An essay on the employment of physiological characters in the classification of animals : being the substance of a paper read before the Greenwich Natural History Club, December 6, 1856 / by Edward Newman.

AN ESSAY

ON THE

Employment of Physiological Characters

IN THE

CLASSIFICATION OF ANIMALS.

BEING THE SUBSTANCE OF A PAPER READ BEFORE THE GREENWICH NATURAL HISTORY CLUB, DECEMBER 6, 1856.

BY

EDWARD NEWMAN, F.L.S., &c., &c.

PRINTED BY ORDER OF THE COMMITTEE,
AND SOLD BY JOHN VAN VOORST, PATERNOSTER ROW, LONDON.

(Price One Shilling.)

ADVERTISEMENT.

On submitting this paper to the judgment of naturalists at large, a few observations appear to be required.

It was written in 1853, and extended much beyond its present limits.

During the winter of 1855—6 I found the impracticability of publishing it in its extended form, and, having made an abstract, offered it to my friend Mr. Glaisher, for the Greenwich Natural History Club.

On the 6th of December, 1856, I had the pleasure of submitting it to that Club. After I had concluded reading it, Mr. Currey invited my attention to some published observations by Pringsheim on the reproduction of Vaucheria. These observations induced me to erase a portion of the paper in which conclusions were drawn somewhat irreconcileable with Pringsheim's observed facts. On the same occasion Dr. Collingwood and Mr. Hudson firmly, but most courteously, opposed the entire theory of agamogenesis. I have carefully reconsidered this theory also, but cannot agree to withdraw anything I have written.

Early in the present year, 1857, Siebold's work on 'True Parthenogenesis' appeared in an English dress. From this

I have borrowed largely as regards agamogenesis in the honey bee.

I have also very carefully re-read Professor Owen's work intituled 'Parthenogenesis,' but have failed in my attempts to reconcile that learned author's views with my own. Professor Owen does not seem to give sufficient, or indeed any, prominence to the undoubted cases of agamogenesis so repeatedly cited by authors, but to have appealed to the equivocal case of the Aphides, a case that is yet unexplained.

I am indebted to the kindness of Mr. Lubbock for reading in type the whole of the observations on agamogenesis, and for several very valuable remarks thereon.

The portion relating to birds was read at a Meeting of the Zoological Society, on the 12th of March, 1850, Mr. Spence presiding; and was published in the April number of the 'Zoologist' for the same year. It appears to have been acceptable to some of our best ornithologists, as we find the more recent lists of birds classified on the same principle.

EDWARD NEWMAN.

ON PHYSIOLOGICAL CHARACTERS,

&c., &c.

EXACTLY commensurate with our admiration of the vast talent displayed by Cuvier in his arrangement of the 'Animal Kingdom after its Organization,' must be the conviction that the differences of form, internal and external, which the author has defined with such masterly perspicuity, are but the requirements of differences of another character, which he has left almost entirely unexplained. It cannot for a moment be supposed that Cuvier disregarded those higher differences, the differences of function; since his works, more particularly his 'Ossemens Fossiles,' occasionally exhibit, in the clearest possible manner, his perception of the fact that form is but the handmaid of function, exactly in the same way that anatomy is but the guide to Physiology. For half a century we have been regarding the 'Règne Animal' as an ultimatum susceptible of improvement only in its detail; and it would seem that the work itself gives a kind of warranty for our worship, if so it may be called, of form; for its author announces, as his single aim and ultimate object, "to arrange the animals he would have to elucidate, in accordance with their structure; so that under one single name of class, order, genus, &c., might be comprised all those species which agree both in external and internal conformation." And, again, he says, "I have proceeded partly

by ascending from the inferior to the superior divisions, on the principles of affinity and comparison; and partly by descending from the superior to the inferior divisions, on the principle of subordination of characters; carefully comparing the results of the two methods, verifying one by the other, and constantly taking care to establish the correspondence of form, external and internal, for these together constitute the integral parts of the essence of each animal." As nothing can be more explicit than this declaration of a determination to adopt form as the basis of classification, so nothing can be more masterly than the mode in which its illustrious author has reduced the principle to practice.

Now, though I do not hesitate to say that I believe form to be insufficient for the attainment of a perfect classification, still I would not willingly be misunderstood as attempting to undervalue it. Form is of necessity of very high importance to the naturalist; it may even be regarded as one of the best guides to the end; but it certainly is not the end; that must be looked for in those differences of function to which all differences of form are but the subservient means. The living being has certain obligations imposed on it by its Creator; the preservation of its individual life, and the transmission of its likeness to future lives, are the chief of these; and these obligations are complied with in a hundred modes. I regard the complying with these obligations as the groundwork of the science of Physiology; and the study of the thousand differences of form, rendered necessary by these diversified modes of obedience to universal laws, constitute the science of Comparative Anatomy, a science absolutely essential to the naturalist, but one which, regarded in its proper light, is simply educational; it contains the letters, or perhaps even the words, of which the higher science is

composed, but must never be regarded as sufficient for understanding the great scheme of creation.

