the district of Liverpool. He also exhibited two young living alligators, sufficiently small to be kept in an ordinary aquarium.

Professor ARCHER exhibited specimens of paper manufactured from sea wrack, *Zostera marina*, by Mr. H. Spooner, of Newark-upon-Trent, Nottinghamshire. From the experiments made by Mr. Spooner, and the results obtained, there appears to be no doubt that this abundant material will not only answer the purpose of the paper maker, but is remarkably well adapted for those kinds required for the finer descriptions of engraving, printing, &c., the fibre being fine, tough, exceedingly elastic, and admitting of complete bleaching.

Mr. BYERLEY, F.L.S., showed a specimen of the common frog enormously distended by air.

Dr. NEVINS gave an account of a large brood of salamanders. The remarkable circumstance connected with the case was the proof it afforded of the length of time the ova had been carried, which would not be less than three months.

The following Paper was then read —

ON HOMOMORPHISM;
OR, ORGANIC REPRESENTATIVE FORM.

BY C. COLLINGWOOD, M.B., F.L.S., &c.

BY Homomorphism is meant the recurrence of certain external forms in various departments of Nature, more or less widely separated by internal structure; so that at the outset, it is necessary to divest the mind of the idea that it partakes in any way of the character of homology.

By Homology, indeed, is distinctly understood a structural affinity, uniting, as it were in a common bond, the same organ, under whatever form it may appear, or whatever function it may assume. The limbs, for example, of quadrupeds, the wings of birds, and the fins of fishes, are thus structurally

united, and although taking very different *forms*, are strictly homologous one of the other. But the wing of a butterfly, though bearing a general analogical resemblance to that of a bird, has yet no community of structure with it; nor has the wing of a bat any stronger claim to be considered homologous with the wing of a true bird. The wings of a bat, or a butterfly, are *homomorphous* with the wings of a bird, and indeed perform the same function;—so far, therefore, they may be regarded as *analogues* of those organs. But it must also be understood that homomorphism does not necessarily imply analogy, in the proper sense of that term; for by analogy is understood, as distinguished from homology, an agreement of function, where there is no community of structure, as just instanced; whereas homomorphism, while it expresses, primâ facie, an *absence* of agreement in structure, or homology, may, or may not, be accompanied by similarity of function, though the want of such functional agreement is the rule, and its presence an accidental exception.

From this it will readily appear that the study of homomorphism cannot be expected to be so prolific of important results as the study of homologies, inasmuch as these latter are believed to be the bonds of connection which unite forms apparently widely separated, and which throw light upon the true affinities of obscurely constituted organisms. And herein probably lies the reason why homomorphism has attracted so little attention from naturalists. I am not aware of any essay (though such there may be) upon this curious subject, which either collects and compares the various examples with which Nature abounds,—or, still less, which attempts to treat it upon such a basis as that on which all natural science should be treated. It appears indeed to be barely referred to here and there in the writings of zoologists, as something striking and remarkable, usually called up by some peculiarly curious fact in connection with the special subject upon which they

happen to be engaged, and then quickly dismissed as a barren topic, unworthy of further investigation. A singular resemblance thrusts itself upon the attention, claims a passing allusion, and is no more thought of. My object, therefore, in the present paper, is to dwell more at length upon the vast number of recurrent forms met with in the *animal* kingdom, referring to the considerations which seem to be derivable from them, and the generalizations which appear to be legitimately deducible from the enquiry.

It will probably occur to some, at the first blush, that organic homomorphism has a correlative in the inorganic world; but the restricted definition already given will exclude the class of representative forms known to the chemist under the name of *isomorphous*. This term refers to a similarity of crystalline form, assumed by substances (even compounds) of different constitution, a strong corroborative argument in favour of Wollaston's theory of the simple form of atoms.* But Mitscherlich has shown that isomorphism implies, primâ facie, in bodies subject to it, a certain agreement of chemical properties, which may be regarded as the analogues of organic functions. Thus, "the acids of arsenic and phosphorus form salts which crystallize alike, and their respective bases not only correspond in a more general way in acquiring acid properties with oxygen,—forming gaseous compounds with hydrogen, &c., but also in the unusual proportions in which oxygen and hydrogen enter into union with them,—while the corresponding arseniates and phosphates also agree in taste, and in the degree of force with which they retain their water of crystallization."† This similarity of properties therefore raises isomorphous bodies from being homomorphs to the dignity of analogues.

The animal kingdom has been so severely scrutinized during the last half century by men of keen perception, such

* Bakerian Lecture, 1813. † Daubeny, Atomic Theory, p. 170.

as Cuvier, Owen, Huxley, and others, that science is no longer at a loss for the key to the general plan upon which it has been constructed. The study of morphology, or the science of form in connection with structure, has demonstrated that there is a certain unity of plan running throughout it; and that although it is impossible to construct an archetype which shall stand for all animals, it can be shown that four such archetypes, or at most, five, will represent the primary forms around which, as centres, the whole animal kingdom may be grouped. This being the case, we might expect that there would be a certain degree of similarity of form among animals; indeed, on learning these facts, we might be disposed to look for and expect a far greater degree of similarity than we shall find; and we cannot help feeling surprised at the vast and interminable variety of form which is made as it were the vehicle for the modification of four or five types. But Nature is inexhaustible in resources, and variety is one of the charms of Nature which the Creator has afforded in an eminent degree for the adornment of the earth, and for the intellectual exercise of his highest creatures.

It is often said that no two things are alike in nature,—and with truth,—for the resemblance, whether in outward form, or in internal organization, always partakes of the character of a *near approach*, and never of direct repetition. It must not be supposed that homomorphism means repetition—Nature never repeats herself; the resemblance may be striking, and such as at first sight may cause the uninstructed to confuse together animals of very different groups; but a close study of either by degrees reveals differences no less striking than are the points of resemblance. Of this many instances will be adduced as we proceed. And this rule is constant throughout nature; for even in the inorganic world, where the resemblances are even more close than in the organic, (inasmuch as the forms assumed by inorganic matter, such as

crystals, are far more simple than those exhibited by organized beings,) this fact has long been recognised. Some writers, indeed, who aim at greater precision of language in chemical technology, have proposed the term *plesiomorphism*, as a substitute for *isomorphism*; and Daubeny, while he objects to the necessity of the change, yet admits "that it would be perhaps difficult to point out two bodies which are exactly isomorphous."*

It cannot be a matter of surprise, considering the number of such resemblances existing throughout the animal kingdom, that while the study of homologies was making but slow progress, and the true affinities of animals were but little understood, the real nature of many aberrant forms should have been lost sight of in the contemplation of their homomorphic resemblances. Who can wonder if Pliny spoke of the bat, as "the onely bird that suckleth her little ones," in quaint old Holland's phraseology? What malacologist even can feel surprise that up to recent times the Polyzoan molluscoids were mistaken for zoophytes, or that Lhuyd, and at one time the illustrious Ellis, should have regarded them both in the light of "remarkable sea-plants;" while his predecessor, Baker, had even looked upon them as the production of "salts incorporated with stony matter"† Who can wonder that before the time of Savigny, the tunicated Botrylli should have been regarded as polyps—that Linnæus should have placed Teredo among the annelids—that before the Memoire of Dujardin in 1835, the Foraminifera should have been classed with the cephalopodous mollusca? In all these cases, (and others might be brought to swell the list,) the animals have been raised, or have sunk from one *sub-kingdom* to another, and have even *overleaped* a whole sub-kingdom, to take that place in the scheme of nature which their affinities

* Atomic Theory, p. 175.

