dyes of scarlet, crimson, orange, and yellow. We shall see, on closer inspection, that every one of these organic bodies has been specially developed to meet the wants of animal eyes. We shall find that the flower has been given its brilliant corolla in order to attract the bee and the butterfly; that the fruit has acquired its glowing coat in order to lure on the bird and the mammal; and that the feathers, scales, and gaudy fur of these animate creatures themselves have a special relation to the nature of their food, their habits, and their surroundings. In other words, the beautiful colours of the external world, and the delight which conscious minds feel in their beauty, have both a common origin in the great principles of evolution and natural selection. Let us see what light can be shed upon this intricate question of their interdependence by the magnificent generalisations which science and humanity owe to Herbert Spencer and Charles Darwin.

If we wish to get at the very origin of flowers, we must go a long way back in time to the earliest geological age; and we must look at the condition of those vast primeval forests in which terrestrial animal life made with trembling feet its first forward steps. We must imagine ourselves placed as spectators in the midst of a flora totally unlike any now existing on our earth—a flora which we can only picture to ourselves by its incomplete resemblance to a few surviving but antiquated forms. In the great tropical swamps whose refuse supplies the coal for our grates, there grew a thick herbage of ferns and club-mosses and strange green plants, but probably not a single distinguishable flower. It is true that a fair sprinkling among the vegetable productions of those luxuriant wilds belong to the botanical sub-kingdom of Phanerogams or flowering plants; but these few exceptions are almost all trees or shrubs of the pine and palm kinds, bearing the green cones or catkins which science recognises as inflorescences, but not the conspicuous bunches of coloured leaves which ordinary people know as flowers. In the forests which then bordered the great deltas of forgotten Amazons and Niles, it seems probable that no gleam of scarlet, blue, or purple ever broke the interminable sea of waving green. Uncanny trees, with sculptured or tesselated bark, raised their verdant heads high above the damp soil into which they thrust their armour-plated roots; huge horsetails swayed their jointed stems before the fiercer tempests raised by a younger and lustier sun; tree-ferns, screw-pines, and araucarias diversified the landscape with their quaint and symmetrical shapes;* while beneath, the rich decaying mould was carpeted with mosses, lichens, and a thousand creeping plants, all of them bearing the archaic stamp peculiar to these earliest developments of vegetable life: but nowhere could the eye of an imaginary visitor have lighted on a bright flower, a crimson fruit, or a solitary gaudily-painted butterfly. Green, and green, and green again,

* These names must only be accepted in a representative sense, as giving a modern reader the nearest familiar congener of the extinct forms.

on every side; the gaze would have rested, wherever it fell, upon one unbroken field of glittering verdure.

To put it simply, all the earliest plants belonged to the flowerless division of the vegetable kingdom; and though a few flowering species made their appearance on earth even before the epoch at which our coal-beds were formed, yet these were of the sort whose pollen is borne by the wind, and whose blossoms are accordingly unprovided with gay colours, or sweet scents, or honeyed secretions, as a bait for the insect visitor to rifle and fertilise their bloom. The greater part of the larger coal flora consisted of acrogens, that is to say, of plants like the ferns, club-mosses, and horsetails, which have spores instead of seeds, and so of course bear neither fruit nor flower. The smaller creeping plants belonged to the same class, or to the still more humble thallogens, represented in our world by lichens and seaweeds. Only a few conifers foreshadowed the modern tribes of flowering plants; and even these were of the most abnormal and antiquated type to be found in the whole sub-kingdom.

How, then, did those crimson, orange, or purple leaves which make up the popular idea of a flower first originate? And how did the seed which it is their object to produce, become coated with that soft, sweet, pulpy, and bright-coloured envelope which we call in every-day language a fruit? Clearly the first of these questions must be answered before we attack the second, both because the flower precedes the fruit in point of time, and because the tastes formed by the flower have become the *raison-d'être* of the fruit. I propose, therefore, in the present paper, to attempt some slight solution of the earlier problem; and I hope in a future number of the CORNHILL MAGAZINE to set before my readers some remarks upon the later one.

The origin of flowers is not a difficult subject upon which to hazard a plausible conjecture. Even in the flowerless plants we see occasionally some approach to that separate set of organs for reproductive purposes which reaches its fullest development in the coloured and scented blossoms of our gardens. Most ferns, as we all know, bear their spores on the under side of every frond, where some of them form the beautiful powder which gives a name and a charm to the gold and silver ferns. But the splendid Osmunda regalis, besides several smaller species, has its seed-vessels on an independent stem, thus exhibiting that division of labour among its parts which allows each more efficiently to perform its own special function. And the horsetails carry this movement one step further in advance, having a distinct fruit-bearing growth early in the spring, which is followed by sterile shoots later on in the year. So that through these faint indications we can picture dimly to ourselves the gradual stream of evolution by which the frond-borne spore made its first onward metamorphosis towards the flower-borne seed.