It is now made manifest, through the researches of geologists, that Creation was not that rapid process which those who assign scientific as well as religious teaching to the first chapter of Genesis believe it desirable to establish. For my own part, I prefer separating these sources of instruction. Let the Bible teach religion; Nature, natural philosophy. Much would be gained by keeping these two objects perfectly and permanently distinct. Creation, be it remembered, is none the less miraculous, none the less stupendous, because its details do not harmonize with our preconceived views: it is impossible to escape the conviction that creating is an attribute of Omnipotence. Looking, then, at this subject as a legitimate one for study, geologists have found that the first creation, recorded on the tablet of the adamantine rock, was shapeless, lifeless, earth, water; and that the second was the peopling of the water with living forms innumerous. Now, all the earlier forms of life bear a close and striking similarity to each other in the simplicity of their mode of reproduction. Wagner, and indeed most of the authors whose writings I have read, commence their descriptions of the "phœnomenology of the generative act" by the "encounter of the generative elements." I believe that throughout the aquatic forms which comprise the earlier creations no act of generation, and no encounter of generative elements, has been satisfactorily made out. The reproduction of sponges and other simple beings, whether regarded as animals or plants, takes place by the evolution of minute particles from the substance of the parent, not from any ovary or uterus, but from the general surface; and these particles are of one character; they wander free, like the pollen granules of plants or the spermatozoa of animals, and eventually seek a resting place, not in con-

nexion with an ovule, but simply as a nidus on which to vegetate during life. Such beings, thus owing their vitality to a single element, and not to the encounter of two generative elements, may be called Monoprotogens; and it is wonderful to how large a proportion of created beings the definition may be applied. These sexless beings hover between two worlds, the world of animals and the world of plants. The scientific may argue as they please about the true nature of a sponge; their arguments can only demonstrate its claim to the neutral ground.

The next series of creations was of a very different character; it comprised beings possessing two generative elements, a zoosperm and an ovule; and the encounter of these was the ordinary origin of reproduction. The plants now produced were phænogams; and the animals were of three kinds, readily distinguished by the structural differences which Cuvier has so admirably enunciated. These are, ACTINIATES, in which the various organs radiate from or are arranged round a common centre; ANOSTEATES, which have no bones or solid points for the attachment of muscles; and EXOSTEATES, which have such solid parts external. These three divisions correspond very closely with the Radiata, Mollusca and Articulata of Cuvier; but a physiological character of the highest importance separates a large section from his Articulates, and transfers them to my Anosteates. This character is deserving the most profound attention; it is this: the presence, in every well-defined division of Anosteates, of great numbers of species which are truly androgynous, that is, possess in each individual, in a state of the most perfect development, all the sexual organs of the male and of the female. The fact is so familiar to naturalists that I need not dwell on it for a moment; but the application of the fact to system is, I believe, new. The examples to which

I would allude are—the earth-worm, as an Exosteate, and the snail, as an Anosteate. The copulative act in these has been observed by every one: two individuals lie side by side, the heads being placed in opposite directions; the male organ of A is thus presented to the female organ of B, and the female organ of A to the male organ of B; and two separate and impregnating acts of copulation take place simultaneously. By this character the Annelides are transferred from the Articulates to the Anosteates, which thus, forming a group differently constituted, must bear a different name. I would here invite attention, also, to a distinction drawn by Cuvier, as I think needlessly, between his Annelides and his mollusks; I allude to the terms "red-blooded" and "white-blooded." Now, the blood is, in some instances, perfectly colourless, and in others more or less tinged with pink; but I have long ago pointed out that this colouring disappears under the microscope, and does not seem attributable to the presence of red corpuscles, which I take to be the cause of colour in the blood of those animals which are emphatically distinguished as red-blooded.

Having now arrived at the existence of two generative elements, the zoosperm and the ovule, the possessors of which elements I would call Diprotogens, we are enabled to enunciate a law which at once affords a diagnostic between an animal and a plant: in an animal the zoosperm is always conveyed to the ovum in water, and in plants always by the air; the animal zoosperm is rendered abortive by contact with air, the vegetable zoosperm by contact with water. The law that animals are hylebrotic, or feed on beings possessing or having possessed life, and plants on aqueous and gaseous amorphs, or are strictly azoobrotic, is also important; and these characters, into which the consideration of structure does not enter, constitute the infallible diag-

nostics between animals and plants when clearly diprotogenous.

Now, although the two generative elements are present in every species that has been examined with sufficient care, still they are not indispensable to reproduction: Nature provides them in exuberant abundance, but also provides for the perpetuation of the species without their encounter. In explanation of this assertion it is necessary to dwell on a character common to the three great divisions of animals here characterized as Actiniate, Anosteate and Exosteate, and vulgarly amalgamated under the negative term invertebrate, and that is, the power of the virgin female to produce perfect progeny without the intervention of the male, and of course without the presence of the zoosperm. This is the *Lucina sine concubitu* of the earlier physiologists, the agamogenesis of the present era. In explanation of this phenomenon we first appealed to "spontaneous generation;" but this solution was too vague, too unmeaning, for the logical mind of a physiologist. Subsequently we rushed to the opposite extreme, and sought an explanation in the rejection of facts: it was said that the experiments were not conducted with sufficient care, that the observations were not sufficiently accurate; it was declared impossible for reproduction to take place under the conditions laid down. This roused the supporters of the theory to greater exertion, to more careful investigation; and they established their point. In the Actiniates, most of which are hermaphrodite, the operation of brepheogenesis, which is either another law or a distinct modification of the same law, interferes with our researches, and therefore the results are unsatisfactory, because not sufficiently precise, still in no respect interfering with the theory of agamogenesis. In Anosteates the large water-snail (*Lymnæa stagnalis*) will, as a rule, produce

fertile progeny for three generations; and at this point my observations have ceased, without any indication of cessation in the phenomenon. The experiment is within the reach of every observer, now that parlour ponds are so general. But here, again, the absence of the zoosperm may be questioned, on account of the androgynous nature of many Anosteates, as previously described.