† Employment for the Microscope, p. 219.

claimed for them. So late as 1812, the whales and dolphins were classed in a systematic work as "cetaceous fishes." Even now, indeed, many an animal is provisionally placed in a position which it occupies, perhaps solely, by its morphic analogies, because, from the rarity of its occurrence, or from the difficulty of bringing specimens under the scalpel of competent anatomists, its true homologies cannot be tested, and its correct position verified.

These homomorphic resemblances, however, have proved useful in their way, by affording an easy clue to a nomenclature which shall be at once apt and serviceable. Amidst the vast number of species requiring to be distinguished by a generic and specific name, systematists are often hard pressed to frame a new designation; since the same name given to two species, or even to two genera, however widely separated, is liable to lead to confusion. The inevitable result is that the most barbarous words are constantly being coined in the natural history mint, and bad Greek and Latin are mixed up with native names in nearly all the dialects of the world; and these, with a dash of the Smithii, and Jonesii, and Brownii, form altogether a Babel which is the opprobrium of natural history. But a homomorphic resemblance at once suggests a *natural* nomenclature, that is to say, a word which, by indicating the nature of the resemblance, is at once an appropriate name, and a good guide to others in the recognition of the animal *Auricula Midæ* (Lam.) is an excellent name, not only affording a clue to the shell referred to, but also delighting the scholar with the imaginative associations raised up by the beautiful classic fable on which it is founded. Few names indeed are so happy, but still such as *Cestum Veneris*, *Phyllium siccifolium*, *Crioceratites*, *Ophiura*, and the like, contrast favorably with such cacophonisms as *Hyperöodon Butzkopf*, *Pterodictycus potto*, *Balœna Agamachshik*, (Pallas), *Notopocorystes Broderipii*, or *Ardea brag!*

But although they were not always recognised as such, the existence of recurrent forms in nature could not be overlooked by the framers of systems, inasmuch as they were stumbling-blocks which almost seemed placed in their path to prevent the natural arrangement of animals from being too easy a task. A too cursory examination has not unfrequently resulted in the false position of an animal, only to be detected and triumphantly exposed by a succeeding zoologist; for not only are classes and sub-kingdoms homomorphically represented by widely separated ones, but the naturalist has often been led into exclamations of surprise at the remarkable homomorphisms existing between orders of the same class. These curious resemblances cannot better be illustrated than by comparing, first the classes of the vertebrata one with another, secondly the vertebrata with the invertebrata generally, and thirdly the sub-kingdoms of the invertebrata one with another.

Beginning then with the classes of the Vertebrata,—every one knows, whether he have thought about it or otherwise, that the four vertebrate classes are homomorphically connected. Thus, there are flying mammals, such as the bats and flying squirrels (Pteromys) uniting them with the class Aves; as well as that anomalous monotreme, the ornithorhynchus, or web-footed duck-bill. The Edentata among quadrupeds connect them with reptiles, by means of the armadillos; the great armadillo (Dasypus gigas), and prëeminently, the mataco (D. apar), being homomorphic with the Testudinata; while to the saurian reptiles they are united by the scaly pangolins (Manis), and to the extinct pterosaurians (Pterodactyls) they are again united by the bats. With fishes, the mammalia are most singularly connected by the cetacea; while a special resemblance appears between the narwhal (Monodon) and the sword-fish (Xiphias.) The homomorphic resemblances between birds and reptiles are not so striking, but the Draconine

saurians or flying lizards (Draconis sp.) supply examples, and the extinct pterodactyl once afforded another; while with fishes, the various species of flying fish (Exocœtus) among the soft-finned, and flying gurnards (Dactylopterus and Pterois) among the hard-finned, are good illustrations. It only remains to connect reptilian forms with fishes, and here the snakes (Ophidia) with the eels may well be compared, and less striking instances of resemblance occur between the saurian reptiles, such as the alligator, and the bony-cased sturgeon; and between the testudinata and the trunk-fishes (Ostracion.) Perhaps also that great enaliosaur, the Ichthyosaurus, might be here mentioned.

I remarked just now, that even between orders of the same class very curious homomorphisms may be observed; and I will select the class mammalia as the best one with which to illustrate this remark. The organic structure and affinities of one *order* are dissimilar from those of another, just as the structure and affinities of one *class* differ from those of another; the difference between class and order being one of *degree* and not of *kind;* so that it is as remarkable to find resemblances of form in widely separated orders, as in still more widely separated classes, although, of course, homomorphic resemblances are more striking between orders than between classes. Let us take, for example, the order quadrumana, (for I will not speak of the homomorphism existing between the bimana and the quadrumana,) and we shall find among them representative forms of various other orders. Thus, the genera Midas and Jacchus, known as marmozets, true platyrrhine quadrumana, represent the rodentia through the genus Sciurus (squirrels); and the Douricouli (Nyctipithecus felinus), in the same division, represents the cat (Felis) in the digitigrade carnivora; while among the strepsirrhine quadrumana, the loris (Stenops tardigradus) represents the true sloths in the order bruta, and the very

aberrant animal, falsely called the flying squirrel (Galeopithecus), is the representative of the order cheiroptera or bats.

Among the pachydermata are some no less striking examples of species, homomorphic with those of other orders. Thus, the hyrax, an animal in structure intermediate between the rhinoceros and the tapir, a miniature rhinoceros as it has been called, yet so closely resembles the rodentia in its outward form, that it was long classed with them, and Cuvier makes the following remark concerning it: "There is no quadruped," he says, "which proves more forcibly than the daman (Hyrax capensis) the necessity of having recourse to anatomy as a test by which to determine the true relationship of animals."

The general resemblance between the cetacea and the pinnigrade carnivora (seals) need only be referred to; it is made very distinct through the herbivorous family Manatidæ, especially the dugong (Halichore dugong.)

We have seen how the loris resembles the sloth; and on the other hand, the edentate genus Bradypus (Ai) bears a singular resemblance to monkeys in general, even in that particular which is so characteristic of them, viz., their physiognomy,—while it has a carnivorous homomorph in the sloth bear (Ursus labiatus), called by Pennant the ursiform sloth, and by Shaw, Bradypus ursinus.

The insectivora are connected through the hedgehog (Erinaceus Europæus) with one of the most anomalous of animals, the singular monotreme genus Echidna, which has besides other homomorphs to be afterwards mentioned; and further through the shrews (Sorecidæ), with the rodent genus, Mus; and with the carnivora, by the bulau (Gymnura Rafflesii) of the East Indies, formerly described as a Viverra.