But such fructiferous heads of embryonic acrogens differ widely in the most important particular from true flowers. They do not need fertilisation.* The very essence of the flower consists in the fact that its ovule, or embryo seed, must be quickened into fresh life by the contact of pollen, either from the same or another blossom. All the rest which we ordinarily think of as belonging to the flower—its bright petals, its sweet scent, its store of honey—are merely so many accessories to this central fact. The true flower begins at the point where pollen and ovules first make their appearance. And in the earliest geological flowering plants, the pollen was apparently wafted to the ovule on the wings of the wind, not on the heads or bodies of insects. They belonged to that coniferous family in which the seeds are borne on a scaly head, such as we know so familiarly in the pine and the fir-tree: so that their green scales could have formed no exception to the prevailing verdure of a palæozoic forest.

"But what advantage did the plant gain from this complicated arrangement of seed-producing organs?" A not unnatural question to ask, yet a very difficult one to answer. So far, only a speculative explanation of the facts has been attempted; and that speculation is too intricate and too fundamental for any but the trained physiologist to appreciate. Happily, however, the facts themselves have been placed beyond all doubt by Mr. Darwin's minute observations on *cross fertilisation.* Our great master has shown us that when any organism is the product of interaction between the parts of two other organisms, it possesses a vigour, plasticity, and vital power far surpassing that of any similar individual produced by one unaided parent. He has proved incontestably that young plants derived from a self-fertilised flower are weaker, poorer, and shabbier than those derived from the pollen of one flower and the ovule of another. And this general principle, illustrated on the small scale by Mr. Darwin's experiments, has been demonstrated on a gigantic scale by Nature herself: for when once the flowering plants were introduced upon the earth by a favourable combination of surrounding circumstances, their superior vitality enabled them in the struggle for existence to live down their flowerless neighbours, and to spread themselves slowly but surely over the whole habitable globe. While the flora of the coal and the earlier formations consists almost entirely of ferns, club-mosses, and horsetails, the surface of our existing earth is covered by grasses, herbs, and forest-trees; and only in a few tropical ravines or a stray patch of English warren do we still find the degenerate modern representatives of those Titanic calamites and lycopodites which flourished in the jungles of the Black Country a million æons since.

We can guess, accordingly, how flowers, in the botanical sense, came first to be developed. Where a chance combination of external agencies

* The obscure phenomena connected with the antheridia and pistillidia of cryptogams do not interfere with the practical truth of this statement, accepted in a popular sense.

occurred to carry certain cast-off reproductive cells of one plant to the most exposed cells of another, there may have resulted such a race of hearty descendants, endowed with a similar tendency to produce their like in future, as could compete at an enormous advantage with the sexless and flowerless plants around. Vague and indefinite as our conception of this process must necessarily be, we can still figure to our imagination enough of its nature to find in it no miracle, but a simple physical fact. The next step in our inquiry must be to account for those bright and conspicuous masses of leaves which the popular eye recognises as flowers. To do so properly, we must glance first at the few animals and insects which peopled the green palæozoic forests, and whose descendants were to prove the principal agents in developing the blossoms and fruits that we see around us.

Few if any birds or mammals lived amongst those rank jungles of more than tropical growth. Reptiles of serpentine or lizard-like form crawled through their dense underbrush of club-moss and lichens; while primitive scorpions, beetles, and cockroaches eked out a hard-earned livelihood by devouring smaller prey, or by feeding on the more succulent parts of the dry and horny plants around them; but not a single moth or butterfly flitted among the primæval tree-ferns and pines, as they flit in countless myriads now on the banks of the Amazon or the mountain slopes of Ceylon and Jamaica.* The higher and brighter forms of insect life are entirely dependent upon the honey or other secretions of flowers, and without flowers they could not continue to exist for a day, much less come for the first time into existence.

As soon, however, as any flowering-plants at all began to show themselves on the face of the earth, if only in the form of cones or green panicles, we may be sure that they were visited for the purpose of feeding by some of the smaller insects of those days. The pollen and other parts of the incipient blossom would almost certainly attract attention both by their softness and their nutritious properties. We shall see hereafter, when we come to examine the case of fruits, that those very portions of plants which are devoted to the growth of their offspring are the exact portions best fitted for animals to devour and thrive upon. And as the insects would carry away small quantities of the pollen, adhering to their legs and heads, they would be very likely to deposit some part of it on the stickier portion of similar blossoms which they afterwards visited. Any flower that offered exceptional advantages to