In Exosteates alone have our researches been brought to a satisfactory result. Beginning with the Aptera, we find in the phyllopodous Crustacea, species which, as a rule, contain only female individuals, the presence of a male being the exception. Polyphemus Oculus, Apus cancriformis, and Limnadia Gigas are familiar examples. Daphnia has males as well as females; but the females appear equally prolific in the absence of the males. In Arachnida, males and females are familiarly known; but the fertility of the female is not dependant on coition with the male. This latter phenomenon, indeed, appears to be of somewhat rare occurrence, and often to be fatal to the husband, as the wife always attempts to devour him, and mostly succeeds, immediately after the act has been accomplished. I have found the isolated female of Epeira Diadema invariably produce her circular mass of eggs, and have as invariably found these to be fertile. If coition had taken place at all, it must have been while the females on which I experimented were in the infant or larval state, and prior to the first ecdysis; affording, if this be made out, an instance of a phenomenon altogether abnormal. The females of Agelena labyrinthica, Tegenaria domestica, and Tegenaria civilis have also been proved to be perfectly fertile in the absence of the males. It is not, however, in the apterous but in the tetrapterous Exosteates that agamic exception to diprotogenous reproduction becomes characteristic. In Lepidoptera, entomologists

report its existence in Sphinx Ligustri, Smerinthus Populi, Smerinthus ocellatus, Liparis dispar, Liparis monacha, Dibola cæruleocephala, Saturnia Polyphemus, Saturnia Pyri, Saturnia Carpini, Orgyia gonostigma, Orgyia antiqua, Bombyx Mori, Lasiocampa Quercus, Arctia caia, Arctia casta, Arctia villica, Odonestis Pini, Odonestis potatoria, Gastropacha Quercifolia, Psyche fusca, Psyche Helix, Psyche graminella, Psyche nitidella, Solenobia triquetrella, Solenobia clathrella, and Solenobia lichenella. The observations on many of these species have been made very carelessly, and the records penned in terms the most loose and unsatisfactory; but after eliminating the apocryphal there remains a substratum of truth which carries conviction to every ingenuous mind. In Bombyx Mori, Lasiocampa Quercus and Psyche Helix the experiments have been performed with a care and precision that leaves nothing to be desired; those on Lasiocampa Quercus were made by the late Mr. Tardy, of Dublin, during my editorship of the 'Entomological Magazine,' in which journal I quite hoped to have published them *in extenso*. The facts, however, were only referred to occasionally, in letters from Mr. Tardy to Mr. Davis, and the connected detail was never communicated for publication. The substance of the experiments may, however, be given in a few words. Mr. Tardy reared a single female of Lasiocampa Quercus from the larva. This female laid abundance of eggs in the breeding-cage; the eggs in due time became larvæ, fed as usual, and spun up. These circumstances attracted Mr. Tardy's close attention; but he felt inclined to suppose that, without his knowledge, a male might have gained access to the female. Still, he was so interested in the subject that he determined to repeat the experiment, and to guard against the possibility of mistake. The result was a second and third generation of perfectly vigorous and full-

sized moths, without a single coition having taken place. Experiments on Psyche Helix and Bombyx Mori appear to have been conducted with equal care. It is worthy of notice that no instance of a Papilio, Noctua, Geometra or Pyralis has been reported, if we except Noctua pacta, a name evidently given in error. There are Sphinges, Bombyces, Tineæ, and the remainder are of the group of Psychidæ which are supposed to hover between Bombyx and Tinea. The instances recorded, and this is worthy of note, occur amongst those insects which are most frequently reared from the larva, and therefore those in which such phenomena are more likely to be observed. In Diptera I have noticed a single instance of this phenomenon, and that in Musca vomitoria, an insect of which the sexes appear equally abundant, and in which coition of sexes is constantly to be observed; nevertheless, a virgin female will certainly deposit fertile eggs; and more than this, the eggs will not unfrequently be disclosed prior to extrusion, and be extruded as living maggots. In this instance it must be recollected that the insect has an important mission to perform, that of ridding the surface of the earth of substances of which the effluvia is injurious or offensive to man and the larger animals; and Nature has provided that this mission shall be carried out to the utmost. In Hymenoptera no less than twenty-eight ascertained species of gallflies consist of females alone, yet are most abundantly prolific in individuals. From galls of Cynips Lignicola, a common insect in Devonshire and Dorsetshire, although not noticed until lately by our entomologists, I have reared 1095 females, and, placing these on oaks, have observed them apparently preparing for oviposition in the axils of the leaves; with what result, I am unable, at present, to state. In another order of Hymenoptera, the Apina or bees, there is every reason to believe in the existence of

the same phenomenon; and in this instance the anatomist has greatly assisted the physiologist in his inquiries. It appears that female insects possess two peculiarities in the structure of their generative organs, each intimately connected with the other: the first is a double external sexual orifice, one orifice being for the reception of the male organ, the other for the extrusion of the egg. Connected with the first orifice is the second peculiarity in structure, the presence of a sperm bag or spermatotheca, which is filled with semen by a single act of coition, and, being filled, retains the semen or a portion thereof during the remainder of life, however prolonged. In passing this sperm bag each egg receives the supply of zoosperms requisite for fertilization; but this fertilization appears a law subject to striking exceptions; for it is well known that the queen bee, deprived of her wings, and thus rendered incapable of leaving the hive, a course that is supposed essential to sexual intercourse, is nevertheless capable of laying her customary number of fertile eggs; but those eggs invariably produce drones.