The rodentia are united homomorphically with the pachydermata by means of the capybara (Hydrochœris capybara, Buff.), formerly called, from its pig-like appearance, Porcus

fluviatilis (Fermins), thick-nosed tapir (Pennant), cochon d'eau (Desmarchais), and Sus maximus palustris (Barrère.) By the flying squirrel (Pteromys) they claim some homomorphic affinity with the cheiroptera; but their chief homomorphism is with the marsupialia, and most striking are the resemblances. Not only do the rodentia and marsupialia bear a general mutual resemblance throughout,—both orders possessing that extraordinary development of the hinder extremities and tail, which enables the jerboas in common with kangaroos to take such wonderful leaps,—but there are particular animals in both orders which bear a most remarkable resemblance to one another. Thus, the rodent jerboas (Dipus) are closely imitated by the tufted-tailed rat-kangaroo (Hypsiprimnus penicillatus, Gould); and the true kangaroos (Macropus) are equally nearly approached in form by the Cape leaping hare (Pedetes capensis, Ill.) There is also a considerable resemblance between the wombat or badger of the Australian colonists (Phascolombys Wombat, Per. and Les.) and the rodent cavies and lagomys; while a further homomorphism occurs between individuals belonging to aberrant groups in either order, viz., the Brazilian porcupine (Synetheres) among the rodents, and the echidna among the monotremes, whose relation to the insectivora has already been pointed out.

These external resemblances between rodents and marsupials are none the less remarkable when we learn that there is less true affinity between them than between the marsupials and most other orders; for Mr. Waterhouse, in his excellent "History of the Marsupialia," remarks that in them "we find representatives of most of the other orders of mammalia: the Quadrumana are represented by the Phalangers; the Carnivora by the Dasyuri; the Insectivora by the small Phascogales; the Ruminantia by the Kangaroos; and the Edentata by the Monotremes." He adds "The Cheiroptera are not

represented by any known marsupial animals, and the rodents are represented by *a single species only;*" the species here referred to being the wombat.

Lastly the marsupialia, besides their homomorphism with the rodents, have through the ursine opossum, or native devil of Van Diemen's Land (Dasyurus,) a singular relationship to the carnivorous genus, Ursus; as well as through the squirrel petaurus, to the bats.

I shall not here attempt to follow out the homomorphisms existing in the orders of the class Aves, because it would make the present paper too long for the occasion; but they will be found to be not less striking than those of the mammalian orders; and I will content myself with an illustration by means of the first, or rapacious order. Here the elegant Nauclerus furcatus, or swallow-tailed kite, stands for the passerine genus Hirundo; and the Egyptian vulture (Cathartes aura) is singularly matched by the rare Corvus gymnocephalus, or bald-headed crow, of Guinea. The scansores are connected by the similarity between the sparrow-hawk (Accipiter nisus,) and the cuckoo (Cuculus canorus,) as well as more generally between the owls and parrots. The burrowing owl (Noctua cunicularia,) of America, unites the rapacious with the rasorial birds—the anomalous secretary bird (Gypogeranus,) of Africa and the Philippines, connects them in a most remarkable manner with the grallatores, and the çariama (Sariama cristata,) in particular, for which it might readily be mistaken. The long legged harriers (Circus,) also maintain the resemblance, while the sea eagle (Haliäetos) completes the homomorphism, by connecting the raptorial birds with the natatores through the albatross (Diomedea.) Having thus illustrated one order I will quit this class of birds, only calling attention to the remarkable general resemblance between the rare Conirostral genus opisthocomus and the rasorial guans (Penelope,) the fissirostral hirundines and the natatorial terns (Sterna,)

and the grotesque parrots, and equally grotesque puffins, (Fratercula.)

We shall not find it so easy to discover homomorphic resemblances among the reptiles, for there is no class which exhibits less variety within the limits of its orders, and the observation of Professor Bell, in his "Monograph of the Testudinata," with respect to the tortoises, may be applied with nearly equal force to the whole class Reptilia. "At present," says that eminent erpetologist, "they certainly remain the most isolated order, not only amongst the reptiles, but perhaps in the whole animal kingdom." Small indeed, in number, as a class, the four orders into which they may be divided are singularly characteristic and circumscribed, as well as constant in their characters. The chelonian reptiles shut up in their unyielding box—the saurians, all more or less lacertine in form—the elongated and simple ophidians, nor the short and long-tailed amphibians are capable of the same degree of diversity as are the other vertebrate classes; and although I have pointed out their homomorphic connection with the latter, with the aid of extinct forms, it is not easy to find homomorphic individuals in distinct orders, except among the lacertine sauria, and the long-tailed amphibia. When, however, they do apparently occur, it becomes probable that they are of the nature of *links* connecting different orders, and therefore partake of homological rather than homomorphic resemblance, and are inadmissable for our purpose.

A different remark, however, is applicable to the class of *fishes*. There is perhaps no tribe of animals, not even excepting the vast class of insects, which present such extraordinarily singular and eccentric forms, as do fishes. There is no degree of anomalous shape, nothing so marvellously *outré* which the imagination can conceive, which is not paralleled in this most wonderful class. I venture to say that if a person of the wildest fancy, but unacquainted with piscine

forms, were to depict in his most exuberant moments an imaginary creature, as unlike any living being as he could conceive, some finny reality might be advanced to cap the monster. Take for example, and as a familiar instance, the hammer-headed shark (Zygana laticeps,) or the painted angler (Lophius pictus,) or the viper-mouthed pike (Esox viridis,) or Syngnathus foliatus, Stylophorus chordatus, Raia fasciata, and a host of others, which might easily be mentioned. But with all this wonderful variety, the forms of fishes are *sui generis*, and in no class is it less easy to find homomorphic shapes. Their morphic affinity to the other vertebrate classes has been already indicated, but order with order has little in common. The inexhaustibility of Nature's plastic resources is shown in no class to more advantage; and yet, strange to say, there is no class in which I have succeeded less in tracing homomorphic resemblances.

There is a remark which has occurred to me, and which, though it will be proper to introduce it here, must be carefully borne in mind, as it will be particularly referred to hereafter; namely, that among such animals as bear homomorphic resemblance to those of another and differently organized group, an agreement in form is generally accompanied by a singular agreement in habits. It matters not how different are the habits of the group to which it homologically belongs, from those of the group which it homomorphically resembles; it diverges from its own tribe as much in its *actions* as it does in *form*, as though a certain external configuration necessitated certain habitual movements. A few examples will illustrate my meaning, taken from within a class, where such habits are more easily compared than in animals of different classes. Thus the ursine opossum (Dasyurus ursinus,) widely separated as it is from the plantigrade carnivora, not only agrees far more closely with a bear in form than with its own congeners, having a short, clumsy figure, and plantigrade step, but it is

said of them by their discoverer that "they frequently sat on their hind parts, and used their fore paws to convey food to their mouths; and many of their actions, as well as their gait strikingly resembled those of a bear."* The quadrumanous douricouli, (Nyctipithecus felinus,) not only resembles a cat in form, but is, like it, nocturnal in its habits, glides about with the stealthy movements of a cat, and "when irritated, in the posture it assumes, and the puffed state of the fur, it resembles a cat attacked by a dog." The pachydermatous hyrax lives gregariously in burrows, like the rabbits which it so much resembles in form. The echidna rolls itself up into a ball when disturbed, like its homomorph, the hedgehog. The lemurine Galeopithecus makes its flight with its young attached to the nipple, as do the true bats. The habits and food of the sea-eagle closely agree with those of the albatross; and the burrowing-owl is diurnal in its habits, and uses its feet more or less for purposes of scratching, in both which respects it differs from its congeners, and agrees with the Rasores, which it resembles in form.

