Having both flowers and foliage leaves of their own, they merely make use of other plants as a support, to raise them up in the air, as is the case with the well-known tropical orchids called air-plants. Such plants therefore are not parasites but *epiphytes*, and nourish themselves entirely, instead of absorbing nutriment from their host.

Plants may, however, be real parasites in one of two different degrees. They may be but incomplete parasites like the mistletoe (*Viscum album*), which developes its own foliage leaves, although in part it derives its nutriment from the juices of the plant it infests, and into the substance of which its own fibrovascular bundles find their way. It lives, indeed, upon the unelaborated, but not upon the elaborated juices of its prey. If it absorbed the latter it would not need green leaves. An example of a complete parasite is the Dodder (*Cuscuta*), which has a thread-like stem, but no foliage leaves, only flowers, and is to be found on heather or furze-bushes. Its seed, when it germinates, gives rise to a wiry plant, which shoots up and attaches itself to a prey, when, having secured its hold, it loses all connection with the ground. It attaches itself by developing little concave discs, or suckers, which develope adventitious roots, which again penetrate their prey. Other parasites in England are the tooth-wort (*Lathræa*), which grows on the roots of plants, as *e.g.* on those of the alder. Another is the broom-rape (*Orobanche*), which is parasitic upon clover. But the most wonderful parasite of all is the immense *Rafflesia* of Sumatra.*

No flowering plants are parasitic upon animals, but the great group of fungi, so many of which are parasitic upon plants, give us examples of plants which are truly animal parasites. Amongst these is the fungus which thrives in the bodies of flies, and shows itself in the form of white bands protruding through the intervals of the abdominal rings. It also further exhibits itself—when such a fly is to be seen dead and adhering to a window pane—by a multitude of spores which form a circular disc of dust on the glass around the fly's body. Another curious fungus is that inhabiting a large New Zealand caterpillar. It lives within it till the animal descends into the earth to become a

* This plant has no stem or foliage leaves, but consists exclusively of one enormous flower, which may measure nine feet in circumference and weigh fifteen pounds. It was discovered growing from a sort of vine, with the substance of which its own substance was closely interblended.

chrysalis, and is there and then fatal to it. Afterwards it grows up from it to the surface, and thus comes to have the appearance of a plant, the root of which has assumed the form of a caterpillar. But, indeed, many minute vegetable organisms are parasitic upon animals, being the cause of disease by their presence, as is the case in the splenic fever of hogs; and such will probably be found to be the case in many other instances.

The number of animal parasites is immense. Above a dozen different kinds may find their appropriate and happy home upon or within the human body. Creatures of the earth, air, and water alike swarm, with smaller creatures living upon them externally and internally. The most familiar external parasites of men and beasts are lice; one or two species of which inhabit each kind of beast, while three kinds live upon man. Besides these we have creatures belonging to the mite class, as the itch insect and the curious little *Demodex folliculorum.* As to the former, it is a small, flattened, short-limbed creature, with long spine-like processes. The latter is a minute worm-like animal, inhabiting the sebaceous follicles of our hairs. Other creatures, allied to mites, are called *Linguatula,* and they inhabit the frontal sinuses of the dog. When adult they are like anything but mites, being very elongated worms. Amongst crab and lobster-like creatures we find remarkable instances of external parasitism in such forms as *Lerneocera* or *Tracheliastes,** which begin life like other creatures of their class, but after attaching themselves to the bodies of fishes, and nourishing themselves by suction, lose by degrees all their members, become little more than elongated sacks containing nutritive and reproductive organs. Still more remarkable are the *Rhizocephala* already described.†

But many animals feed upon plants in such a modified way that they may be termed vegetable parasites. Such are the plant-lice or Aphides,‡ which, plunging their suctorial proboscis into the tissues of plants, remain quiescent, and move but little and slowly between the intervals of sucking. Such, again, are the still more quiescent cochineal insects, which look like small scales of the cactus to which they adhere, and the true nature of which was long doubted.