* Those readers who have personally made acquaintance with tropical scenery will be able to recognise in the picture of green forests given above a strong family likeness to the existing vegetation in the warmer zones of our earth. It is a great mistake to suppose that the tropics are noticeable for their brilliant colouring. Here and there, under exceptional circumstances, one may light upon a solitary tree covered by huge scarlet or yellow flowers, of a kind which we seldom see in temperate climates; but the general aspect of a tropical hillside is that of monotonous and wearisome verdure.

such visitors in the way of food, would thus be able to substitute the new mode of fertilisation by means of insects, for the old one by means of the wind. Moreover, this substitution would prove economical to the plant, because wind-fertilised flowers require a large number of stamens and pistils, hanging out in conspicuous situations, so that the pollen may be borne away upon the breeze in sufficient quantities to fertilise a large proportion of the neighbouring blossoms. Of course such a system is comparatively wasteful and expensive to the parent plants, since they are obliged to produce vast quantities of pollen, which will be dissipated ineffectually by the wind, and vast quantities of ovules, which are never destined to receive the quickening influence of the pollen. Now, every device which enables a plant or animal to perform any one of its necessary functions at a less physiological cost than formerly will obviously leave it a greater surplus of energy to be expended in other directions, and will thus prove of use to it in that long and ceaseless struggle which eventuates in the survival of the fittest. Accordingly, if any special combination of circumstances at any particular time happened to give one plant such a structure that its pollen was specially sheltered from the wind and specially attractive to insects, while at the same time its ovules were placed within a specially sticky receptacle, adapted to retain any pollen grains which might fall upon it—then that plant and its descendants would enjoy such exceptional advantages as would enable them to live down their less fortunate neighbours, and to become the ruling vegetable races of the world. What might be the special causes which first gave rise to such a structure we can hardly even conjecture; but that they did occur, and, having occurred, produced the result above sketched out, we know with a considerable degree of certainty from the mere inspection of nature as it unfolds itself to inquiring eyes at the present day.

So soon as certain plants have thus begun to depend upon the visits of insects as a means of fertilisation, a competition will naturally spring up between them for the favour of their little guests. Hence it will happen that any flower which has in its neighbourhood patches of bright-coloured leaves, or which disperses odorous particles from its surface, will be benefited by the additional attractions it offers, and will be oftener fertilised, on the average of cases, than any less alluring blossom. But how will these colours originally present themselves? I believe it was Mr. Herbert Spencer who first pointed out that the undeveloped leaves at the ends of a long shoot have a great tendency to assume a reddish or purply hue; and that such terminal bunches are exactly the places where inflorescence occurs. Long before, Wolff and Goethe had shown that the flower consists essentially of several whorls of aborted or oddly-developed leaves. And Mr. Spencer suggested that wherever such coloured immature shoots contained the seed-producing organs, they might offer an additional means of attracting insects, and might thus become more and more distinctly coloured from generation to generation, until they reached their present noticeable form. If we look closely into this matter, we may perhaps be enabled clearly to understand the various steps by which this development of colour in flowers was brought about.

All common leaves contain a green pigment, known to chemists as *chlorophyll*, from which they derive their ordinary colour. The cells of the leaf are stored with this pigment, while their transparent walls give them that superficial sheen which we notice so distinctly in the glossy foliage of the laurel and the bright fronds of the hart's-tongue fern. But very slight chemical changes in the composition of leaves suffice to give them a different colour; which is not surprising when we recollect that colour is nothing more than light, reflected in greater or less proportions of its constituent waves. The fashionable pelargoniums, coleuses, and begonias, or the dark sedums which are employed to form the quaint carpet-gardens so much in vogue, show us how easily the green colouring-matter can be replaced by various shades of purple, red, and brown. These changes seem on the whole to be connected with some deficient nutrition of the foliage.* It would appear that the normal and healthy pigment is a rich green; but that as the leaf fades and dies, it passes through successive stages of orange, pink, and russet. The autumn tints of the forest, the crimson hues of the Virginian creeper, and the transitory colours of a dying plant, all show us these passing *nuances*. If a single leaf, or even a particular spot upon a leaf, is insufficiently supplied with nutriment, its first symptom of ill-health is a tendency to paleness or jaundiced yellowness. If an insect turns some portion of it into a gall nut or a blight, the tips assume a beautiful pink hue. In short, any constitutional weakness in the leaf brings about changes in its contained pigments which result in an altered mode of reflecting light. Or, to put the same fact in another way, any change in the composition of the pigments is apt to be accompanied by a change in their colour. Now the ends of long branches are naturally the least nurtured portions of a plant, and the young leaves formed at such spots have a great tendency to assume a brown or pinky hue. Furthermore, these spots are exactly the places where flowers are formed; flowers being, as we saw above, mere collections of aborted leaves, destined to fulfil the function of parents for future generations at the point where the vigorous growth of the original plant is beginning to fail. Nothing can be more natural, therefore, than that the flower-leaves should show an original tendency to exhibit brilliant hues: a tendency which would of course be strengthened by natural selection if it gave the plant and its descendants any superiority over others in the struggle for life.