Besides, however, the general homomorphism connecting whole animals in different classes or orders, it is at least curious that there are certain appendages in each class, which are characteristic of certain individuals, and distinguish them perhaps from every other, not only in their order, but in their class, but which reappear homomorphically in certain individuals in the other classes. Such an appendage is the nasal horn of the rhinoceros, which is so peculiarly distinctive of that animal. Among birds there are several instances of a central horn, but it usually springs too high up on the forehead to bear out the resemblance; as for instance the horned screamer (Palamedea cornuta). In the carunculated chatterer of Brazil, (Procneas nivea,) the appendage, which is not really

* G. P. Harris, in Linn. Trans. ix., 174.

a horn, is situated far in front of the eyes, and better represents the rhinoceros' horn; in the rough-billed pelican, however, (Pelicanus trachyrhynchus,) a stout horn-like excrescence really grows from the middle of the upper mandible; and in some species of hornbill, (Buceros,) the analogy is well carried out. Among reptiles, the extinct Iguanodon distincly reproduces the nasal horn, though it was small in comparison with the size of that colossal brute. There are many fishes which possess a single central horn, but in some of them, as in the birds, it is situated too high up on the head to bear out the resemblance. This is the case with the genus Monacanthus; but in Naseus fronticornis of Cuvier a horizontal horn projects in front of the eyes; in Chimæra monstrosa of Bloch, an inconsiderable appendage occurs in the middle of the nose; while the true homomorph perhaps may be considered to be a very rare fish, Lophotes siculus, of Swainson, of which a specimen exists in the British Museum. Here the first dorsal ray assumes the form of a horn-like process, a palm and-a-half long, Sicilian measure, somewhat three sided and pointed.

The proboscis also, so characteristic of certain pachydermatous mammalia—but which is not peculiar to them—being found in the elephant-seal (Macrorrhinus proboscideus,) as well as in some Insectivora, as Solenodon paradoxus, may be seen repeated in such birds as have the upper mandible longer than the lower, but particularly in the Heterorhynchus olivaceus of Lesson,* supposing that bird to be a normal form. Among reptiles, proboscidian forms are numerous in serpents of the genera Rhinophis, Langata nasuta, &c., and the remarkable Matamata of Cayenne, (Chelys fimbriata, Spix,) an aquatic chelonian, possesses a nasal development, precisely similar to the tapir among quadrupeds. The proboscidian species of

* Magasin de Zoologie, 1839.

fish are best represented by the curious frog-fish (Malthe nasuta,) and the extraordinary sword-fish (Xiphias gladius).*

The horns characteristic of ruminant mammalia, are paralleled, as simple elevations, by the tufts on the heads of owls of the genera Scops, Bubo, and Otus. The Egyptian Cerastes, or horned viper (Vipera cerastes,) among reptiles, and the eared trunk-fish (Ostracion auritus, of Shaw,) a formidable-looking native of the Indian seas, complete the analogy. So also with the frill round the neck from which the frilled lizard (Chlamydosaurus Kingii,) takes its name, whatever its use, it is nearly approached in form by the union of the pectoral fins of either side at their base in certain fishes, as the lump-sucker (Cyclopterus,) of our own shores; while among birds, the ruff (Machetes pugnax,) takes its name from a similar development of feathers round the head, seen also in certain humming birds, as Trochilus ornatus, and tricolor. In quadrupeds, hair supplies the resemblance in such animals as the full-maned colobus, or full-bottomed monkey of Pennant, (Colobus polycomus.) And lastly, the pouch of the pelican finds its representative in the Iguanas among reptiles.

Having thus examined the homomorphisms which exist within the sub-kingdom vertebrata, we have next to enquire what morphic connection is found between it and the other great division of *in*vertebrata. We can hardly expect to find in animals constructed on so different a plan as are the invertebrates generally from the vertebrates, that there should be so much recurrence of form between them, as we have found within the vertebrate sub-kingdom, all the members of which may be reduced to one archetypal form; nevertheless we shall meet with some striking instances of it.

Let us commence with the Mammalia; and here we find a

* It is perhaps worthy of remark that a proboscidian form occurs among the invertebrata. Thus, in the curious annelid, (Derris sanguinea,) a native of our shores, "the mouth consists of two lips, the lower one straight and fixed, the upper one hooked and moveable."—*John Adams, in Linn. Trans.*, iii., 68.

general resemblance of form between the mailed armadillos and the molluscous chitons; the isopodous crustaceans, Oniscus, and Lygia, and the fossil Nileus armadillo. The extraordinary development of the posterior extremities in the marsupials and rodents is paralleled in a remarkable manner among the Insecta by the kangaroo-beetle (Scarabæus macropus); and some of the Tardigrade arachnida, or water-bears, have a most ludicrous resemblance to certain mammalia, as may be seen particularly between Echiniscus suillus,* and a pig, or perhaps rather the insectivorous genus Centetes.

Passing on to birds, the homomorphism which is borne to them by winged insects generally, and more particularly by the stout-bodied moths and sphyngidæ, will be at once recognised. Between special birds and special insects even, homomorphism may be established. Thus the Nemoptera angulata of Latreille, a neuropterous insect, from the peculiar direction and form of its posterior pair of wings, bears a near resemblance to more than one species of Cynanthus, among the trochilid family of humming birds, as well as to the scissor-tailed blackcap (Gubernetes Yetapa, Viell,) of South America. And what closer resemblance can be looked for than that between the head of the vulture, and the avicularia, or bird's head appendages so common in the polyzoa, especially Bugula, and which are considered by Huxley to be truly a part of these molluscoids, and not of a parasitic nature.

Among the Invertebrata, we find no less striking recurrent forms of reptiles. Thus the snakes are represented by the terricolous annelids; as well as by the Ascaris lumbricoides and Strongylus among the nematoid entozoa. A very curious special homorphism also happens between the Siphonops (Cecilia annulata,) and the common earth-worm (Lumbricus terrestris.) The shelled Testudinata have a singular homomorph in a shelless mollusk, viz: the tunicated Chelysoma, so

* Ehrenberg Microgeologie, pl. 36.

called from this resemblance; as well as in the chitons, and the remarkable coccus described by Shaw as Coccus cataphractus, or the mailed coccus, connects them with insects.

Nor are the fishes altogether without their invertebrate imitators. The Diodon hystrix, or porcupine diodon may be compared with an echinus; the head of the anomalous hammer-headed shark has a parallel in the dipterous genus of insects, Diopsis, as well as the Achias oculata of Latreille, remarkable for the enormous prolongations of the sides of the head; and the curious little Pegasus draco, is the counterpart of a pteropodous mollusc.

Let us now dismiss the Vertebrata, and launching into the midst of the vast host of invertebrate animals, let us see what homomorphisms exist among their various classes and orders, dividing them simply and conveniently into mollusca, annulosa, cœlenterata and protozoa. Let us then begin with the mollusca. The tubicolous annelids are well represented through the Serpulæ and Vermiliæ, by the tubulibranchiate molluscan genera, Vermetus and Siliquaria. The pteropod genus, Spiratella (S. limacina,) bears a close resemblance to the tubicolous Spirorbis; as does also the freshwater Planorbis among the gasteropods. The limacine slug, Vaginulus, resembles the leech (Hirudo,) among the suctorial annelids; while the cyclobranchiate genus Chiton is homomorphic with certain species of dorsibranchiate annelids, the agreement perhaps being most complete between Chiton spinosus and Aphrodite hispida. The conchiferous Teredo was placed by Linnæus (who was misled by its morphic analogies,) among his Vermes, between serpula and sabella. The cœlenterata also possess their share of homomorphism with the mollusca,—principally, however, through the molluscoids of Milne Edwards. Among these, the tunicated genus Botryllus revives in appearance that radiism which seemed to have disappeared with the echinoderm Sipunculidæ, and bears a close

resemblance to the first section of the Lamarckian division of corals, called Astræadæ, and of which Astræa rotulosa is a good example.