But much more remarkable are those insects (called Ichneumons) which plunge their ovipositor into the tissues of a plant and then deposit one of their eggs, with an accompanying secretion, the effect of which is to produce a large, generally spheroidal, growth of modified vegetable tissue around the egg. Such a growth is a gall, and serves not only to protect the egg, but to nourish the grub which comes forth from that egg when hatched. Other ichneumons lay their eggs within the bodies of living caterpillars, and the grubs, when hatched, nourish themselves by devouring the body of their host. They instinctively avoid the vital parts till the last, so that the caterpillar generally lives long enough to spin its cocoon and enter on its chrysalis stage, after which it dies.

* CONTEMPORARY REVIEW, Sept. 1879, p. 31. † *L. c.* p. 31. ‡ *L. c.* p. 32.

The ichneumons also transform themselves within the skin of their host, so that there comes forth from the cocoon, not the animal which formed it, but the fatal progeny it had involuntarily nourished. A curious example of an analogous kind is the wasp, Sphex, which stings caterpillars or spiders in a particular spot, and so paralyses them as to motion. It then takes them to the cavity in which it has placed its eggs, and leaves them there, so that its young, when hatched, may be able (though but grubs) to feed upon the still living, but helpless prey.

Such creatures naturally lead us to consider true internal parasites, of which there are a vast multitude of higher and lower forms. Amongst the former may be mentioned the now celebrated *Trichina*, first described by Professor Owen in 1832. *Trichinæ* are minute thread-like worms, which live coiled up in the flesh of men and beasts. As many as 700,000 have been counted in a pound of human flesh. They are also found in pork. If pork so infected be eaten imperfectly cooked, the worms are set free from the flesh they inhabit by the process of digestion, and when free they reproduce with wonderful rapidity, the eggs when hatched giving birth to young worms, which bore through the walls of the stomach and intestines, and lodge themselves in the flesh, there awaiting the opportunity of being eaten by some other animal, and so finding an opportunity to complete their development and reproduce their kind. When present in great numbers they cause grave disorders, and even death. Another well-known worm is the Guinea worm—a thread-like worm, which may be 12 feet long, and is found infecting the feet and legs of the people of the tropical parts of Asia and Africa. A very large worm is *Strongylus gigas*, which infests the kidney of the horse, dog, and rarely of man, partly destroying that most important viscus. A very curious worm is the Bilharzia (of Cobbold), another African parasite, and one that is very dangerous. It is one of the greatest causes of disease in the Nile valley, half the population being more or less injured by it. The male worm is much larger than the female, and is so bent as to form a deep concavity on one side of the body, in which concavity the female lies permanently embraced. Both, however, are very small, as is evident from the fact that they inhabit in millions the blood-vessels of infected subjects, especially those of the urinary organs, where they cause ulcers through which their eggs pass out.

But the most characteristic internal parasites are the multitudinous kinds of tape-worm, an animal which exists in two conditions. One of these is the larval state, devoid of reproductive organs, and is short and rounded. It is called the bladder worm, or cystic stage. In the other perfect or reproductive stage (analogous to the imago stage of insects), the body is very elongated and pointed. In at least most cases, a tape-worm requires two distinct animals as hosts, in order that it may be able to go through its whole development. Thus, if the eggs of a certain kind find their way into the alimentary canal of a pig, they only develop in that animal into the larval form and get no further, and leaving the intestines, pass into the flesh, liver, or elsewhere, causing the meat of such creature to be what is called "measly." If such meat be eaten raw or under-done by man, the larvæ then rapidly assume the imago or sexual stage, and grow indefinitely, reproducing their kind by millions of ova, the overwhelming majority of which never have the opportunity of developing at all. Similarly, a bladder-worm of the ox becomes an adult tape-worm in man, and other bladder-worms of the rabbit, of the mouse, of the sheep, of cattle, and of man, attain their perfect condition only in the intestines of the cat, dog, or fox. Sometimes the larval condition is much more prejudicial to its host than is the fully developed or imago stage. Thus, one tapeworm of the dog (*Tænia cœnurus*) is insignificant as to its ill effects on that animal. But if its eggs are taken into the alimentary canal of the sheep, the progeny is carried by the circulation into the brain, and there developes into such large bladder-worms as to destroy great portions of the brain producing the disease called "the staggers," and ultimately death. Thus, the very animal used to protect sheep, is indirectly their fatal enemy by unconsciously depositing (along with its excrement) the ova of this deadly bladder-worm, amidst the grass on which the sheep feed.