It should be remembered, too, that the flower differs from the leaf in the fact that it is not self-supporting. The green portions of a plant

* I purposely avoid all reference to the purely technical question of the relation between chlorophyll and erythrophyll.

are its mouths and stomach: they are perpetually engaged in assimilating from the air and the water those elements which are fitted for its growth. But the flower is a purely expensive structure: it does not feed itself; it is fed by other portions of the plant. It uses up, in the act of growing and expanding, energies derived from the food which has been stored up by the chlorophyll elsewhere. Accordingly, we might expect its pigment to present that less energetic, more worn-out form, which produces the brighter hues of autumn and the pink tips of a growing bough. From whatever point of view we regard it, we see that a flower is naturally supplied with some colouring matter less active than that green substance which forms the assimilative agency in common leaves. It is easy, therefore, to guess how certain plants may have acquired the first tinge of colour around their organs of fructification, and thus have attracted the eyes of insects by their superior brilliancy.

This, however, is only one side of the problem. We can imagine how leaves may have become coloured to attract insects, but we do not yet see why insects should be attracted by coloured leaves. Side by side with the development of colour in flowers must have gone the development of a colour-sense in insects. The creatures which strayed through the green carboniferous brushwood were doubtless endowed with eyes, sensitive in a considerable degree to light in its varying shades, and to visible form; but there is little reason to suppose that they were capable of distinguishing between red and blue. We know of nothing in their external circumstances which would have made such a faculty of any value to them; and we have now learnt that every structure presupposes some advantage to be gained by its development. On the other hand, Sir John Lubbock's experiments and observations upon bees leave us little room to doubt that the higher insects, at least, now possess considerable discriminativeness for colours, in a manner which does not differ greatly from our own. Sir John discovered that a bee habitually fed from a piece of paper of a particular colour, would at once select that colour from a considerable number of others, thereby demonstrating the essential identity of its senses with those of human beings. Now, it was pointed out above that colour means physically nothing more than particular kinds of light-waves; and, accordingly, the perception of colour means nothing more than a special susceptibility of individual nerves for the reception of particular light-waves. What can be more natural than that a body so modifiable as nerve-substance should show an aptitude for accommodating itself to slight differences in the external agencies which affect it? Accordingly, we can easily imagine how the small insects of the palæozoic world may have soon acquired a power of discriminating vaguely the red and purple ends of shoots where pollen and soft nutriment were to be found from the comparatively innutritious green and horny portions of the plant. Once this power had begun to exist, the two must continue to develop side by side. Those plants which had the most conspicuous blossoms must have best attracted the insects around them; and those insects which were most strongly attracted by conspicuous blossoms must have fed most easily and lived most persistently. The bee, flying straight from flower to flower, shows us the accuracy which is reached at last in this mutual adaptation of the one to the other.

The facts of geology sufficiently prove that such has been really the case. From age to age we can trace, among the few remains which survive for our inspection, a gradual spread of flowering plants and a gradual growth of flower-fed insects. Step by step they go on advancing, until at last we get the wonderful modifications of each to each which have been traced out in detail by Mr. Darwin, Sir John Lubbock, the Müllers, and countless other earnest interpreters of nature. These modern teachers have shown us how the lip of the flower has been shaped for the bee to alight; how the honey has been secreted at the very end of an ambrosial labyrinth; and how the pollen has been placed just where the hairy forehead of the insect will brush gently against it, and carry it off in a powdery mass or in a sticky club. And they have noted how, simultaneously, the legs and body of the bee have grown adapted to the exact shape of the lip and bell; how the senses have been quickened to perceive the colour and the odour; and how the proboscis has lengthened itself to the very dimensions of that ambrosial labyrinth which leads in its inmost recesses to the prize of honey. They have told us, too, how in many cases a particular insect has adapted itself to a particular plant, while the plant in return has laid itself out to deserve and secure the good services of that specific insect. In short, they have taught us to see such a minute interdependence of animal and vegetable life as had never before been dreamt of in the whole history of natural science.

Leaving out of consideration for the present those modes in which flowers and insects have been mutually modified in shape to meet one another's convenience, let us look more closely at those various ways in which the flower has been adapted to the senses of the insect, while the senses, in return, have been strengthened and developed by the properties of the flower. There are three principal means by which this interaction takes place, namely, by the senses of taste, of smell, and of sight. We shall examine all three in order, and we shall notice as we do so how singular is the bond of connection between the lower and higher forms of life; for we shall find that our own likes and dislikes in taste, smell, and colour, can be traced down with great plausibility to the exactly similar likes and dislikes of bees and butterflies. It will aid us in explaining and comprehending this connection if we remember that what flowers are to insects, fruits are to birds and mammals. Both are coloured, scented, and sweet; but they have acquired their various allurements for the attraction of widely different creatures. Yet it shows the general community of structure and function running through the whole animal world, that the very same sweet tastes, fragrant perfumes, and bright hues appeal in the very same way to bees and butterflies as they appeal to parrots, to humming-birds, and to men. . .