The lowest division of the mollusca, however, afford as a class, the most singular example of homomorphism which exists in the animal kingdom. The polyzoa, as Huxley remarks, "are as truly and as wholly molluscan as any other mollusca;" but even up to the year 1827, they were universally confounded with the sertularian, and other zoophytes. It was Dr. Grant, who, in that year, in his "Observations upon the Structure and Nature of Flustræ," announced the peculiar ciliated character of the tentacles, and the molluscan type of the intestinal canal, and thus raised these animals, as Busk observes "from one sub-kingdom to another." None but those who have studied these two groups in their relation to one another, can properly appreciate their remarkable resemblance;—the oral tentacles in both arranged in circlets—their compound character, the form and very nature of the polyparies, sometimes horny, sometimes calcareous, agree so curiously, that no examples of homomorphism could be more apt to set the mind meditating upon the philosophy of these resemblances, and searching for their final causes. It is however the cheilostomatous, or marine division of the polyzoa which chiefly represents the polyps; for in the fresh-water, or hippocrepian group, with the exception of the genera Fredericella, and Paludicella, the tentacles are set upon a peculiar horseshoe-shaped prolongation, or lophophore, which to a certain extent modifies *their* homomorphism with the sertularian polyps. But here another sub-kingdom steps in, and an annelid was discovered in 1856, by Dr. Strethill Wright, on shells from Torquay, and described by him in the "Edinburgh New Philosophical Journal," for that year, which appears to be the homomorph of the hippocrepian polyzoa, and has hence received from Dr. Wright the name of Phoronis hippocrepia.

We have next to point out the homomorphisms between the second invertebrate sub-kingdom, annulosa, with the cœlenterata. Considering, however, that *annulism* is the type of the one, and *radiism* of the other, it is obvious that they are incompatible with much resemblance, and can have but little in common. The very names of annulose and radiate animals indicate that they are natural divisions presenting a marked constancy to the particular forms which have given rise to those terms; and it is only in some doubtful or aberrant groups, at either extremity of the cœlenterate class, that any resemblance to the Annulosa can be traced. Thus, among the nematoid entozoa, as Strongylus, Ascaris, &c., which, however, form the last group of Huxley's *Annuloids*, there are animals bearing a close resemblance to the typical annelids, as on the other hand do the vermiform Echinodermata, as Holothuria, and particularly Sipunculus. With regard, however, to the affinities of these latter, naturalists are not agreed, and Professor Huxley, whose opinion is worthy of great respect, places the echinodermata in the annuloid division of the Annulosa.*

Between the various subdivisions of the large sub-kingdom Annulosa, however, singular resemblances may be traced. Thus, the insecta reproduce the form of the arachnida in the orthopterous Acheta arachnoides, or spider-like cricket of Jamaica, as well as in the apterous genus Phalangium, of which P. reniforme has the aspect of a spider, and P. cancroides was considered both by Swammerdam and Roesel to be a scorpion. This arachnoid appearance is also shared in the crustacea by the macrourous decapod Thalassina scorpioides, of the Chilian coast, which, as its name indicates, also bears a close resemblance to a scorpion. The dipterous Tipula is homomorphic with the araneiform edentate crustacean, Nymphon gracile; as well as with the macropodian genus

* Med. Gazette, vol. xxxiv., p. 638.

Leptopodia, or sea spider; and the form of the orthopterous genus of insects Mantis, is reproduced in the macrourous decapod, Squilla mantis. The myriapodous genus Scolopendra (Centipede,) represents the annelidans through such forms as Phyllodoce; and the Julus through the nereid, Ioida macrophthalma. Insects, too, of different orders, will bear a close comparison, as the lepidopterous Sesia apiformis with the hymenopterous bees; the sphynx, Macroglossa bombyliformis, with the dipterous Bombylius; and this again with the hymenopterous Bombus; the homopterous Aphis (as A. sorbi,) and the neuropterous Phryganea; the dipterous Syrphus and the hymenopterous wasp; the orthopterous Phasma, or walking-stick insect, and the smaller hemipterous family of hydrometridæ as Hydrometra and Velia.

The tubicolous annelid, Pectinaria belgica, is the homomorph of the Limnias ceratophylli, among the rotifers, wherever that curious order may be located.

Between the cœlenterata and protozoa, there are no less striking resemblances, not only through the foraminifera which will be alluded to presently in connection with another subkingdom, but also through some curious compound forms of polypine infusories, of which Carchesium polypinum is a good example, as representing the campanularian zoophytes, as would also the well-known Vorticella; while Dinobrion sertularia, another form, is so called from its resemblance to a sertularian zoophyte; and this also completes the morphic relations of the polyzoan molluscoids. The curious rhizopod, Actinophrys sol, also is naturally referred to the echinite forms, particularly to the long-spined species, such as Cidaris papillata, &c.

With the exception of those between the polyzoan molluscoids and the hydroid polyps, there are none more worthy of attention than the very remarkable homomorphisms existing between the very humble rhizopodous foraminifera,

and certain members of the highest class of invertebrata. The foraminifera form the lowest group of the sub-kingdom protozoa, being only raised above the gelatinous Amœba by the possession of a calcareous investment, perforated with numerous foramina, (whence their name,) through which the gelatinous body of the creature, or sarcode, is thrust in the form of long threads, or pseudopodia, whence their name of rhizopods. The calcareous investment is divided into segments or thalami, variously arranged, which communicate with one another by minute pores. But this calcareous investment assumes such beautiful forms, and so closely imitates those of the highest shelled mollusks, that, misled by the external resemblance, these lowly organised creatures were, until 1834, classed by D'Orbigny, with cephalopods. In that year, Ehrenberg reduced them to the level of Flustræ, then regarded as polyps, under the name of Bryozoa; and thus there was the curious spectacle of two groups of animals arranged together, both in their wrong position, one of which was destined to take a place in the highest invertebrate sub-kingdom, and the other in the lowest. It was Professor Williamson, who in 1848, first published the fact of their affinities with the sponges; since which time, they have been studied in a better light, and their correct position assigned to them among the rhizopods.

The majority of these remarkable little organisms go to form the section Helicoidea of Schultze, and they bear so great a resemblance in form to the tetrabranchiate division of cephalopodous mollusca, of which the nautilus is the type, that the only difficulty is to select from the examples. Few, however, will bear a closer comparison with them than Nummulina planulata, Nonionina barleeana, Peneroplis planatus, and Geoponus stella-borealis. But although a vast number assume this form, many other of the higher molluscs have their homomorphs among them. Thus the Spirulina perforata,

and S. foliacea closely resemble the freshwater Planorbis: the genus Marginula most strikingly imitates the terrestrial Megaspira; the elegant Bulimina pupoides is the counterpart of the spiny Melania setosa; Polymorphina lactea, (var. fistulosa,) bears a great resemblance to the well-known stromb, Pteroceras aurantiacum; Cristellaria is capped by the British Pileopsis ungarica; and Patellina corrugata by the genus Patella. Nor are the mollusca alone represented by the foraminifera, for the remarkable acalephs, Stephanomia imbricata (Q. & G.) and Protomedea lutea, have their homomorphs in the species of Textilaria.