Still more serious is the enormous and complexly formed bladder-worm, which is the larval condition of another still more insignificant tape-worm of the dog, called *Tænia echinococcus*. The egg of this tape-worm may be voided by some dog into a stream or rivulet, and if such egg be accidentally drank in by a human being, it grows into a kind of bladder-worm, the ravages caused by the growth of which are so serious, that in Iceland (where the social conditions lead to the maintenance of many dogs), it is estimated to be the cause of one death out of every seven. So great is the evil, that the Iceland Legislature, some years ago, ordered that all the dogs of the island should be simultaneously purged and their excreta burned. These facts with respect to the dog show that the filthy unclean habit in which so many ladies indulge of allowing their lap-dogs to lick their hands and faces is a practice not unattended with danger.

10. That animals may injure each other by rivalry is evident, since two sets of plants cannot simultaneously inhabit the same stretch of surface soil, or two sets of animals nourish themselves with the same food. We have lately seen how the introduction into St. Helena of foreign vegetation completed the destruction begun by the goats, and it is a notorious fact that when European plants have been introduced into regions the vegetation of which was widely different, as in New Zealand, the European kinds have propagated themselves, to the destruction of masses of the native flora. So also with animals, we see even in the neighbourhood of our English towns how sparrows multiply themselves and starve out many other kinds of birds, a process now going on even in many remote parts of the country.

11. That organisms may occasionally injure other organisms by involuntarily benefiting the enemies or rivals of the latter is also a patent fact. We have an example of this in the destruction of cattle by the African elephant—a destruction so great, that where the elephant is found no cattle can live. This relation is due to the circumstance that the tsee-tsee fly (an insect so fatal to cattle) also requires the elephant as a host in which to pass one stage of its existence. Thus the elephant, by harbouring the tsee-tsee fly, indirectly destroys the cattle.

Again, we may see from facts which Mr. Darwin has pointed out that a destroyer of cats would necessarily be the enemy of a certain kind of clover which needs for its fertilization the visits of a particular species of humble-bee, the nests of which are destroyed by mice. Consequently the cats, by destroying the mice, help the clover, and whatever tends to diminish the number of cats tends also to destroy the clover by rendering it sterile.

12. This last example will also serve to illustrate how one kind of living being may injure another by hindering the carrying on of the latter's reproductive processes. Such injury in the case just cited was effected by the mice or by anything tending to destroy cats, or hawks, or owls, or other enemies of mice. Similarly, whatever tended to extirpate any kind of insect would also tend to extirpate such plants as might be dependent on such insect for the fertilization of their flowers.

It now only remains to consider those curious phenomena called *mimicry*. "Mimicry" is a close and striking, yet superficial resemblance borne by some animal or plant to some, perhaps, very different object. A familiar example of mimicry is seen in the bee and spider orchis, and in clear-winged moths, which may be mistaken for bees. One of the most perfect examples of mimicry is afforded by an insect (of the grasshopper and cricket order) which is called, on account of the appearance it presents, the "walking leaf," since both in form and colour its body so closely resembles a leaf, that it is most difficult of detection when found amongst real leaves. Not only moths, but also beetles imitate bees. Wasps and objects the most strange are also mimicked by beetles, such, for example, as pieces of dung, or drops of dew. There are also creatures called bamboo or walking-stick insects, which present a most striking resemblance to twigs of bamboo, and this the more from the strange habit they have of hanging with their legs stretched out unsymmetrically, and so more perfectly resembling the plant. One of the most complete instances of mimicry is that afforded by an Indian butterfly, as to which Mr. Wallace remarks* :—