First, then, as to taste. The need for food is, of course, the primary allurement in every case, both of the fruit and of the flower. The scents and colours are only useful as guiding the seeker to his dainty meal. In the earliest times, doubtless, the insect prowlers who carried pollen from head to head regaled themselves upon the actual juices of the plant, which in all fairness should have gone to provide for the general needs of the flower and seed. But plants must soon have learnt the trick of letting a little of their more nutritious juice exude of its own accord, at once as a bait to draw the insect fertiliser, and as a security against his breaking in upon the tissues themselves. This juice is what we know as honey. Many parts of plants contain small quantities of sugar, and in some (like the sugar-cane and the American maple) it exists in large proportions in the sap; but wherever we find it deposited in the concentrated form of honey, we may be sure that the plant has distilled it for some special purpose of attraction. Honey-glands sometimes occur on the stem, in which case they are often mere traps to attract the presence of ants, who act as guards to the plant against the approach of noxious insects. But more commonly they are to be found in the flower; that is to say, somewhere among the whorls of stunted leaves which surround the seed-producing structures. There they are set as insect-attractors, to draw the fertilising agents into the neighbourhood of the pollen and the ovules. Of course we can only suppose that this production of special honey-secreting organs proceeded very slowly during long ages, parallel with the development of specialised honey-seeking insects. And we have some warrant for the belief—more fully to be set forth in a subsequent paragraph—that some of the greatest honey-storing plants are quite modern denizens of our earth, and owe their existence to the general demand for sweet-stuffs amongst their insect contemporaries. Similarly, we have reason to think that the honey-eaters have gone on adapting themselves more and more continuously to the flowers, until at last, in the fulness of time, we get such specialised creatures as hive-bees and humming-birds. But perhaps the most noticeable fact of all is this—that the very same sweet juice which was developed to suit the taste of humble-bees and emperor-moths, is the symbol for sweetness in the language of mankind, whose tastes have been formed upon the strawberry, the plum, and the banana. And is it not likewise significant of the same general community of nervous impressibility that while the humming-birds, belonging to a mainly fruit-eating class, have taken to the honey of bignonia and hibiscus, the wasps, in turn, belonging to a mainly honey-eating class, have taken to the sugary juices of the peach and the nectarine? I think these facts may guide us greatly when we come to ask how the love of colour has been devolved in the human race.

Secondly, as to smell. So soon as flowers have developed the honey-producing structures, they will gain an advantage by giving insects at a distance some warning of their presence. There is no simpler way of doing this than by means of etherialised particles, which may chemically affect some exposed nervous structure in the insect; and such chemically affected structures are what we know as organs of smell. Here, too, we see the same essential agreement between the higher and lower forms of animal life; for just as our taste for sweets corresponds to the insect's taste for honey, so our love for the perfume of flowers is absolutely identical with the pleasure which draws the butterfly towards the luscious blossoms of the tuberose and the stephanotis. In our own English meadows we may see the bees and the children alike, collected around the fragrant meadow-sweet, or seeking together for the scented clover. And it is worth while to observe that most of the sweet-smelling flowers appear to be quite late developments of vegetable life, a fact which harmonises well with the correspondingly late development of the bees and other highly-adapted honey-suckers. There is no tribe of plants, for example, more noticeable for their perfume than the family of Labiates. To this family belong the various kinds of mint, thyme, balm, sage, marjoram, lavender, rosemary, horehound, and calamint, besides innumerable foreign or little-noticed species, like patchouli, hyssop, and basil. These plants are almost all very peculiarly shaped and highly scented, and their attractiveness for bees has become proverbial—the honey of poetry is always "redolent of thyme." Now the Labiates, so far as known, are late tertiary plants; that is to say, they made their first appearance upon earth only a short period before the advent of man himself. In short, it was not until bees and other specialised honey-suckers had reached a high point of development that scented flowers began to possess any advantage over their neighbours. I shall endeavour to show in a future paper that our chief fruit-bearers, the Rosaceæ, are similarly late in making an appearance on the earth, and that they owe their evolution to the higher birds and frugivorous mammals who began to exist in large numbers about the same period. For the present it will be sufficient to point out the intimacy of the interdependence which we thus see to exist between the evolution of the animal and vegetable worlds.