There is, however, another class of homomorphisms which are exceedingly curious, and which I cannot pass over in silence. I refer to the recurrent forms which make their appearance in larval stages of the development of various animals. The invertebrate sub-kingdoms, in the case of very numerous species undergo certain metamorphoses before acquiring the perfect form which they are ultimately destined to assume; and these larval stages differ so much in appearance from the perfect animal, that from a misapprehension of their nature, they have not unfrequently been located in other divisions of the animal kingdom. Among vertebrated animals the only order which undergoes a true metamorphosis is the amphibia, such as the frog and salamander. The larvæ of the tailless and tailed amphibia are at first alike in form, provided with external gills and tail, and unprovided with legs. In the anourous amphibia, the tail disappears, and a frog is the result, in the salamander the tail remains. But not only is this tadpole form characteristic of the amphibia, but it was first observed by Sir J. G. Dalyell,* that the tunicated ascidians, both solitary and compound, pass through a tadpole form, and are then locomotive by means of a

* Edin. New Philosophical Journal, 1830.

vibratile tail, which they ultimately cast off when they assume their permanent fixed condition.

The only group of gasteropodous mollusca which undergoes metamorphosis is the Nudibranchiata, and these are first hatched as nautilines, bearing a great resemblance through their shell to the cephalopods; while like the pteropods they swim actively about by means of large lateral ciliated lobes, which afterwards become the epipodium. The larval forms of those decapodous crustacea in which a metamorphosis is observed to take place are so remarkably characteristic, that although they were once supposed to constitute distinct genera, they were never confounded with other species; but in the cirrhiped genus Balanus, the larval form has, as Mr. Gosse observes, "exactly the figure, appearance, and character of the young of the common Cyclops (an entomostracon,) so that you would, without hesitation, if you knew nothing of their parentage, assign them to that well-known genus."* Among insects, the larva and pupa forms of several orders are universally familiar, and the general resemblance of the former to annelids has been remarked by every one. With regard to the pupæ, indeed, especially of the lepidoptera, so great is the homomorphism existing between them and certain shells of molluscs, that a genus of pulmobranch helices has been established under the name of pupa, of which, Pupa chrysalis is perhaps the best example.

The habit of inhabiting cases, adopted by the larvæ of some insects, causes them to bear a considerable analogical resemblance to tubicolous annelids; as for instance, between such caddis worms (or larvæ of phryganeæ,) as form cases of sand, and the Sabella alveolaria; while those which collect together freshwater shells to form their habitations, may be compared to the Terebella medusa, among annelids.† But I must not

* Evenings with the Microscope, p. 238.

† A curious instance of an analogous habit is afforded by Trochus agglutinans.

pursue this subject, and will dismiss it with one or two more examples; thus, the earliest form assumed by the young of the Tubularia indivisa and Medusæ, is called a Planula, from its close resemblance to the turbellarian annelids known as Planariæ; and the polypiform stage of the so-called alternate generation of the acalephæ, (of which *Hydra tuba* is an example,) is the counterpart of the perfect condition of those polyps of which Hydra is a genus.

But one more category of recurrent forms will I allude to, those, namely, which reproduce special parts of more than one animal, and result in certain figures which we should be inclined to call *composite*. In his inimitable Epistle to the Pisos, Horace says,—

"Humano capiti cervicem pictor equinam," &c.

"If a painter were to join a human head to a horse's neck, or a fish's tail to the body of a beautiful woman, would you not laugh at him?" Yet spite of Horace, and under the name of Art, monsters are produced no better amalgamated, and which it must be confessed are more artificial than artful.*

Other such curious analogies may be found both among the vertebrate and invertebrate animals; for example, between the gnat (Culex pipiens,) and the oceanic snail, (Janthina fragilis,) both of which form a raft for their eggs, by means of which these delicate structures are preserved. In the case of the former the eggs are glued together at the moment of extrusion; in the latter they are fastened to the under side of a peculiar apparatus of air cells. An example taken from the vertebrata is afforded by the habit of certain opossums with incomplete marsupial pouches, such as Merian's opossum (Didelphis dorsigera,) which is fain to carry all its young upon its back with their tails all twisted round the common maternal tail; and an analogous dorsigerous habit exists in the Surinam toad (Pipa monstrosa,) of Bufo dorsiger of Latreille, which carries its young for 82 days in pits upon its back, until at the end of that time they are fully developed.

* I cannot help referring here to an admirable illustration of the principles which I shall presently endeavour to lay down with regard to the adaptation of forms, which occurs in Ruskin's "Modern Painters" (vol. iii. p. 106,) where the author compares a piece of true grotesque from the Lombardo-Gothic with one of false grotesque from classical (Roman) architecture. In these sculptures the workmen have combined a lion and an eagle; in the false griffin they have been fitted together by line and rule in the most *ornamental* manner; in the true griffin the most essential parts of the two animals are thoughtfully and skilfully combined, and the result is "not merely a bit of lion and a bit of eagle, but whole lion incorporated with whole eagle." p. 108.

But that which the Horatian precept condemns in Art as only worthy of derision, Nature effects in such a masterly manner as not only to excite our curiosity but to command our admiration. Nature joins together in a wondrous manner the bill of a duck with the body of a mole (Ornithorhynchus); the horns of a stag with the head of a beetle (Lucanus); places a fish's head upon a reptile (Chamæleon), a horse's head upon a fish (Hippocampus), a bird's head upon a mollusk (Bugula); and provides a fish with hands (Malthe.) She even combines the body of a lizard, the head of a fish, the prehensile tail of a new-world monkey, the tongue of a wryneck, eyes which are only found elsewhere in the telescope carp (Cyprinus buphthalmus), and the feet of a woodpecker; and from this curious compound springs the chamæleon, a creature as perfectly adapted to its requirements and mode of life as the most normal organism or the most graceful animal.

Seeing then that we meet with so many forms recurring in widely separated groups, the question now arises, in what light are we to regard them? Must we look upon the lower as dawning anticipations of higher and more perfect forms? or must we, on the contrary, regard the higher as fashioned upon an inferior and degraded type? This is a question which in a general way it is not difficult to answer; although the questions which arise out of it are not so easily disposed of. First, let us enquire what we are to understand as a degraded type. There are grades in organization, from man downwards, as everyone admits. Vertebrated animals are more complex and more highly organized than invertebrate. Mammalia are constructed upon a higher type than birds, birds than reptiles, and these again than fishes. Their whole circulatory apparatus, materially affecting every part of the organization, proves this. Again, the monkey is more highly organized than the mole, the mole than the opossum, and the opossum than the echidna; the cerebral system, no less than the generative apparatus, is

proof of this. Granting, then, a scale of *organization*, may we not also claim in a general way similar gradations for organic *form*? The animal form is as superior to the vegetable form as are the complex functions of which it is the medium in the one to the simply vegetative functions which are required for the other. The vertebrate form consisting of an axis and diverging appendages is as superior to the invertebrate as are the functions of locomotion, &c., in the former superior as a class to those in the latter. Again, the mammalian type of form, adapted to walk or leap, to traverse the earth's surface with the greatest ease and advantage, is superior, as a type, to that of birds whose home is the aerial medium, or of fishes whose movements are strictly confined to the water. And no one will question that the highest type of all is the *human*, whether we regard form *or* organization; while it is only approached in form by that order, which though far below, stands next in point of organization, viz., the quadrumana. If this is granted, then it follows that there is to a great extent a graduated type of *form* as well as of *organization*.