The sexual intercourse of bees is a subject on which the naturalist is almost without facts: in the absence of these he has recourse to hypothesis; he suggests that the queen takes one nuptial flight; that she mounts in the air, and at a great height, far beyond the reach of human eyes, receives the embrace of the male. This is poetical, and possibly true; but it seems to require that ocular demonstration without which the true naturalist feels he is leaning on frail support, that at any moment may crumble from beneath him. I will, however, state that on three occasions I have seen united pairs of Bombi descend to the ground in a manner that suggested their coming from a considerable elevation, thus favouring the popular idea of the aërial copulation of the honey bee. It is generally admitted that after these nuptials have been

consummated the queen never again leaves the hive, but is occupied with the domestic occupation of oviposition; and here an interesting question arises, the solution of which is likely to assist us greatly in working out the true history of agamogenesis. It seems to be made out, with some degree of precision, that the eggs laid by a virgin queen are invariably fertile, but as invariably produce drones: how, then, does it happen that the impregnated queen can lay the eggs of queens or workers at pleasure? It is true that different cells are provided for the different sexes; but how does she manage to lay the different eggs? Dzierzon and Siebold thus solve the question. The queen has the power of opening and shutting the mouth of the sperm bag at pleasure; when she desires to lay drone eggs, she closes it; when she desires to lay worker eggs, she opens it: she is guided to the description of egg required by the different size of the cell constructed for its reception, a difference instantly perceived by the queen on the introduction of her abdomen into the cell. This appears purely hypothetical; but there is collateral evidence adduced that gives it a strong colouring of probability. In the first place, a microscopical examination of the contents of the egg shows that those of the workers always contain zoosperms, those of the drones never. In the second place, the theory is supported by the experiment of hybridizing. There is a beautiful yellow variety of the honey bee kept in Italy, which, on account of its good qualities as well as beauty, has lately been largely introduced into Germany by the transport of queens. The attempt has been made to produce a hybrid race between the German and Italian bees, which should combine the cold-enduring properties of the former with the gentleness and beauty of the latter. It would follow that if the drones are produced solely by agamogenesis the drones resulting from this experiment

would not be hybrids, but pure Italians like the parent. This has invariably been the case: the drones always resembled the queen only; the queens and workers are always hybrids; and a hybrid drone is only to be produced by a hybrid queen, in which case, again, it exactly resembles its parent. It is with great pleasure that I notice, for the first time, a spirit of philosophic inquiry springing up amongst the apiarians: a spirit at present confined to Germany, but which must hereafter extend to other countries. The Report of the Juries at the Great Exhibition, in 1851, states that for 200 years every alteration in the structure of the bee hive has been a retrograde movement; and the naturalist might truly, however reluctantly, add that every work on the history of the honey bee has served no other end than to involve, in almost impenetrable obscurity, the natural history of one of the most wonderful and most valuable of created beings.

I must not conclude this brief summary of the instances of a phenomenon, the occasional exhibition of which characterises so vast a portion of the world of animals, without noticing the hemipterous order of plant-lice, Aphidina, which have been selected by all naturalists as affording, *par excellence*, the best illustration of its existence; yet, although we have the most unexceptionable evidence of reproduction for several generations without coition, still it is clear to the reflecting mind that another although perhaps cognate phenomenon, is here exhibited; the parent is not a virgin female or a female imago at all, as in the case of the insects I have just enumerated, but a sexless being not yet escaped from the larval state, and totally distinct from the female imago, which is equally familiar to all entomologists: and it is a little remarkable that the genus Aphis, thus selected by our authors as the great illustration of

agamic reproduction, is one of the few groups of Exosteates that have never yet clearly revealed the phenomenon of agamogenesis to the inquiry of the physiologist.

The plant-lice afford a curious illustration of what has been called by Steenstrup the alternation of generations, a phenomenon of which the learned author has adduced many apt examples, without reducing them to that methodical form in which the theory can be examined, weighed, or satisfactorily received. To me it seems that the phenomenon in question should rather be regarded as larval or fœtal procreation. I have already spoken of it as brepheogenesis, for it takes place not only without the encounter of generative elements, but while the individual is absolutely infantile. I have no doubt that a similar phenomenon takes in the instance of the larva of a species of the dipterous genus Anthomyia, which has been discharged, for a series of years, from the human intestines, in every stage of growth; but of this there is only presumptive evidence.

It is worthy of remark that the familiar instance of the viviparity of the plant-lice should have called forth so many intended explanations, which are in no respect really explanatory. The best of these, that by Kirby and Spence, the highest authorities in entomological matters, is, like the rest, insufficient: these truly illustrious authors suggest that "one conjunction of sexes suffices for the impregnation of all the females that in a succession of generations spring from that union." Now, I think it must appear clear to the candid inquirer that the problem is not solved by the phrase or truism, as it may be called, that "one act of coition suffices for six, eight or ten generations," as the case may be, because this is but another mode of asserting that five, seven or nine generations are produced by these sexless, and therefore unimpregnated, larvæ; and this is only an altered form of

the same phrase or truism: it is the expression, not the solution, of a problem.

It must, however, be observed that both the phenomena, agamogenesis or monosexual procreation, and brepheogenesis or larval or asexual procreation, are characteristic of the same great groups, and are never to be detected in the endosteate tribes, on an examination of which we are about to enter.