It is needful, too, to point out another special case of the sense of smell. While the flower-sucking insects have likes and dislikes, in taste and smell, essentially identical with those of man, the descendant of frugivorous ancestors, and with those of the flower-sucking humming-birds, and the fruit-eating birds and mammals, there is another class of carrion-feeding insects which have likes and dislikes more in unison with the vultures, the turkey-buzzards, and the jackals. Since it is possible for life to be sustained upon decaying animal matter, it must result that some small class possessing the unusual taste for carrion will be able to gain an easy living upon this undisputed prey. Hence the growth of such uncanny creatures as flies, condors, and sopilotes. Accordingly, we find certain flowers adapting themselves to these abnormal tastes, and acquiring the appearance and smell of decaying meat. The Sumatran *Rafflesia*, and the South African *Hydnora*, are large and lurid blossoms, which thus deceitfully induce the carrion flies to visit them for the purpose of laying their eggs, and are accordingly fertilised by means of an organised deception. To naturally frugivorous man the scent and the appearance are alike disgusting.

Lastly, we arrive at the device of colour, the most important of all from an æsthetic standpoint. We have seen already how reds, yellows, and purples came to be developed in the neighbourhood of the floral reproductive organs, but we have yet to inquire why they should prove attractive and pleasurable to the eyes of insects. In order to do so properly, we must glance a little at the nature of pleasure generally.

Without entering into any ultimate physiological question, it will suffice for our present purpose to point out that pleasure results from the normal stimulation of any fully-nurtured and underworked nervous structure. For instance, in a state of health, our limbs, when properly fed and not previously fatigued, derive pleasure from the mere act of exercise. So with each of our senses; any particular stimulation is pleasant if it has been sufficiently intermitted, and is not excessive in amount. Now, if we apply this simple principle to the case of sight, we shall see that so soon as the eyes of insects have been differentiated enough to discriminate the pinkish or ruddy tips of boughs from the green leaves about them, the special nerves involved in this process will receive pleasure from their due stimulation. The more intermittent each such stimulation may be, the more pleasurable will be the resulting sensation. So we can see how, as the petals of flowers grew gradually more and more distinguishable in colour from the green leaves about them, and as the eyes of primordial bees or butterflies grew gradually to distinguish them better and better, an ever-increasing pleasure would grow gradually up by their side, and become stronger and stronger as the nerves increased by practice in calibre and strength. And so, too, we can understand how at last we reach the pure and brilliant colouring of the gladiolus, the laburnum, the hyacinth, the peony, and the tulip; and how the insect eye is drawn on by the pleasure hence arising to the nectary of the flower, and to the pollen or the stigma from which the future seed is to take its rise.

Here too, in like manner, we may observe the practical identity of taste in the flower-feeding insects and the fruit-eating vertebrates—including the human species, who, as we have already noticed, derive their likes and dislikes from their frugivorous ancestors. For, just as the sweetness of fruits answers to the sweetness of honey, and just as the scent of fruits answers to the scent of flowers, so the colours of fruits are identical in origin and nature with the colours of flowers. It would seem as though in every case nature found a single mode of modifying the nervous substance was amply sufficient (because simplest and easiest) alike for insect and reptile, for bird and ape and human being.

As for the particular colour of each particular species, little is known as yet of its determining causes. In a few cases we can plausibly account for the special hue selected; thus the plants which depend for fertilisation upon carrion insects naturally imitate the lurid red appearance, as well as the noisome smell, of putrid meat; while the night-flowering blossoms are apt to be white or bright yellow, as those colours best reflect the scanty light of evening or the scattered rays of the moon. But in the majority of instances we can scarcely hazard a conjecture as to the reasons which have influenced insects in their unconscious selection. It must suffice to point out that in many cases the spots, lines, and bars on the flower seem to act as guides for the insect in discovering the exact locality of the honey-store, while in others they are placed for some purpose of mimicry which is directly or indirectly useful to the species. With this brief indication of a great field for future inquiry, we may pass on to some other interesting aspects of the colour-sense as applied to flowers.*

As the object of the coloured whorls is merely to attract the attention of insects, it does not matter, of course, which particular whorl is supplied with pigment in each instance. It is only needful that the bunch of coloured leaves should be so placed as to guide the insect towards the pollen and ovules. Hence we find a great variety in the portions of flowers which are thus decorated with brilliant tints. The stamens and pistil themselves rarely take part in this function of attraction, though sometimes even these working organs are brightly painted with pink, yellow, or pearly white. In such plants as the mallow, the bramble, the tulip, the fuchsia, the mignonette, and the clematis, the stamens and pistil form very conspicuous portions of the attractive organ. More frequently, however, the corolla, or petal-whorl, which succeeds the fructifying structures, is alone entrusted with the special function of alluring insects by its hue. This is the case with the buttercup, the pink, the pea-tribe, the rose, the poppy, the violet, and the great mass of ordinary flowers in general. Indeed, one may say roughly that the popular conception of a flower is mainly founded upon the corolla, while the botanical idea of an inflorescence is mainly founded upon the stamens and pistil. But in a considerable number of plants the colouring of the corolla is not by itself sufficient to allure the fertilising visitors, and so the calyx, or outer whorl, originally a protective sheath for the blossom, is sometimes diverted wholly or in part to this secondary function. In the milk-wort we see an early stage of such a process, where only a portion of the calyx is devoted to the purpose of allurement; but in the fuchsia it is the calyx which forms the principal and most brightly-coloured feature on the whole flower. Then again, a large number of