Now, although we have found that in nearly every class and order certain wide departures from the typical form are met with, nevertheless it will be observed that a certain form is characteristic of a certain group. If therefore the aberrant form is homomorphic with some type of form placed far above it in the scale of organization, (which on the whole may be regarded as agreeing with that of form), then we may consider it as *anticipating higher forms*. Thus the very dawn of animal life, as it were, represented by the rhizopod forms, known as foraminifera, anticipate the greatly superior class of mollusca; and even the symmetrical shapes of members of the highest order of invertebrate animals, viz., the testaceous cephalopods. So also the insecta anticipate, in their winged forms, the highly organized class of birds.

But instances of degradation of typical form are far more common; thus, the bats descend to the form of a lower vertebrate class—the pangolins to the reptilia—and the cetaceous mammals assume a still inferior piscine form. The ophidian order of reptiles quit the reptilian, and even the vertebrate type, for still lower resemblances, assuming the general vermiform shape which is the typical form of the invertebrate annelidans. The polyzoan molluscoids are degraded to the morphism of the hydroid zoophytes, and these again to the still lower type of vegetable forms.

The same differences may be observed within the limits of a class;—thus, the gyrencephalous Hyrax descends to the typical form of the lissencephalous rodents, (to use the admirable classification of Professor Owen;) while on the other hand, the lissencephalous Opossum (Dasyurus ursinus) ascends to the high morphic position of the gyrencephalous Bear.

Thus it is evident that no general law of anticipation of higher, or of degradation to lower forms, can be laid down; and even the assumed law of the general agreement of form with organization, it must be confessed, cannot be shown to be unexceptionable.

Since, then, no regular system can be detected in the recurrence of forms, which agrees with an ascending or descending type of organization,—and by means of which we may satisfactorily account for homomorphism,—it becomes necessary to make an appeal to final causes. In a former passage I have alluded to the connection which exists between form and habits, and in those remarks I produced instances of striking deviations from typical *form*, which were accompanied by no less striking modifications of typical *habits*. Taking, then, this principle as a starting-point, let us see if we cannot discover a clue to the morphic deviations referred to: and in order that we may advance with safety, let us commence with instances of the greatest simplicity, and pass on from them to the more complex.

Now, among all the vertebrate classes there are certain general homologies which structurally unite every animal contained within them, however it may differ in external form. In all, the diverging appendages are present under some form or other, except indeed in certain ophidians, in which they are entirely absent. In birds, the modification of the fore extremity is obvious, and in fishes only somewhat less so; but although the relative position of the pectoral and ventral fins is sometimes reversed (as in the perch, for example), still the pectorals are *always* homologous with the fore, and the ventral with the hind limbs of other vertebrata. There is, therefore, a great community of *plan* in vertebrates, with respect to those parts which constitute the elements of external form.

Let us now glance at the media in which they move. Mammalia are, as a class, destined to tread the surface of the earth, birds to fly in the air, and fishes to swim in the sea; but neither is the air nor the sea devoid of mammalian inhabitants; and both land and water, as well as air, afford a home for birds. Reptiles also occupy all three stations; and fishes alone, being essentially water-breathing animals, as well as of a decidedly inferior grade of organization, never quit that element. But in order that a mammal should be adapted to an aquatic existence, it must be fashioned more or less in the form of a fish; an elaborate hand or foot would be useless, and projecting appendages injurious. It is therefore piscine in form, covered with a smooth skin, and differs from a fish only in the position of the tail, which being horizontal instead of vertical, is an index of its air-breathing habits. So also, an aquatic bird has a smooth covering of close-set feathers, an attenuated head, fin-like wings, and feet situated so far back as to answer the purpose of a propelling tail when in the water; and could we see a Penguin in the act of swimming beneath the waves, it would undoubtedly have the aspect of a

fish. Take again the Seals, in which these aquatic habits are not so complete as in the cetaceans, and we find them modified in form to be something intermediate between a fish and a mammal; while an Otter, which is rather terrestrial than aquatic, has its quadrupedal character still less modified—in it, there is the close-set fur, the depressed form, and the webbed feet; but the feet are not fins, nor is the tail.

With regard to flying quadrupeds, it is of course more or less necessary that the upper extremity should form a wing of some kind, which, however different in the homologies of its parts from the wing of a bird, must necessarily bear some general resemblance to it in form. A bat is as purely an aërial animal as is a bird, but its wing not being formed upon the type of that which exists in a true bird, must be inferior; nevertheless it is as truly and completely a *wing* as is the far more perfect, but less bulky, wing of a bird.

Further, if we select a single class, such as the mammalia, and bear in mind the same principle, we shall find it lead to the same results. Some quadrupeds of each order are arboreal, some terrestrial, and others subterranean; some are carnivorous, some insectivorous, and some frugivorous; some are nocturnal, some diurnal, and some crepuscular. If, now, an animal belonging to one order, is, like an animal of a different order, insectivorous, the former probably bears some remote analogy to the latter by virtue of that fact;—if the animals of two different orders are not only *both* insectivorous, but also crepuscular, for example, the probability of their resemblance is increased; but if the two are insectivorous, crepuscular, *and* subterranean, then the great agreement of their habits must be accompanied by a considerable approximation of form.

Perhaps there are no facts in the natural history of animals which are simpler, or with which we are more familiarly acquainted in a general way, than the broad characteristics which differentiate the habits and modes of life of quadrupeds,

birds, and fishes; and on the other hand, the aberrant forms which are assumed by aquatic mammals and birds, and by aërial quadrupeds, and the homomorphism of these aberrant forms with those of the classes of vertebrata which they most nearly approach in their habits and modes of life, are highly important questions, which thus admit of elucidation with a degree of probability commensurate with this exactness of our knowledge of those habits. The kind of homomorphism which obtains between members of a class (such as among the various orders of the mammalia) requires a different kind of knowledge, viz., not a general acquaintance with broad facts, but a special familiarity with individual habits. Now, such a special knowledge is by no means always possessed, or even easily attainable; but when it is so, it is found that the greater the agreement of habit and modes of life between any two animals of distinct orders, the more striking is the homomorphism which exists between them. Of this proposition, several illustrations have already been given.

Taking now our stand upon these facts, and carrying the principle which I have laid down into the invertebrate division of animals, the first thing which strikes us is the comparative artificiality of some of the resemblances which have been mentioned as existing between them and the vertebrate subkingdom. The habits of a mollusc and a fish can scarcely be compared, still less can those of a tunicate and a reptile, or of an infusory and a quadruped; and yet we perceive between them close resemblances of form; but between a worm and a siphonops, or between an insect and a bird, we can readily argue a community, because we at once estimate the narrow limits in the one case, and the wide extent in the other, of their analogical functions. It would be highly unphilosophical to suppose that these close resemblances were the effect of accident, and still more so to say that they result from accident in one case, and from profound design in another.