"But the most wonderful and undoubted case of protective resemblance in a butterfly which I have ever seen, is that of the common Indian *Kallima inachis*, and its Malayan ally, *Kallima paralekta*. The upper surface of these is very striking and showy, as they are of a large size, and are adorned with a broad band of rich orange on a deep bluish ground. The under-side is very variable

* "Natural Selection," chap. iii. p. 45.

in colour, so that out of fifty specimens no two can be found exactly alike, but every one of them will be of some shade of ash, or brown, or ochre, such as are found among dead, dry, or decaying leaves. The apex of the upper wings is produced into an acute point, a very common form in the leaves of tropical shrubs and trees, and the lower wings are also produced into a short narrow tail. Between these two points runs a dark curved line exactly representing the midrib of a leaf, and from this radiate on each side a few oblique lines, which serve to indicate the lateral veins of the leaf. These marks are more clearly seen on the outer portion of the base of the wings, and in the inner side towards the middle of the apex; and it is very curious to observe how the usual marginal and transverse striæ of the group are here modified and strengthened so as to become adapted for an imitation of the venation of a leaf." . . . . . "But this resemblance, close as it is, would be of little use if the habits of the insect did not accord with it. If the butterfly sat upon leaves or upon flowers, or opened its wings so as to expose the upper surface, or exposed and moved its head and antennæ, as many other butterflies do, its disguise would be of little avail. We might be sure, however, from the analogy of many other cases, that the habits of the insect are such as still further to aid its deceptive garb; but we are not obliged to make any such supposition, since I myself had the good fortune to observe scores of *Kallima paralekta* in Sumatra, and to capture many of them, and can vouch for the accuracy of the following details. These butterflies frequent dry forests, and fly very swiftly. They were seen to settle on a flower or a green leaf, but were many times lost sight of in a bush or tree of dead leaves. On such occasions they were generally searched for in vain, for while gazing intently at the very spot where one had disappeared, it would often suddenly dart out, and again vanish twenty or fifty yards further on. On one or two occasions the insect was detected reposing, and it could then be seen how completely it assimilates itself to the surrounding leaves. It sits on a nearly upright twig, the wings fitting closely back to back, concealing the antennæ and head, which are drawn up between their bases. The little tails of the hind wing touch the branch, and form a perfect stalk to the leaf, which is supported in its place by the claws of the middle pair of feet, which are slender and inconspicuous. The irregular outline of the wings gives exactly the perspective effect of a shrivelled leaf. We thus have size, colour, form, markings, and habits, all combining together to produce a disguise which may be said to be absolutely perfect; and the protection which it affords is sufficiently indicated by the abundance of the individuals that possess it."

But there are facts yet more extraordinary. Some insects which mimic leaves, mimic even the marks made upon leaves by the ravages of other insects, or by mould. As to this, Mr. Wallace tells us*:—

"One of these creatures obtained by myself in Borneo (*Ceroxylus laceratus*), was covered over with foliaceous excrescences of a clear olive-green colour, so as exactly to resemble a stick grown over by a creeping moss or jungermannia. The Dyak who brought it me assured me it was grown over with moss, although alive, and it was only after a most minute examination, that I could convince myself it was not."

In a certain leaf butterfly we come to a still more extraordinary part of the imitation, for we find representations of leaves in every stage of decay, variously blotched and mildewed, and pierced with holes, and in many cases irregularly covered with powdery black dots, gathered into patches and spots, so closely resembling the various kinds of minute fungi that grow on dead leaves, that it is impossible to avoid thinking

* Op. cit., p. 64.

at first sight that the butterflies themselves have been attacked by real fungi.