Geologists next find a creation in which this preponderating importance of the female is in great manner obliterated, and in which the ovule is never vivified, unless it be encountered by the zoosperm; the structure also changes, and this is the only point noticeable by geologists; the framework of bone is internal and clothed with muscle, and the muscle, again, is covered by skin. These I call Endosteates, and they correspond with the Vertebrates of Cuvier: the name is changed to harmonize with the rest; and, moreover, the distinctive character, the presence of the endoskeleton, is better expressed by the term "endosteate." These Endosteates are comprized of fishes, reptiles, birds and sucklers; and they offer another division, of a purely physiological character. Fishes, reptiles and birds perfect their fœtus, usually under the character of an egg; and the female can always mature, perfect and extrude this egg, of full size and normal proportions, or, as it is commonly termed, perform the act of oviparity, without the intervention or even presence of the male; a female carp, a female tortoise, a domestic hen, will demonstrate this familiar fact to the entire satisfaction of the most sceptical. But here the affinity to the Exosteates ceases: that egg, from the moment of extrusion, is a lifeless mass, and cannot attain life by the action of any inherent principle or external application. There is virgin oviparity, but not agamogenesis. Naturalists in all ages have agreed that ovi-

parity is the result of two generative elements. Even lately we find it said by Dr. Carpenter, in the 'Medico-Chirurgical Review' for 1848, that oviparity "is effected by the concurrent agency of two sets of sexual organs, situated on the same individual or appertaining to two different beings;" and this definition is quoted, with apparent approbation, by Professor Owen, at page 42 of his Essay intituled 'Parthenogenesis.' Now, I believe this definition to be entirely erroneous, and that oviparity is invariably effected without any male agency whatever; nevertheless, in oviparous Endosteates the introduction of the zoosperm is absolutely essential to vitality, although neither to the full development nor normal extrusion of the egg. How different is this female power of oviparity from the condition of female sucklers, in which the presence of the zoosperm is essential to give the initiative to reproduction.

Pursuing the inquiry, and extending the application of physiological differences to further subdivision, we cannot fail to be struck with its paramount importance. It affords by far the readiest means of subdividing each of the four great endosteate provinces of animals. To commence with the fishes, we find that some of them exactly correspond with birds and tortoises in their mode of reproduction: the egg, composed of vitellus and albumen, is matured by the female, and when of sufficient size is detached from the ovary, covered with a shell in passing through the oviduct, and extruded by the anal aperture. This process uniformly takes place; and although, in a state of nature, the female almost invariably receives the embrace of the male, and consequently the vital principle or spermotozoon, still this encounters the vitellus only in its passage through the oviduct, immediately before its investment with the albumen and shell, yet always prior to extrusion. This definition applies equally to the

isogenous reptiles, and to all birds; but the earliest appearance of the phenomenon is in those more highly organized fishes which I propose to call eremogenous, because their young, or more properly ova, are matured singly, and extruded at intervals; they are also few in number, probably varying from five as a minimum to thirty as a maximum. The male in these fishes seeks the female with ardour, and the act of copulation and intromission of semen is as complete as in birds or even sucklers. The fishes in question are familiarly known as sharks and rays; and a singular fish, called the chimæra, which extrudes its young in an active and matured state, an exact representation of the parent, must be added to the group. The phenomenon of animals which, in our limited judgment, ought to be oviparous, becoming truly and normally viviparous, is one which has long ceased to excite the wonder of naturalists; the deviation occurs sometimes through entire genera, sometimes in species, and occasionally in individuals: it is referrible to the simple fact that the egg passes its quiescent period, and is hatched, within the uterus or oviduct of the parent. Returning for a moment to the eggs of sharks and rays, which are probably familiar to all naturalists, they are generally flattened parallelipidons, each of the four corners emitting a long, attenuated tendril, which, before it has attained its final state of hardness and intractability, twines itself round sea-weeds or stones, and thus anchors the egg firmly, and entirely precludes the possibility of its receiving injury from the violence of the waves, to which it is constantly exposed.

The other division of fishes may be regarded as apathetic; the females have no attraction for the males, nor does any act of coition ever occur; the males and females, usually termed milters and spawners, mature an immense mass of ovules and zoosperms; the ova in a single female have been

found to exceed 600,000 in number; these appear to be simultaneously matured, for I am unable to detect the slightest difference among the myriads which, in a dense and compact mass, constitute the roe of a female herring. On account of this massing together of the ova, I call these fishes Desmogens; when mature, this load of roe passes, in a kind of continuous stream, through the anal aperture, and is committed to the waters; the ovules and zoosperms come in contact with each other, and the ova receives vitality. This grand distinction therefore obtains, that in the Eremogens the zoosperm is introduced into the uterus by an intentional act of the male; in the Desmogens it casually meets with the ovum when both are cast free upon the waters. These facts are too familiar to require detail; but it is remarkable how entirely they have been disregarded, or rather how completely they have been rejected, as a groundwork of classification; the very types of these most natural divisions, fishes most dissimilar in all respects, the lampreys and sharks, have been associated under the title of cartilaginous fishes, on account of a certain but very questionable similarity in the structure of their bones. As an economical character, it is worthy of observation that nearly all the desmogenous fishes constitute a wholesome nutritious food for man, while the flesh of the eremogenous fishes is almost as universally rejected, and regarded as coarse, unwholesome and unpalatable.