* Those who wish to find out how much is already known on this curious point of special adaptations may turn to Mr. Darwin's work on *Orchids*, or to Sir John Lubbock's on *British Wildflowers in their relation to Insects.*

blossoms have only a single duplicate whorl to represent both calyx and corolla, in which case we sometimes conclude that the two original whorls have coalesced, and sometimes that the plant never possessed more than one. Instances are to be found in the tulip, the hyacinth, and most so-called lilies. Lastly, we have in the arum a white or purple sheath which encloses a whole group of little inconspicuous blossoms, but performs exactly the same function as the petals in attracting the insect eye.

The most conclusive fact, however, in favour of the purely functional origin here assigned to the coloured leaves is to be found in the case of certain plants, whose true flower, being small and inconspicuous, is surrounded by an irregular supplementary mass of brilliant leaves. The best known instance of this peculiarity is the scarlet poinsettia, which has an insignificant little yellow blossom, so small that it could hardly strike even the microscopic eye of a tropical butterfly. But the comparative poorness of the true flower is made up for by a magnificent bunch of scarlet leaves, which terminate every flower-bearing branch, and are far more striking than the yellow blossom could ever hope to become, even if immensely increased in size and brilliancy. In the midst of this scarlet bunch the flowers nestle securely, and trouble themselves no more about the disposal of their pollen. An equally instructive though less beautiful example is offered by a little West Indian plant, whose tiny blossom is surrounded by three green bracts, while the upper surface of each bract has a patch of red pigment, daubed, as it were, over its face. If you turn up the leaf, you see that the pigment does not penetrate to its lower surface, so that at first you have great difficulty in rejecting the belief that some mischievous painter has been playing you a trick by deftly spreading a little patch of colour in the centre of each bract. Of course the conclusion towards which all these facts point is a very simple one—namely, that if a tendency to the production of bright colours in the neighbourhood of the reproductive organs is once set up, no matter in what portion of the plant it may occur (whether in stamens, corolla, calyx, sheath, bracts, or leaves), it will be perpetually strengthened and further developed by natural selection, provided it proves useful to the plant in promoting cross fertilisation through the agency of insects.

Nor does the process stop here. Some flowers are not sufficiently conspicuous to attract separate attention on their own account, but they manage to do so by massing themselves together in considerable bunches. This massing can be simply effected, as Mr. Herbert Spencer has pointed out, if the internodes (or pieces of stem between each blossom) are permitted to become dwarfed. We see the first instance of such dwarfing in a spike,* like that of the foxglove, the snapdragon, the gladiolus,

* I must warn the reader that I am intentionally and consistently avoiding the cut-and-dried phraseology of botany, in favour of simpler, though less exact terms.

and the orchid. In the head, the dwarfing has proceeded a step further, as exemplified by clover. To one or other of these or similar classes belong those conspicuous bunches of blossom which we find on the lilac, the horse-chestnut, the wisteria, the laburnum, the rhododendron, and indeed, almost all our most noticeable flower-bearing plants, domestic or exotic. The umbellate family, represented by fool's parsley, carrot, and cow-parsnip, attain the same end in a slightly different way. Their small white flowers are grouped together in a flat mass, on the end of a stiff stem, while the outermost blossoms of each mass have much larger white corollas than those of the central ones, thus affording a greater total of attractive area.* But in the composite flowers we see this tendency pushed almost to its extreme limits. These blossoms, of which the daisy is a familiar example, consist of an immense number of separate florets, crowded densely together into a head, and enclosed by a bunch of bracts, known as the involucre, which performs the same protective function for the compound mass as the calyx performs for a separate flower. Each single floret would doubtless fail by itself to secure enough insect attention for safe fertilisation ; but when thus huddled together into a conspicuous head, they have proved very successful plants, forming probably the largest and most populous family of the vegetable kingdom at the present day.