Amongst plants we also find cases of mimicry; thus some *Euphorbias* which grow in Africa so greatly resemble cacti, that it is difficult to believe, when they are not in flower, that they are not really the plants they so resemble. Another close resemblance exists between *Eucalypti* and *Mimosæ* in Australia. Also a certain fern (*Stangerda paradoxa*) closely imitates a Cycad; and as has been pointed out by Mr. Alfred W. Bennett, the winged fruits (*Samara*) of no less than four genera of Brazilian plants belonging to three distinct natural orders, are alike not only in the form of the wing, but in the very texture and arrangement of the veins, so that dissection is needed to detect the essentially different structures which exist beneath this great external similarity.

Besides insects and plants, various fishes, reptiles, birds, and even some beasts, also appear to be unconscious mimics. Thus the pipe fish (*Phyllopterygx eques*) bears curious, long, cutaneous appendages which imitate the forms of the seaweed amidst which the fish habitually lives. There is also one kind of bat which mimics the leaves of the tree on the fruits of which it feeds, while another kind of bat has the appearance while at rest of a large, ripe fruit.

These resemblances are evidently akin to those so frequently observed to exist between the colour of an animal and that of adjacent objects—resemblances which many animals either permanently possess or temporarily assume. Of these instances there are legion: as sandy-coloured snakes and lizards of deserts, and green snakes of trees. Actual changes of colour to harmonize with surroundings are shown by the ptarmigan, the variable hare, the ermine, the Arctic fox and others, and most notably of all, because most frequently and rapidly, by the chameleon. Mr. Leslie enclosed certain caterpillars of one kind in two boxes, one black the other white, and he found that the colour of the chrysalis in each case harmonized with the colour of the box. Mr. Robert Holland also found the cocoons of the Emperor moth to be either white or brown according as they were spun on paper or amid dead grass or on soil. Mr. K. H. Stebbing has found that the chameleon shrimp has the power of changing from a dark purple colour to glassy transparency. The protective effect of many of these changes is evident, but their action in some cases is problematical, like that of the relations between colour and locality which were noted in an earlier chapter.*

But conspicuousness and brilliancy of colour and marked peculiarities of form may accompany quite other relations between living beings. Thus the males of many animals assume marked changes in this respect, toward and at the breeding season, and this to such an extent that it has been supposed by some naturalists that a selection by females of the so distinguished males through many generations, has been the actual cause of such phenomena. This hypothesis is

* See CONTEMPORARY REVIEW, February, 1880, p. 275.

completely negatived, however, by the presence of these sexual characters in many animals in which they cannot have been so caused.* Conspicuousness of colour favours certain creatures,—as *e.g.* certain caterpillars and other insects,—by pointing them out as being inedible through possessing some offensive taste; such colours indicating to their would-be destroyer that its prey would turn out a disgusting morsel, and many experiments show that there often really is such a relation. Nevertheless, cases of colour and ornamental form occur quite independently of all these suggested causes, and, therefore, though the supposed action no doubt often really takes place, it cannot constitute any exhaustive explanation of the phenomena referred to. Amongst such cases is the beauty to be found in the form and colour of many shells, and in recondite recesses of the bodies of animals where no actions such as those suggested can possibly have any influence. This brings us to a final relation between living beings, namely, the relation of beauty as existing in the external world, and as appreciated by man.

It is evident that in most, probably in all, cases the form and colour we appreciate as beautiful, subserve some other, perhaps several other purposes. But such facts do not in the least alter the unquestionable fact that such external beauty *is* perceived by the cultivated human mind. Those therefore who on other grounds see reason to believe that purpose underlies the phenomena of nature may venture to consider one such purpose to have been that which they know to be actually fulfilled in themselves, and that amongst its other ends, the beauty of the material world was intended for the enjoyment of beings which possess an intelligence capable of truly appreciating the beautiful—capable, that is, not only of feeling its charm but of intellectually apprehending it.

St. George Mivart.

* For an exposition of this matter, see "Lessons from Nature," chap. x. London: Murray.