The desmogenous fishes must not, however, be left without calling attention to a very remarkable difference in the mode of their reproduction: a considerable number of genera, all of them comprised in Cuvier's divisions Syngnathi and "Acanthopterigians with mailed cheeks," mature their ova in much smaller numbers, and of much larger size, than the rest; yet the ova are matured and discharged simultaneously, and often with incredible rapidity, not one by one as in the

sharks and rays. These fish are highly interesting in many points of view: in the first place, all the parental duties devolve on the male; in one family, that of the pipe-fishes, the male is provided with a marsupium or pouch, into which the ova are received immediately after extrusion, but by what mechanical means still remains a profound secret, yet one which Mr. Warington's marine aquaria may possibly hereafter afford us the means of discovering. What an extraordinary thing it would be to watch a female pipe-fish, its abdomen distended with ova, seek the male, and discharge the contents into a receptacle with which he is provided, and which is precisely analogous to the pouch of a female kangaroo: it would be no less strange to watch the male attending the female while in the act of oviposition, siezing the ova, one by one, as they are rapidly extruded, and passing them into his pouch. It is, indeed, useless to speculate on the *modus operandi:* whatever it may be, it is certain to prove quite as marvellous as any which could suggest itself to the most fertile imagination. It may be that the ova receive the zoosperms while in the marsupium; but this, also, is mere matter of conjecture. Others, again, of these male nurses construct elaborate nests for the reception of the ova; and when the female has condescended to avail herself of this preparation, and immediately afterwards has deserted her own progeny, then the male closes the aperture through which the ova were passed, and watches, night and day, until the tiny fishes emerge, and escape from their dwelling-place. Nor do his cares even then cease, for his attention to the infant colony quite equals that of the most anxious mother.

Proceeding to the reptiles, we find they have already been subjected to a physiological binary division into those which undergo a metamorphosis, and those which retain, through life, their pristine form. These are divisions to

which universal assent appears to have been given; but as to the grade to be taken by the respective divisions a difference of opinion still obtains, some regarding the Amphibia, or, as I call them, heterogenous or metamorphotic reptiles, a group exactly equivalent to the teleiogenous or immutable reptiles; others giving to them only the dignity of a subdivision, equivalent to the familiar groups known as Chelonia, Crocodilia, Sauria and Ophidia. The teleiogenous reptiles are distinguished primarily by the completeness of their copulation, the zoosperms reaching the ovules by as perfect an act of intermission as occurs even in the sucklers: they are truly oviparous, *i. e.* produced from an egg invested with a calcareous covering; this, on its extrusion, is usually secreted in a locality where the required quantity of heat and moisture will be best supplied, since the parent thenceforth rarely takes any solicitude about its welfare. The phenomenon of hatching is always dependant on extraneous circumstances, as the heat or moisture of the earth or of the atmosphere, and is totally independent of parental solicitude. When the shell of the egg is broken and the young escapes, it bears a form exactly similar to that of the parent, and is possessed of its parent's powers of locomotion and self-protection; and, obtaining its normal characters at once, its body, now and henceforth, is invested with a bony, horny or scaly armour, and where interstices occur between the departments of this armour the body is covered with a loose, leathery skin. As a character by which to divide these teleiogenous reptiles, a physiological difference of great interest obtains, and, indeed, obtrudes itself on the notice of the practical naturalist, although not recorded in the books; it is, that two great groups, the Chelonia and Crocodilia, are anecdytic, or do not shed their armour; and the other two, the Sauria and Ophidia, are ecdytic, that is, the armour or

covering in two groups is permanent, in the other two it is shed annually; and, again, the Sauria and Ophidia differ in the mode of ecdysis: in the Sauria the skin is cast piecemeal, in the Ophidia entire.

The anisogenous reptiles present phenomena which have attracted the attention of the scientific in all ages. Commencing with the act of impregnation, we find in the anourous, or tail-less group, a phenomenon exhibited in no other section of the world of animals: the male mounts the female, and, with his fore-legs, clasps her firmly round the body, immediately behind her fore-legs; the ova of the female, consisting of vitellus and albumen alone, are matured and extruded in an unimpregnated state; but the semen of the male, while in the position above described, is discharged simultaneously with the ova, and the zoosperms necessarily come in contact with them, and the foundation of life is thus laid. Many of our most observant authors are, however, unsatisfied with this simple explanation, by which the mode of impregnation is almost identified with that of Desmogens in fishes; but they further assert that the male, whose long and flexible fingers seem admirably adapted for the purpose, enacts the part of midwife, and assists the female in the act of oviposition, impregnating each ovum after its extrusion has been accomplished. The known facts of the case are not merely sufficient for the object, but are sufficiently wonderful, without having recourse to a theory which seems so uncalled for; still, I only express a doubt: I have no means whatever of disproving statements seriously made by truth-loving and truth-seeking naturalists; and it may truly be said that the abnormity of this supposed phenomenon is even surpassed in its miraculous character by the established and familiar fact that one of these Anisogens, the Surinam toad, carries about its

young on its back, each of them concealed in a circular pit in its skin. But the wonders of these metamorphotic reptiles do not cease here: the young, when its active life has commenced, has no resemblance to the parent; its external form is totally different; its blood circulates by a different appareil of vessels; its breathing is on a different principle: and the most skilful anatomist in the world could not detect in the tadpole the elements of the parent frog. But it is quite unnecessary to dwell on these physiological facts, since they have forced themselves on the notice of naturalists, and have obtained, in this solitary instance, that recognition which I seek for them throughout the animal world. The Macroura, long-tailed Anisogens or newts, offer a decided discrepancy in the mode of fecundation: the male newt, as the male frog, seeks the gravid female; but instead of clasping her round the waist he excites her to what appears an act of coition, although I believe there is no intromission of zoosperms; a momentary contact of the anal aperture certainly takes place; the female almost immediately proceeds to the duty of oviposition.