If we look still closer at the individual members of this last-named family, the composites, we shall see yet more ingenious devices for attracting attention by multiplied bunches, or by special arrangement of florets. In the simplest form of composite, which we find in the thistle and the artichoke, all the florets are of the same size and similarly coloured. But in the centaury, the outer florets begin to grow larger than their neighbours of the central mass, thus affording a greater total area of alluring colour. In the corn-marigold, again, the outer florets assume the shape of elongated rays, but still retain the same yellow hue as the central bells. Next, in the daisy, the rays are of a brilliant white, and the central bells a beautiful yellow ; while in the camomile, heads composed of these twin-shaped florets are arranged in bunches, instead of growing each on a separate stalk. These last-named heads closely simulate the appearance of single blossoms, as the long white rays which surround their clustered central bells may easily be mistaken for petals by a careless observer. There are two other well-known composites

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He will learn with pleasure from any botanical critic that the proper expression in this case would have been a *raceme*. Having made this apology once for all, I trust I may be permitted to continue unmolested in a tongue understanded of the people.

* I cannot entirely agree with Mr. Herbert Spencer that this difference is solely due to freer elbow-room and more abundant light. The case of a common English centaury, whose outer florets are sometimes much larger than the inner ones, while at other times they are of exactly the same size, shows that we must make great allowances for the selective action of insects. Were the effect due to position alone, it would occur in all specimens alike.

which exhibit the same tendency to increased conspicuousness in a different way. The bunches of the milfoil, each of which is separately too insignificant to attract attention, are arranged on a number of umbels, which make in the mass a compound head of heads, while those of the golden-rod are disposed on a tall shaft, so as to form a waving plume of floret-bundles. To put it more simply, when individual flowers are too small to prove separately attractive, they derive an advantage from grouping themselves into masses, and when the masses thus composed become in turn too small for effective display, they succeed by once more grouping themselves into compound bunches of masses.

Before we conclude this lengthy investigation, there is one more point upon which I should like to dwell for a moment. While the colours of flowers are apparently due in the main to insects, I believe it to be equally true that the colours of insects are indirectly due to the influence of flowers. We observed above that any set of nervous structures habitually excited in a certain manner becomes thereby strengthened and improved, so as to be capable in future of healthy and pleasurable stimulation. Now, as insects are perpetually seeking their food amongst bright-coloured flowers, it follows that their eyes must have become specially sensitive to the attraction of brilliant light. We get the extreme case of such attraction in the mechanical infatuation which draws the moth irresistibly into the burning embrace of the flame. We get it in a less violent form amongst those nocturnal insects like the fire-flies, which are provided with lanterns to guide the opposite sex to their sides. And there seems reason to believe that those insects which feed habitually upon the beautiful flowers have acquired a taste for colour, which leads them to select mates resembling the flowers in hue. I hope to enter more fully into this subject when we come to treat of the development of fruits; but at present a brief outline of the principal facts which support the theory now advanced may be given shortly by anticipation.

Among the invertebrates, there are no creatures more exquisitely coloured than the butterflies, which are flower-feeders. Those of tropical countries are more brightly tinted than the denizens of northern climes, and exactly the same is true of the flowers. In some special regions, particularly islands such as Madagascar, the flowers and the butterflies are both equally noticeable for their brilliant hues. On the other hand, if we look at their relations, the moths, which are nocturnal in their habits, and feed often upon large whitish or yellowish blossoms, we shall see that their shades are generally dull and dusky, varying from whitey-brown to dingy-black. So too, the carrion-feeding flies are not marked by any such beautiful hues as the honey-feeding butterflies. Indeed, a general glance through the insect world will probably convince us that wherever their colours are not due to protective or imitative devices they are traceable to sexual selection, acting by means of tastes, which take their origin in the attractive hues of flowers.

Similarly amongst vertebrates, the most exquisitely coloured are the birds, and amongst the birds, the palm of beauty must be given to the humming-birds, which are flower-feeders. Next may rank the sun-birds of the Eastern hemisphere, which are also flower-feeders. And after them come a whole mass of tropical species, the birds of paradise, the toucans, the macaws, the parrots, the cockatoos, all of which feed upon bright-coloured fruits. And in the case of the bower-birds we know with certainty that a love for colour as colour exists, because these queer little creatures actually take possession of all the brilliant objects they can find to decorate their meeting places. All these instances lead one to suppose that the colours of birds are due to a liking for pure tints, originally derived from the nature of their food, and afterwards extended to the choice of mates.

When we compare the birds of prey and the carrion-feeding vultures with these bright creatures, we get an instance exactly analogous to that of the flies and the butterflies. So, in like manner, the dingy nocturnal owls are the obvious counterpart, amongst birds, of the whitish or gray-coated moths. Indeed there is a good physiological reason for believing the owls to be destitute of the colour-sense altogether, since a particular kind of nerve terminals in the eye (known to anatomists as the *cones*, and supposed to be the special organs of colour perception) are totally wanting in these night birds, which is only what one might expect in the case of creatures who sit at home all day, and only prowl about in the grey twilight.

Without pushing this speculation, then, to any further length at present, we may recognise as probable the theory that while insects have developed the colours of flowers, flowers have reciprocated the attention by becoming the *raison d'être* for the colours of insects.

G. A.