The homomorphisms existing between the vertebrata and invertebrata are not numerous; indeed, as might be expected in animals so widely separated, they are rare, and usually imperfect. I confess they present the greatest difficulty. And yet where knowledge of habit assists us, the difficulty to a great extent vanishes. There is no class of invertebrata more familiarly known than the insects, and there are no clearer homomorphisms between these great sub-kingdoms than those between insects and birds; and who is there that does not perceive that the forms assumed by insects are as much the necessity of their habits—and that in habit, as in form, they assimilate to birds, just as a bat does, or as a whale does to a fish.

Again, how little do we know of the habits of the invertebrate classes generally. The majority of them are marine; and it is only quite recently that they have even been *seen*, except through the medium of pictures, by the majority of persons. We are not on terms of familiarity with *them*, as we are with quadrupeds and birds; and seeing that our comprehension of their homomorphism is in direct ratio to our knowledge of their habits and modes of life, it is not a matter of surprise that we should be unable to penetrate the mystery of the similarity between the Foraminifera and the Mollusca, or between the Polyps and the Polypine Infusories. For here, again, the explanation of their homomorphisms is measured by the amount of our knowledge. We know why a Bombylius resembles a Bombus, or a Teredo a Sabella, having some acquaintance with the similar habits of each, and seeing a degree of similarity between them. We know why a caddis-worm resembles a tubiculous annelid, and this again a tube-inhabiting rotifer; it is the common habit of forming a tube for their otherwise unprotected body which assimilates them. But we know not why a Chiton resembles an Aphrodite, because we are equally ignorant of the habits of either.

Let me now, in application of the foregoing principles, throw out some suggestions in relation to the most striking instance of homomorphism which occurs, perhaps, in the animal kingdom,—viz., that existing between the polyzoan molluscoids and the hydroid polyps. In both these widely separated groups we have certain compound forms, made up of numerous membranous or calcareous cells, upon a common axis or stem, which branches in a plant-like manner, each cell being the habitation of a distinct animal. These are their homomorphic characters; now let me state what are the special characters of each group. First, hydroid polyps:—mouth with filiform, simple tentacula; stomach excavated in the cellular substance of the body; no distinct muscular apparatus; body contractile in all its parts—gemmiparous externally. Second, polyzoa:—body not contractile, symmetrical; mouth and anus separate; gemmiparous and oviparous. It therefore appears that the polyzoa are minute molluscs, differing in all their homologies from polyps. Let us next inquire of which group the polyzoary form is typical. Clearly not of the mollusca, which are for the most part of very different form; and equally clearly it *is* typical of the polyps, in which class it assists their analogy with vegetable forms. The polyzoarian form, then, is aberrant from the molluscan, and typical of the hydroid polyps. *Why* this form is the best adapted for the life of polyps I am not required to prove, but only why (that being granted) it is also the best form for the polyzoa. Next let us enquire what differences exist in the form of the animals themselves. In the polyp there is a gelatinous substance hollowed out into a stomach, a single aperture serving the purposes of taking in food, and passing out rejectamenta and ova—this common outlet being surrounded with a circlet of gelatinous contractile tentacles, armed with nettling capsules. But the molluscoid has an œsophagus, stomach, gizzard, intestine, distinct anus, besides a liver and nervous system.

In none of these particulars has it any relationship with polyzoa; but the mouth is surrounded with a circlet of tentacles, not indeed like those of the polyps, simple and contractile, but uncontractile and covered with vibratile cilia. They are probably the homologues of the labial palpi of other molluscs. This circlet of tentacles, then, is the *great point of resemblance* between molluscoids and polyps; in the latter the common arrangement—in the former, arising as it were from an accident or variety of organization. But yet, is it not easy to perceive that the common possession of tentacles exhibited by polyps and polyzoa implies a very great similarity, nay, almost *identity*, in one of the most important *habits*, namely the mode of procuring food?

Having so far established a community of habit between them, let us next refer to the grand organic distinction which is implied in the widely different form of the digestive apparatus. In the polyps, the rejectamenta being passed out by the mouth, such animals are well fitted, doubtless, for living in cells with a single aperture; the mollusca, however, have an intestinal canal, and anal aperture besides. But it must be borne in mind that the anus in the polyzoa does not open at the extremity of the body opposite the mouth, as in the archetypal mollusc; but by a sudden bend of the intestine, the anal aperture is brought into the closest possible proximity to the mouth; so that, although separate, they both open at the same spot; and let it not be supposed that this diminishes aught from their position as molluscs, for in the highest molluscs, viz., the cephalopods, the same thing takes place in a somewhat less degree. Here again is a structure which implies great *community of general habit*. Lastly, there is another most important community of habit between the polyps and polyzoa, viz., that although the mollusca, as a class, are oviparous, the polyzoan molluscs are, in addition, *gemmiparous*, like the polyps; and this power is evidently the

secret of the production of those compound forms which the polyzoa present in common with polyps. Hence we see that with scarce anything in common, except superficial characters, the habits of polyzoa and polyps are nearly identical; and to this fact I would look for an explanation of their identity of form.

In conclusion: Lord Bacon has somewhere remarked that experiments and observations are of two kinds, viz., first *of fruit*, and second, *of light*—by which he meant that some led directly to some plain and definite ends, which amply repaid the labour bestowed upon them; while others, by no means to be despised, yet were not so obviously accompanied by actual fruit. Far be it from me to raise homomorphism to the rank of homology; I have endeavoured throughout to place them in strong contrast; and although I do not wish to forego all claim to fruit from these observations, I am willing to allow them rather to belong to the second category. But I cannot sympathize with those who would taboo such curious questions, simply because some others lead to more important results.* Everything in Nature is worthy of investigation, and although I may not have succeeded in fully tracing out the law of order which probably exists in these homomorphisms, still I have by the enquiry improved my own knowledge of Nature, and have given, I trust, an insight into the creative workings of the Almighty, which cannot fail to increase the desire to be more closely acquainted with them. Surely, human works fall infinitely short of the surpassing interest which appertains to those of the Great Artificer; and human history is but a line in the great scroll of the universe, which has been inscribed from the beginning with the works of the Creator. Let no one presume ignorantly to contemn, or

* For an example of such reasoning, see Bain "on the Senses and Intellect," p. 499, where the writer of that generally excellent work argues rather as the disciple of a severe school of logic, than as a loving and humble follower of Nature.

conceitedly to overlook the stupendous work of creation, of which man is the keystone and the crown: but if ever he be tempted to assert his superiority by underrating the matchless perfection of Nature, let him humble himself in the dust, when he remembers that the God who formed *him* looked upon all the things which he had made, "and behold they were very good."

THIRTEENTH ORDINARY MEETING.

ROYAL INSTITUTION, 2nd April, 1860.

The Rev. H. H. HIGGINS, M.A., President, in the Chair.

The Chairman alluded to the interview of a deputation from several learned societies in town, with William Brown, Esq. and the Town Council, relative to a contemplated plan of setting apart a portion of the Free Public Museum for the display of models and scientific objects applied to purposes of utility.

The Chairman also drew attention to the development of medusæ, from *Hydra tuba* in the aquarium under Mr. Moore's direction in the Derby Museum.

Mr. JAMES YATES, F.R.S., corresponding member, attended the meeting, and spoke on the question of a decimal system of measures, time, and money, referring to Mr. Statter's plan of employing the equatorial circumference of the earth instead of its polar axis, as the basis of his unit.

The Secretary exhibited and described a working model of Newcomb and Lovell's engine, for using water as a motive power. The chief peculiarity was the adaptation of a donkey