I proceed to the birds. These at first sight appear the most difficult to deal with physiologically: first, because the characters of nidification and incubation are so similar; and, secondly, because the greatest naturalists have, from the earliest dawn of Natural History, laid down characters for their subdivision, in which physiological characters have been utterly ignored. Turning to works on Ornithology, we shall find that almost all authors agree in dividing birds into several minor sections, which they have called orders: the number of these has varied from five to fifteen; but, notwithstanding this seemingly ample subdivision, we find still an unmanageable multitude left together, under the name of Passeres or Insessores; this enormous mass has,

however, recently received the attention of a field naturalist; and he finds that the living birds offer characters by which the Passeres are not only conveniently, but most naturally, divisible into three groups; the form of beak, which in structural groups, has been the principal, if not sole, basis of classification, being abandoned, the author clearly perceiving that the divisions Conirostres, Tenuirostres, Dentirostres, &c., of Cuvier were merely awkward substitutes for ardently desired but undiscovered truths. These three groups, which appear to me fully equal in importance of characters, as well as in number of species, to either of the received orders, I shall, for the present, designate by that title, the names employed to distinguish them being only suggested: they are, first, Hirundinina, birds which live and feed on the wing, and therefore require that organ to be largely and strongly developed; which swallow their food entire, and therefore require an enormous gape and gullet; which rarely walk, hop or run, and seldom descend to the ground, and therefore have little need of feet; these are consequently small, and extremely weak. A structural peculiarity in the direction and formation of the toes accompanies these conditions. The birds included in this order are the Caprimulgidæ, Hirundinidæ, Trochilidæ, Alcedinidæ, Trogonidæ, Bucerotidæ, Meropidæ and Galbulidæ. The second order I would call, provisionally, Picina, birds which never feed on the wing, never take long flights, and very rarely ascend in flying, but, if a longer flight than usual be required, climb a tree or other eminence, and then, flying off, gradually descend in their progress; this, however, is mentioned only as the rule, and is subject to striking exceptions; the feet and legs, being required to secure great muscular efforts in climbing, are large and extremely powerful, and, like those of the Hirun-

dinina, have a structural peculiarity in the direction and formation of the toes: these birds are the Psittacidæ, Picidæ, Musophagidæ, Cuculidæ, Bucconidæ, Coliidæ and Rhamphastidæ. The third group contains the familiar passerine birds, the Passerina, in which the powers of flying and running on the ground are equally well developed, no preponderance being given to either; the legs, toes and wings are perfectly, but never enormously, developed; and there is no peculiarity in the structure or direction of the toes, the normal bird formula of three before and one behind uniformly obtaining throughout the order: the families included are the Nectarinidæ, Sylviadæ, Turdidæ, Muscicapidæ, Ampelidæ, Laniidæ, Corvidæ and Fringillidæ. Each of these orders thus seems to contain eight of those families which ornithologists working in the museum have founded on structural characters alone. Considering these groups equivalents of each other, and of those which follow, I proceed to enumerate others which are universally admitted, *viz.*, Accipitrina or the birds of prey, Ardeina or the heron tribe, Pelicanica or the pelicans, Larina or the gulls, and Columbina or the pigeons. Here, then, we have eight orders of birds which agree in the characters I am about to define: they are strictly monogamous; they build large nests, almost invariably in trees; they incubate with the utmost assiduity: the young are born blind, naked, incapable of standing, incapable of feeding, except food be presented by the beak of the parent: these birds I call Gymnogenæ, on account of their naked young. Viewed as a whole we find they are birds *par excellence;* and although the bird attributes may be carried to greater perfection in some of the orders than in others, for instance in the Hirundinina than in the Picina, still, taken as a whole, these Gymnogens are emphatically birds; they use the air as a

medium, and their wings as a means, of progression, in preference to the land and their legs; they fly by choice, both for food and for recreation; they perch in trees; they build elaborate nests in trees; but one of their most remarkable characters is the rapidity of their growth; the young sparrow or swallow, or even the gigantic albatross, leaves the nest of its full normal size, and this has been obtained in comparatively a few days. As an economical character, gymnogenous birds are not sought by man as food; the pigeon, lark, ortolan, &c., are exceptions; but even in these instances the pigeon owes all its gustatory merits to domestication, the flesh of its prototype, the rockdove, being fishy, strong-smelling and repulsive, and the taste of the lark and ortolan, like that of bitter beer, is rather acquired than instinctive, and is not a little due to the same peculiarity of flavour. Those who have eaten the flesh of rooks or birds of prey, herons or gulls, to say nothing of cormorants, the smell of which is sufficient, will at once concur with me in the assertion that the gymnogenous birds are not adapted for the food of man.

The other division of birds is in all respects the opposite of that I have been describing; the flesh is wholesome, nutritious, and highly palatable; the bustard is the type of one order, the woodcock of another, the wild duck of a third, the pheasant of a fourth; then we have grouse, partridges, quails, barndoor fowls, snipes, geese, ducks, turkeys, guinea-fowls, and a host of others. It may be said that some of these owe a degree of their excellence to domestication; but I am by no means confident that this is the case, and, if so, it is simply the perfecting of innate excellence, and not, as in the edible Gymnogens, the substitution of a new character. These birds, when the egg-shell is broken, are produced in a state of perfect dependance on self; they

see, run, feed, at once, without any preliminary instruction; they are densely clothed with a warm coating of down, and hence I call them Hesthogenæ, or birds with clothed young; their growth to a normal size is very slow, in many instances occupying an entire year. These are not so emphatically birds as the Gymnogens; they never fly when the object can be accomplished by running; they confine themselves to the earth for general locomotion; their legs are consequently strong, and the muscles of the thighs largely developed; they are generally polygamous, the females greatly exceeding the males in number, and the males being proverbially salacious; they make very slovenly nests, often none at all; when nests exist they are placed on the ground; but very frequently the eggs are laid on the ground itself, or on ledges of rock. The birds comprised in this group are—the Anserina or duck tribe, the Colymbina or diver tribe, the Rallina or rail tribe, the Scolopacina or snipe tribe, the Charadriina or plover tribe, the Struthionina or ostrich tribe, and the Gallina or poultry tribe. With regard to the flesh of the ostriches as a food for man, I am incompetent to speak; but it is certain that it has never been introduced to the notice of Europeans, and therefore we can only judge of its merits second-hand.

We have now reached the sucklers, in which the way to a physiological binary division has been paved by Cuvier, Owen and Waterhouse. The Placentogenæ and Marsupogenæ appear to be rapidly advancing towards a state of full recognition in all countries. The physiological difference between them is at once simple and conclusive. The placental sucklers, Thelazontes Placentogenæ, are born of large bulk, and in a very advanced and comparatively perfect condition; their limbs, also, are of normal size and proportions as regards the body. During the whole of

their uterine existence they are attached by the umbilical cord to an organ called the placenta, in which the nutriment required for their growth appears to be prepared; one extremity of this umbilical cord is attached to the belly of the fœtus, about the centre of its disk; at this point the umbilical vein enters the body of the fœtus, and discharges itself into the hepatic vein, whence its contents are diffused through the frame. The placenta occupies a position of great interest in the economy of the fœtus; it is intermediate between the parent and the offspring, and the researches of physiological anatomists; I believe Baer, Muller, Weber, Bischoff and Wagner may be particularly mentioned as having deeply investigated the subject; find no direct communication between the parent and the fœtus; the blood-vessels of the parent enter the placenta, and there terminate; and the vessels of the fœtus enter the placenta, and there terminate, a fact of the highest interest when connected with classification, because it shows that these, the most highly organized of animals, possess a distinct organ peculiar to themselves. At the period of birth the umbilical cord is separated, the fœtus as well as the placenta being extruded by the parent; the young, immediately after birth, is prepared to suck the nipples of its parent, and from this source it derives nutriment, but whether the whole or only a portion of its nutriment, depends on the degree of advancement in which it is extruded; the differences in these respects affording material assistance to the systematist in subdividing these placentals. It is, however, a distinguishing character of placentals that the periods of the act of sucking are brief and occasional.

Contrasted with the placental, the marsupial sucklers, Thelazontes Marsupogenæ, are extruded in a condition scarcely more advanced than that of a placental fœtus three

days after conception; they are almost incapable of motion, and scarcely exhibit the rudiments of limbs, or of the external organs of the senses; they are unaccompanied, during their brief uterine existence, by a placenta, and appear to receive no intra-uterine nutriment after the period of their detachment from the ovary; on extrusion they are passed from the uterus to the nipple, by some process hitherto undiscovered, and, arrived at this, they adhere, with a tenacity only to be overcome by taking their life, until they attain that degree of development in which the placental sucklers are born. The young of a kangaroo, examined by Professor Owen twelve hours after birth, resembled an earth-worm in the colour and transparency of its skin, adhered firmly to the point of the nipple, breathed strongly but slowly, and moved its rudimental fore-legs when disturbed; the posterior portion of its body was bent forwards towards the abdomen, and the tail, at this period short and small, was tucked in between the hind-legs, which were only two-thirds as long as the fore-legs, but the triple division of toes was already manifest; the total length from the head to the extremity of the tail was rather more than an inch. In the adult the skin of the abdomen of the parent is arranged in the form of a pouch, which covers and protects the nipples with the young attached; and this pouch has been compared by Cuvier to a second uterus, concealed within which the young remains until it has acquired the form and habits of the parent. The sexual organs present several structural peculiarities which may be mentioned as intimately connected with the physiological phenomena of birth. In the female I think the descriptions warrant us in saying there is no normal uterus, its place being supplied by two lateral tubes which open in the vagina; this, however, I only infer from the definitions of Professor Owen, and not from

absolute knowledge. The differences in the male are obvious to the most superficial observer: the scrotum hangs before the penis, and this latter is directed backwards, or towards the anus. In many respects, especially in this peculiar relative position of the penis and testes, the marsupial sucklers much resemble birds; and the pouch may not unaptly be compared to the nest of a bird; the superimposed body of the parent forming in both instances an incubating or heating apparatus, without the aid of which the young could not be matured.

Thus we see that each of the four great divisions of endosteate animals is divisible by a purely physiological character, the mode of reproduction. The fishes, reptiles, birds and sucklers present a very obvious division on this ground alone; the clasping fishes, the immutable reptiles, the hesthogenous birds, and the placental sucklers are parallel groups, separated by one character, the advanced state of the young when it makes its first unequivocal appearance on the stage of life. But, regarding sucklers as the most perfectly organized of animals, we must also regard the placentals as the highest or normal sucklers; whereas the hesthogenous birds, the immutable reptiles, and the clasping fishes, although they approach the sucklers more nearly than the gymnogenous birds, the metamorphotic reptiles and apathetic fishes, still these last must be regarded as most emphatically fishes, reptiles and birds,—indeed, as normal fishes, reptiles and birds; while the three groups which in some minds appear higher in the scale, as more nearly approaching sucklers, may be regarded as abnormal, and as holding a secondary position in their respective divisions of the animal world.

PRINTED BY E. NEWMAN, 9, DEVONSHIRE STREET, BISHOPSGATE.